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Part IX

Environmental Protection Agency

Criteria for Classification of Solid Waste Disposal Facilities and Practices; Final, Interim Final, and Proposed Regulations (as corrected in the Federal Register of September 21, 1979)

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 257

[Docket No. 4004, FRL 1234-1]

Criteria for Classification of Solid Waste Disposal Facilities and Practices

AGENCY: Environmental Protection Agency

ACTION: Final rule and interim rule.

SUMMARY: This regulation contains minimum criteria for determining what solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment. Those facilities that violate the criteria are "open dumps" for purposes of the State Solid Waste Management planning effort supported by EPA under Subtitle D of the Resource Conservation and Recovery Act (RCRA or the Act) The criteria also provide the standard to be applied by the Federal district courts in determining whether parties have engaged in acts that violate the prohibition of open dumping, also contained in Subtitle D of RCRA The criteria also partially fulfill the requirement of Section 405 of the Clean Water Act (CWA) to provide guidelines for the disposal and utilization of wastewater treatment plant sludge Any owner or operator of a publicly owned treatment works must comply with these criteria when disposing of sludge on the land.

EFFECTIVE DATE: October 15, 1979.

DATE: For purposes of the Interim Final portions of the criteria [sections 257 3-5 and 257.3-6(b)], public comments will be accepted until November 20, 1979.

ADDRESS: Submit comments to Mr. Emery Lazar, Docket 4004 1, Office of Solid Waste (WH-564), EPA, Washington, D C. 20460

FOR FURTHER INFORMATION CONTACT: Mr Truett V. DeGeare, Jr, P E., Office of Solid Waste (WH-563), U.S. Environmental Protection Agency, 401 M Street, S W , Washington, D C. 20460, Telephone (202) 755-9120.

SUPPLEMENTARY INFORMATION:

I. Authority

This regulation is issued under authority of Sections 1008(a)(3) and 4004(a) of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, 42 U.S C 6907(a)(3) and 6944(a), as well as Section 405(d) of the Clean Water Act, as amended, 42 U.S C 345.

II. Background

This regulation was published in the **Federal Register** in proposed form for public review and comment on February 6, 1978. The Agency held five public hearings and eleven public meetings to discuss the proposed regulation and received a substantial number of written comments on the proposal. Having considered the views of the public, the Agency is now promulgating this regulation in final form. This preamble discusses some of the more significant issues raised during the public comment period and revisions made on the basis of those comments.

The objectives of the Act are to promote the protection of health and the environment and to conserve valuable material and energy resources. In order to accomplish this, the Act sets forth a national program to improve solid waste management, including control of hazardous wastes, resource conservation, resource recovery, and establishment of environmentally sound solid waste disposal practices. This is to be carried out through a cooperative effort among Federal, State, and substate governments and private enterprise

Subtitle D of the Act fosters this cooperative effort by providing for the development of State and regional solid waste management plans that involve all three levels of government. As the Federal partner in this process, EPA seeks, through regulations and financial assistance, to aid State initiatives in the formulation and implementation of such plans.

Section 4002(b) of the Act requires the Administrator to promulgate Guidelines for the Development and Implementation of State Solid Waste Management Plans On July 31, 1979, EPA issued those guidelines (44 FR 45066) While those guidelines are to consider a broad range of topics, Section 4003 of the Act identifies the minimum requirements which State plans must address. EPA provides financial assistance to help the States develop and implement their plans. Under Section 4007, EPA reviews and approves State plans which satisfy the minimum requirements of Section 4003.

The State solid waste management plan is the centerpiece of the Subtitle D program. Through the plan the State identifies a general strategy for protecting public health and the environment from adverse effects associated with solid waste disposal, for encouraging resource recovery and resource conservation, for providing adequate disposal capacity in the State, and for dealing with other issues relevant to solid waste management The plan must also set forth the institutional arrangements that the State will use to implement this strategy. (A more detailed description of the planning program is contained in the Preamble accompanying the Section 4002(b) guidelines)

A Section 4004. Disposal Facility Criteria

Under section 4004(a) of the Act the Administrator is to promulgate "regulations containing criteria for determining which facilities shall be classified as sanitary landfills and which shall be classified as open dumps * * *" The criteria establish the leve of protection necessary to provide that "no reasonable probability of adverse effects on health or the environment" will result from operation of the facility In setting these criteria EPA is providing a general definition of "sanitary landfill" and "open dump". As part of their planning programs, the States will evaluate existing disposal facilities to determine whether they comply with the Section 4004 criteria. Those facilities which do not satisfy the criteria are "open dumps" under the Act EPA will, under authority of Section 4005(b), publish a list of open dumps in the **Federal Register**

The inventory of "open dumps" will serve two major functions First, it will inform the Congress and the public about the extent of the problem presented by disposal facilities which do not adequately protect public health and the environment. Second, it will provide an agenda for action by identifying a set of problem facilities, routinely used for disposal, which should be addressed by State solid waste management plans in accordance with Section 4003 of the Act.

Essentially, the inventory is a planning tool which supports the State planning effort The States must know where the problem facilities are in order to satisfy Section 4003(3) which requires that the plan "provide for the closing or upgrading of all existing open dumps within the States * * *."

B. Section 1008(a)(3). Open Dumping Criteria

Under Section 1008(a)(3) of the Act the Administrator is to publish suggested guidelines that provide minimum criteria "to define those solid waste management practices which constitute the open dumping of solid waste or hazardous waste " Thus, these criteria are to establish a broad definition of the act of open dumping, which is prohibited under Section 4005(c) of the Act.

The prohibition may be enforced in Federal district court through the citizen suit provision in Section 7002 The Act does not give EPA authority to take legal action against parties that may violate the open dumping prohibition. The application of the open dumping criteria to the specific acts of specific individuals is a matter for the Federal courts to determine in the context of particular cases. Judicial review of specific acts in the context of open dumping suits should not be confused with State planning activities, particularly the evaluation of disposal facilities for the inventory of open dumps. The inclusion of a facility in the list of open dumps is not an administrative determination by EPA that any particular parties are engaging in prohibited acts of open dumping. (The Preamble accompanying the Guidelines for Development and Implementation of State Solid Waste Management Plans (44 FR 45066) provides a more detailed explanation of this issue.)

C. Section 405(d) Sludge Disposal Guidelines

Under Section 405(d) of the Clean Water Act EPA issues guidelines for the disposal and utilization of sludge. Under Section 405(e) of the CWA owners and operators of publicly owned treatment works (POTW's) must dispose of sludges from such works in accordance with those guidelines. Criteria designed to avoid a reasonable probability of adverse effects on health or the environment from disposal of sludge on land are clearly within the scope of this provision of the CWA.

D. Copromulgation of the Criteria

The criteria which EPA promulgates today are designed to fulfill or partially fulfill the requirements of each of the provisions discussed above. While all three provisions embody different implementation schemes, they all are concerned with the adverse effects on health or the environment that may be caused by solid waste disposal activities. Since there is an inherent compatibility of purpose among the three provisions, EPA has decided to structure the criteria so they may be used in all three contexts. EPA believes that co-promulgation of regulations, where possible, improves the quality of its regulatory efforts by eliminating the potential for inconsistencies among similar regulations and by providing a clear statement to the regulated community of the standards to which they will be held.

As an example of the compatibility between provisions, the facility classification criteria for purposes of the State planning program can, and probably should, be concerned with the same set of environmental effects as the criteria defining the prohibited act of open dumping. Regardless of whether one is evaluating facilities to aid in the establishment of setting state planning priorities or examining the acts of specific individuals to determine legal liability for open dumping, the same set of environmental effects should be of concern. At the same time, having a single set of criteria for defining unacceptable environmental effects does not undermine the use of that definition for different purposes.

It should be pointed out that these criteria are not necessarily the only guidelines to be promulgated under Section 405(d) of the CWA. These criteria apply where the owners and operators of POTW engage in the placement of sludge on the land. Future EPA guidelines on sludge disposal and utilization may address incineration, energy recovery, and give-away or sale of processed sludge.

III. General Approach

This regulation sets forth eight criteria that address broad classes of health and environmental effects that may be caused by solid waste disposal activities. The criteria are structured to define unacceptable impacts, those that present a "reasonable probability of adverse effects on health or the environment." In terms of the three statutory provisions authorizing this regulation, the criteria define an open dump (RCRA Section 4004), the minimum elements of prohibited open dumping practices (RCRA Section 1008(a)(3)) and the effects which must be avoided by POTW owners and operators (CWA Section 405).

EPA recognizes that these criteria will be applied to a variety of situations and that there is a need for flexibility in the standards to allow them to be applied to particular circumstances. During the comment period some reviewers expressed preference for greater specificity in the criteria, including more detailed design and operating requirements. Others favored greater flexibility and opportunity for consideration of local, site-specific conditions.

In developing the final criteria the Agency attempted to be as specific as possible without reducing the opportunity for State and local solid waste management and enforcement agencies to take into account the site-by-site variations and make assessments based on local conditions. Wherever possible EPA tried to set specific performance standards that define unacceptable environmental effects. Such an approach should provide a concise and measurable means of determining compliance with the criteria. However, in some situations it was not possible to devise a meaningful performance standard for the environmental effect of concern, given the lack of experience with such an approach to regulation of solid waste.

Where specific performance standards were not possible, EPA specified an operational technique to achieve the desired level of protection. When that approach was necessary the criteria maintain regulatory flexibility by allowing for the use of alternative techniques that achieve the same general performance level. Parties claiming that alternative approaches provide protection equivalent to that of methods described in the criteria have the burden of establishing that fact.

In addition EPA wishes to emphasize that the standards established in the criteria constitute minimum requirements. These criteria do not pre-empt other State and Federal requirements. Nothing in the Act or the CWA precludes the imposition of additional obligations under authority of other laws on parties engaged in solid waste disposal.

Various commenters criticized EPA's general approach as being either too restrictive or too lenient. Some argued that implementation of the criteria would substantially reduce needed disposal capacity. The Agency recognizes that one of the most critical problems in the solid waste management field today is the lack of acceptable disposal facilities due, in part, to public opposition to their siting. However, this particular rulemaking cannot deal directly with this problem.

The Agency is committed to evaluating other means by which it can help with the problem. Adequate disposal capacity is essential nationwide. Hopefully, implementation of the criteria will increase the credibility of disposal operations, thereby aiding in reducing public opposition to acceptable and needed facilities.

Some commenters felt that the criteria should be written very stringently in order to provide an incentive for initiation of resource recovery and conservation practices. Other commenters observed that, even with increased levels of resource recovery and conservation, disposal facilities would continue to be required into the foreseeable future, even resource recovery facilities produce a residue which requires disposal. The Agency believes that resource recovery and conservation are desirable solid waste management approaches which should be actively pursued. However, the purpose of the criteria is to define disposal activities which pose no reasonable probability of adverse effects on health or the environment, and the criteria have been developed with that goal in mind. While the implementation of these criteria may make resource conservation and recovery more economically competitive, these regulations have not been formulated simply to advance that cause Such an approach is not authorized by the Act.

EPA also received comments attacking the Agency's use of standards, definitions and approaches developed under other Federal environmental and public health programs. They claimed that incorporating these items into the criteria extends those other programs beyond their statutory authority While the use of particular Federal standards will be discussed later in this Preamble in the context of each criterion, a general point should be made about the use of approaches developed or employed in other programs. The Act requires that the criteria address adverse health and environmental effects of solid waste disposal, whatever those might be. The use of other Federal Standards in responding to this broad mandate is, in fact, quite desirable in order to minimize duplicative, overlapping and conflicting policies and programs. Unless it can be shown that other Federal standards and approaches are clearly inconsistent with the Act's objectives, it is within the Agency's discretion to use them, where applicable, in writing RCRA regulations

IV. The Criteria

A Scope

These criteria apply to the full range of facilities and practices for "disposal" of "solid waste", as those terms are defined in Section 1004 of the Act Various commenters suggested the exclusion or inclusion of specific types of solid waste disposal activities. EPA examined these suggestions in light of the Act's definitions, Section 1006 of the Act (which directs the Agency to avoid duplicative regulatory programs), the Act's legislative history and the objectives of Subtitle D. EPA has concluded that the criteria apply to all solid waste disposal 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 All other disposal of agricultural wastes, including placement in a landfill or surface impoundment, is subject to these criteria. This exclusion is based on the House Report (H.R. Rep No. 94-1491, 94th Cong, 2nd Sess. 2(1976)) which explicitly indicates that agricultural wastes returned to the soil are not to be subject to the Act

2. The criteria do not, at this time, apply to overburden from mining operations intended for return to the mine site. The House Report indicates that this type of overburden is not to be the immediate focus of the Act's programs.

3 The criteria do not apply to domestic sewage or treated domestic sewage However the criteria do apply to disposal of sludge resulting from the treatment of domestic sewage. In defining "solid waste" the Act specifically excludes solid or dissolved material in domestic sewage. Treated domestic sewage from which pollutants have been removed in a wastewater treatment plant is still considered to be domestic sewage for purposes of the Act Including such wastewater effluents within the Act's scope is particularly unnecessary because existing EPA programs concerning treatment of domestic sewage are seeking to assure that these effluents are disposed of in an environmentally sound manner

However, during the treatment of domestic sewage, solid and dissolved materials are removed from the sewage and collected as sludges Typically, these sludges are disposed of separately from the treated sewage which passes through the treatment plant. The language of Sections 1004(27) and 1004(26A) indicate that sludge generated by a wastewater treatment plant, water supply treatment plant or air pollution control facility is solid waste for purposes of the Act. EPA believes that while the Congress intended to exempt treated sewage effluents from the Act's provisions, it intended to include sludges created by the operation of treatment facilities. This approach is consistent with Congressional intent, expressed in Section 1002(b)(3) and the legislative history, that the Act specifically address the new solid waste management problem that resulted from effective implementation of programs designed to protect the air, water and other environmental resources.

With this interpretation a question is raised about the operation of septic tanks, a particular type of sewage treatment device. The materials which pass through the tank and are released into drainage fields are analogous to the treated sewage effluent passing through a treatment plant, and thus are not considered solid waste. The materials which settle to the bottom of the septic tank and are subsequently removed for disposal at some other facility are analogous to the sludge created by the operation of other sewage treatment processes Therefore, septic tank pumpings fall within the Act's definition of solid waste

4 The criteria do not apply to solid or dissolved materials in irrigation return flows This exemption is clearly stated in Section 1004(27) of the Act

5 The criteria do not apply to source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat 923) This exemption is stated in Section 1004(27) of the Act.

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. In defining solid waste the Act specifically exempts these discharges The principal purpose of this provision is to assure that waters of the United States (the jurisdictional concern of the Clean Water Act) are not regulated under this Act.

7. The criteria do not apply to facilities for the disposal of hazardous wastes subject to Subtitle C of the Act. Section 3004 establishes the standards which will be applicable to such facilities EPA's final regulations for its hazardous waste program will delineate the class of facilities subject to the Subtitle C requirements

8. The criteria do not apply to disposal of solid waste by underground well injection that is subject to regulations (40 CFR Part 146) for the Underground Injection Control Program (UICP) under the Safe Drinking Water Act, as amended, 42 U S C 3001, *et seq* While the subsurface emplacement of fluids through a well (the activity regulated by UICP) could also fall within the Act s broad definition of disposal, Section 1006 of the Act requires that EPA avoid duplication with its other programs (including those under the Safe Drinking Water Act) in administering the Act. Leaving regulation of underground well injection to the UICP is consistent with that mandate and is especially appropriate since the UICP seeks to achieve objectives similar to those of the Act

B Definitions (Section 257.2)

General definitions which apply to all the criteria are presented in § 257.2. The section defines "disposal," "facility," "leachate," "open dump," "practice," "sanitary landfill," "sludge," "solid waste," and "state " Also definitions that are only applicable to a particular criteria are presented in that criteria section.

EPA received many comments that reflected a concern over the definition of "facility". Several commenters suggested that EPA exempt such things as wastewater treatment lagoons, potable water treatment lagoons, surface impoundments (pits, ponds, lagoons, basins), mining waste disposal facilities, utility waste disposal facilities and agricultural waste disposal facilities The Act does not define the term "facility". EPA believes that the term should be interpreted broadly unless such an interpretation clearly conflicts with other provisions or objectives of the Act.

After examining these requests for exemptions in light of the Act and its legislative history, EPA concluded that there was no statutory basis for excluding these types of facilities All such facilities could present a reasonable probability of adverse effects on health or the environment EPA does not have any basis for determining that such facilities are not "solid waste disposal facilities" for purposes of the Act.

Several commenters asked whether the definition of "facility" would encompass "backyard" disposal practices such as home compost piles or burning of household wastes EPA does not believe that Congress intended the Subtitle D classification scheme to be implemented at the household level. Section 1004(27) refers to wastes from "community activities" In addition, the legislative history indicates at several points that "municipal" wastes are of concern under Subtitle D The Act's emphasis on "community" or "municipal" waste, indicates that the Congress intended to focus on solid waste managment at that level rather than at the household level. EPA believes that "backyard" practices should be controlled through State or local nuisance and public health laws

Some commenters suggested that disposal facilities used by small communities (especially small facilities in rural areas) be excluded from coverage due to the anticipated higher unit cost (cost per capita or cost per ton of waste) of compliance for such facilities The Agency found no basis for such an exclusion. In fact, such an exclusion could foster the development of additional small facilities in order to escape the cost of compliance and, cumulatively, could result in greater environmental damage in rural areas Thus, the criteria apply to large and small facilities, whether urban or rural, because it is essential that all facilities prevent adverse impacts on health and the environment in accordance with the criteria

Less sophisticated and less costly design and operational techniques, however, may be applicable at smaller facilities due to the smaller quantities of waste disposed and reduced magnitude of potential adverse effects. In addition, small or rural communities may take various approaches to reduce the per capita cost burden and achieve economy of scale through regionalized collection and disposal systems, sharing of equipment among facilities, or operation of facilities only during limited hours.

During the public comment period it was suggested that there be less stringent criteria for existing facilities than for new facilities. In considering this suggestion the Agency has found no difference in the potential adverse effects from existing as opposed to new, facilities. With regard to implementation of the criteria, however, the Act does recognize the need to continue the controlled use of existing facilities while alternatives which comply with the criteria are being developed. In taking steps to close or upgrade existing open dumps, a State may issue compliance schedules that allow use of a disposal facility while it is being upgraded or while alternative disposal options are being developed.

A few commenters also raised the question of whether a junk yard, which may buy or sell waste items, is a solid waste disposal facility. While a junk yard is clearly a "solid waste management" facility under the Act there is some question whether the operation of a junk yard constitutes the disposal of solid waste

Under Section 1004(3) "disposal" involves the placement of solid waste into or on any land or water so that a constituent of the waste may enter the environment. This entry of waste materials into the environment is an essential component of the Act's definition As the Senate Report states, "Disposal is letting wastes out of control" (Sen. Rept. No 94-988, 94th Cong., 2d Sess 26 (1976))

If a junk yard is operated in such a way that no waste material enters the environment then it is possible that it is not a solid waste disposal facility If constituents of the waste, however, are entering the environment (e g battery acids from automobiles leaching into the ground), then the junk yard would be a disposal facility It is up to the State to determine whether particular junk yard operations constitute disposal of solid waste

C Reorganization of the Criteria

After reviewing the comments EPA has decided to change the format of two portions of the criteria as they appeared in the proposed regulation The criteria concerning environmentally sensitive areas and disease have been reorganized.

The proposed regulation had one section that addressed the location of disposal facilities in wetlands, floodplains, permafrost areas, critical habitats of endangered species, and recharge zones of sole source aquifers, all of which were categorized as "environmentally sensitive areas" In the Preamble to the proposed regulation the Agency also requested comment on other areas, specifically karst terrain and active fault zones, for similar consideration

Environmentally sensitive areas are no longer addressed in a separate section. Criteria regarding floodplains and critical habitats of endangered species appear in independent sections discussed later Wetlands are addressed in the section on surface water, since wetlands are treated in the same manner as surface waters under the Clean Water Act Concerns for recharge zones of sole source aquifers are directly related to those for ground-water protection, thus, protection of sole source aquifers has been incorporated into the ground-water section of the criteria.

Permafrost areas are no longer addressed in the criteria While EPA is concerned with the effects of solid waste disposal in permafrost areas there are several reasons why it is not appropriate to establish a national criterion concerning permafrost. Permafrost areas only occur in Alaska in the United States. The State of Alaska has authority to regulate solid waste disposal and to protect permafrost EPA believes that the State's program is adequate to protect these areas Under Section 6001 of the Act Federal facilities must comply with applicable State solid waste disposal requirements Thus, there should be full compliance with those State disposal requirements affecting permafrost areas Moreover, the criteria addressing floodplains, surface water and ground water will cover many of the environmental effects of concern in such areas Under these circumstances it does not seem necessary to establish separate permafrost criteria at this time

In response to the Agency's request, some commenters described risks inherent in disposal of solid waste in karst terrain and active fault zones The concerns raised pertained primarily to ground water The Agency believes that these concerns are adequately addressed by the ground-water criteria and has not provided a separate criteria for karst terrain or active fault zones

In the proposed regulation the criterion for disease just addressed the problem presented by disease-carrying vectors. In the section addressing food-chain crops, the proposed criteria provided for controls to reduce the likelihood for transmission of pathogens from the solid waste to humans. Since both provisions concerned the prevention of disease, they have been combined in § 257.3-6

D Floodplains (Section 257 3-1)

Disposal of solid waste in floodplains may have several significant adverse impacts: (1) If not adequately protected, wastes may be carried by flood waters and flow from the site, affecting downstream water quality and structures, (2) filling in the floodplain may restrict the flow of flood waters, causing greater flooding upstream; and (3) filling in the floodplain may reduce the size and effectiveness of the flood-flow retaining capacity of the floodplain, which may cause a more rapid movement of flood waters downstream, resulting in higher flood levels and greater flood damages downstream For these reasons it is generally desirable to locate disposal facilities outside of floodplains.

The proposed criteria required that a facility not restrict the flow of the base flood nor reduce the temporary water-storage capacity of the floodplain, in order to prevent increased flooding upstream or downstream resulting from the base flood. In addition, the proposal required that the facility be protected against inundation by the base flood, unless the facility is for land application of solid waste for beneficial utilization as agricultural soil conditioners or fertilizers.

In developing this criterion EPA sought to comply with Executive Order 11988, "Floodplain Management" (42 FR 26951), which requires Federal agencies, in carrying out their responsibilities, to take actions to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains. In accordance with Executive Order 11988, EPA consulted with the Water Resources Council and the Federal Insurance Administration of the Department of Housing and Urban Development. Both of these agencies deal with floodplain management issues.

A few commenters questioned whether floodplain concerns were within the statutory scope of these regulations. Clearly, improper disposal of solid waste in a floodplain can have adverse effects on health and the environment EPA is not aware of any other Federal program that addresses the particular environmental threat presented by solid waste disposal activities in floodplains. Therefore, there is no question that these concerns are within the purview of this regulation.

After evaluating the proposed floodplains criterion in light of the comments, EPA re-evaluated the rationale for the proposed regulation. There was an apparent contradiction in the criterion between the requirement to prevent any increased flooding and the provision to protect against inundation. As several commenters pointed out, compliance with one was likely to lead to violation of the other. In addition EPA concluded that it was not necessary to eliminate any and all marginal increases, however small, in flood levels caused by disposal operations. Moreover, not all inundation of disposal facilities leads to adverse environmental effects. Depending on the waste material there may be no adverse downstream effects; where such effects could occur, proper control measures to prevent washout of the waste materials (e g. diking) would be sufficient to avoid the problem.

Therefore, EPA made the following changes in the floodplain criterion:

1. The disposal facility or practice should seek to avoid washout of solid waste, rather than necessarily prevent inundation of the waste. This change allows for the development of management practices or facility designs that can avoid washout of the solid waste without preventing all inundation by flood waters. (Several commenters indicated that such approaches were feasible)

2. All of the requirements are linked to an assessment of the hazard to human life, wildlife, land or water. This is designed to avoid a situation where any increase in flood levels attributable to disposal activities or washout of waste is automatically precluded. EPA does not believe that the incremental effect of solid waste operations on floodplain management justifies such a drastic approach. In some cases, however, disposal activities may present a significant marginal increase in the risk of flood damage. It is appropriate to avoid such a risk. EPA cannot specify for all situations what that unacceptable risk will be This issue must be resolved on a case-by-case basis in the implementation of these criteria

3. The exception for land application of solid waste for beneficial utilization as an agricultural soil conditioner or fertilizer has been eliminated EPA believes that special exceptions for classes of activities are no longer necessary. In more clearly specifying the performance objective for disposal in floodplains, the criteria provide the flexibility to allow continuation of those activities that do not present health and environmental hazards.

Some commenters questioned the use of the 100-year base flood in defining the floodplain of concern. EPA believes that this is an appropriate definition. The 100-year floodplain does not represent a flood that will occur only once in 100 years. It is the flood which has a one percent or greater chance of occurring in any one year. Such a flood may occur several times or never occur within a given 100-year period. In selecting the 100-year flood to define the floodplain of concern EPA is maintaining consistency with the approach in other Federal programs and in Executive Order 11988.

Some commenters misinterpreted the criteria as a prohibition against locating facilities in floodplains. While areas other than floodplains are often preferable locations for disposal facilities, the proposed criteria did not provide such a prohibition. Certainly, that point is even clearer in the floodplain criterion issued today.

E. Endangered and Threatened Species (Section 257.3-2)

Solid waste disposal activities can adversely affect endangered and threatened wildlife by releasing toxic materials into the environment and by disrupting the ecosystems on which they rely for food and shelter Therefore, it is appropriate for these criteria to contain provisions designed to mitigate adverse effects of solid waste disposal activities on endangered and threatened species of plants, fish or wildlife

The proposed criterion was designed to ensure that disposal activities did not occur in the critical habitats of endangered species unless it was determined that the activities would not jeopardize the continued existence of endangered species The proposal also required the approval of disposal plans by the Office of Endangered Species (OES) in the Department of Interior (DOI).

Under Section 7 of the Endangered Species Act (ESA), as amended, 16 U.S.C. 1536, all Federal agencies, in consultation with the Secretary of the Interior or the Secretary of Commerce, are to utilize their authorities in furtherance of the purposes of the ESA. EPA held formal consultations with the DOI and received a "biological opinion" recommending changes in the criteria. EPA considered this recommendation from DOI and all public comments in setting this criterion.

EPA has concluded that the criteria should assure that no solid waste disposal facilities or practices cause or contribute to the taking of endangered or threatened species. Taking means harassing, harming, pursuing, hunting, wounding, killing, trapping, capturing or collecting, or attempting to engage in such conduct. In addition such activitites should not destroy or adversely modify the critical habitats of *these species*. EPA *believes that this* criterion is clearly within the scope of the Act and that it satisfies Agency responsibility under the ESA.

Some commenters questioned EPA's authority to address effects on endangered species in the criteria. The Act gives EPA authority to set criteria concerning the full range of health and environmental effects resulting from solid waste disposal. The taking of endangered or threatened species by solid waste disposal activities is certainly an environmental effect of concern. In addition the ESA places a responsibility on the Agency to use its authority under the Act to mitigate such effects.

The major change in this criterion from what was contained in the proposed regulation is the shift in concern to the *taking* of endangered and threatened species. The proposed regulation focused on avoiding modifications of critical habitats that *jeopardized the continued existence* of a species. After examining that approach in light of the comments, EPA decided that the "jeopardize" language was inappropriate for a definition that would be applied to a vast number of site-specific conditions. In deciding whether an act or facility would jeopardize the continued existence of a species, the officials implementing the criteria would have to examine the marginal effect that harm to particular members of a species would have on the national population of that species. Particularly in the case of the open dump inventory, which involves the evaluation of thousands of solid waste disposal facilities, it would be extremely difficult to implement a "jeopardize" standard.

A determination of whether disposal activities are "taking" endangered species is more readily applicable to the site-specific situations for which these regulations will be used. Officials charged with implementing the criteria, as well as parties engaged in solid waste disposal, can quickly determine what is necessary to achieve compliance. Such an approach is consistent with EPA's general intent to establish concise, measurable performance standards wherever possible.

The use of the "taking" concept does not reflect an EPA belief that the ESA requires such an approach. EPA's obligation under Section 7 of the ESA, if any, is to assure that the criteria, which provide a national definition of the unacceptable environmental effects of solid waste disposal, do not jeopardize endangered species. Where those criteria are applied by State agencies, such implementation activities are not *subject to Section 7 because no Federal* action is involved.

Some commenters suggested that in complying with Section 7 EPA could not set criteria applicable to non-Federal parties that are more restrictive than what Section 9 of the ESA now requires of such parties. (Section 9 prohibits the taking of endangered species.) EPA rejects that argument. The Act and Section 7 of the ESA give EPA authority to set criteria different than the requirements otherwise applicable under Section 9.

EPA believes that the best way to ensure that national populations of endangered and threatened species are not jeopardized is to avoid the destruction of members of that population in site-specific situations. While the standard could have been written several ways to accomplish that objective, EPA believes that preventing the "taking" of endangered and threatened species has several advantages. This approach will aid coordination between solid waste and endangered species programs where feasible. It also gives the regulated community a uniform standard defining its responsibility in both contexts. The "taking" definition is broadly stated and thus would encompass the variety of adverse effects on endangered and threatened species that could be caused by solid waste disposal. In its "biological opinion" DOI endorsed this approach.

In the proposed regulation EPA only addressed endangered species. Several commenters suggested that "threatened" species identified by DOI also be included for consideration. EPA believes that such threatened species of wildlife are also deserving of protection and, therefore, has included them in the criteria. Thus, the endangered and threatened species of concern are those listed under authority of Section 4 of the ESA.

In endorsing the "taking" language, DOI's "biological opinion" included exceptions for activities covered by permits under Section 10 of the ESA or allowed by Section 6(g)(2) of the ESA. Section 10 authorizes the issuance of permits for the taking of species "for scientific purposes or to enhance the propagation or survival of the affected species." The operative portion of Section 6(g)(2) makes the Section 9 prohibition of taking inapplicable in states that have negotiated cooperative agreements with DOI. Under cooperative agreement, designated State officials may take endangered species for conservation purposes. Since neither of these situations seemed applicable to solid waste disposal activities they have not been included in the criteria.

EPA has decided to retain that part of the proposed regulation that reflected a concern for the wildlife habitats. Where "critical" habitats of threatened or endangered species have been identified by DOI it is unacceptable under the Act for solid waste disposal activities to destroy or adversely modify such habitats. In setting this criterion EPA is not precluding all disposal in a critical habitat area. Only when such disposal appreciably diminishes the likelihood of the survival and recovery of threatened or endangered species using the habitat does a violation occur. The "biological opinion" from DOI endorses this approach.

EPA has decided to drop that portion of the proposed criteria which required approval of disposal plans by the Office of Endangered Species, Department of Interior. EPA agrees with the several commenters, including OES, who said that such a requirement was inappropriate. The Act and the CWA create the implementing mechanisms for these criteria. While the OES may, and probably should, be consulted on the application of § 257.3–2 to particular situations, the officials responsible for applying the criteria, rather than the OES, must determine whether a violation has occurred.

F. Surface Waters (Section 257.3–3)

It is essential that solid waste activities not adversely affect the quality of the nation's surface waters. Rivers, lakes and streams are important as sources of drinking water, as recreational resources and as habitats for a wide variety of fish and other aquatic organisms. The nation's coastal and inland wetlands provide natural flood and storm control, sediment and erosion control, recharge of acquifers, natural purification of waters, and flow stabilization of streams and rivers. Wetlands produce nutrients which support complex ecosystems extending into estuaries and streams well beyond the marshes and wetland areas. Wetland habitats support fish, shellfish, mammals, waterfowl and other wildlife fauna and flora.

Solid waste disposal has led to surface-water contamination from runoff of leachate, accidental spills, and drift of spray occurring at dumps, landfills, surface impoundments, farmlands, and landspreading operations. In the proposed criteria EPA sought to coordinate its surface water standards under the Act with programs developed under the Clean Water Act (CWA) to restore and maintain the integrity of the waters of the United States (including wetlands.)

The proposed criteria required that point source discharges of pollutants comply with a National Pollutant Discharge Elimination System (NPDES) permit issued for the facility according to Section 402 of the Clean Water Act. A separate section addressed wetlands, a particular category of waters of the United States. This section, which has now been combined with the other surface water provisions, required that facilities not be located in wetlands unless permits were obtained under provisions of Section 402 and/or 404 of the Clean Water Act. The proposed criteria also required non-point source discharges of pollutants to be prevented or minimized.

The final regulation maintains this general approach and has eliminated those parts of the proposed regulation that might have created conflicting RCRA and CWA requirements concerning the adverse effects of solid waste disposal on surface waters. The separate section for wetlands was eliminated because they are treated like all other surface waters under the CWA. The provision affecting non-point source discharges to surface water has been linked more directly to applicable requirements developed for State and areawide water quality management planning programs under Section 208 of the CWA.

Under Section 1006 EPA is required to integrate, to the maximum extent practicable, the provisions of the Act with the Clean Water Act and other statutes. Under the CWA, EPA conducts programs designed "to restore and maintain the chemical, physical and biological integrity of the Nation's water." EPA believes that this goal is also a legitimate objective for its regulatory activity under the Act and that, in the spirit of Section 1006, EPA should use its authority under the Act to see that the goals of the CWA are achieved. Thus, in defining unacceptable solid waste disposal activities, EPA can and should determine that facilities and practices violating the Clean Water Act cannot be acceptable for purposes of RCRA.

Thus, in establishing the surface water criterion EPA used concepts and approaches used under the CWA. The surface waters of concern are the waters of the United States, which include "wetlands" meeting the Agency's and the Corps of Engineers' definition of that term. All point source discharges of pollutants must comply with requirements for NPDES permits pursuant to Section 402 of the CWA. Discharge of dredge or fill material to waters of the United States must comply with requirements for permits established pursuant to Section 404 of the CWA. ("Requirements" under the 402 and 404 permit programs include the general requirement to apply for such permits, as well as the substantive provisions of issued permits.) Non-point source pollution from solid waste disposal activities must not be in violation of legal requirements established to implement a water quality management plan under Section 208 of the CWA. Water quality standards developed to satisfy Section 303 of the CWA may be implemented through either NPDES permits, Section 404 dredge and fill permits, or legal requirements developed to implement a Section 208 plan.

Some commenters suggested that in using a CWA-based approach in these regulations EPA was attempting to regulate discharges to waters of the *United States under the Act.* This is certainly not the intent or result of these criteria. The implementation of CWA programs will be left to those responsible for those programs. In these criteria EPA is merely indicating that where solid waste activities violate the CWA, as determined by officials implementing that law, EPA cannot determine that those activities provide adequate protection to public health and the environment for purposes of RCRA.

Commenters also expressed concern over the definition of "wetlands", arguing that man-made channels and basins (particularly wastewater treatment lagoons) that happen to support vegetation should not be subject to protection under this criterion. In keeping with the goal of coordination, EPA is accepting the approach taken under the CWA, as expressed in the recently issued NPDES regulations (44 FR 32854). Thus, waste treatment lagoons or other waste treatment systems that happen to support vegetation are not waters of the United States. (As indicated in the NPDES regulations, cooling lakes and ponds are generally within the definition of waters of the United States, but certain kinds of cooling ponds may be excluded.)

Several commenters questioned the proposed inclusion of "surface runoff" as a point source discharge of pollutants. Under the existing NPDES regulations the term "discharge of pollutant" is defined to include "* * * surface runoff which is collected or channelled by man." EPA will maintain that approach in these criteria. All other surface runoff is subject to applicable requirements developed under section 208 plans for non-point source pollution.

Several public comments reflected concern about what permits would be necessary under the CWA for solid waste disposal in wetlands. Diking or other dredge or fill operations designed to prepare an area within waters of the United States for disposal of wastes would require a 404 permit as a matter of course. A question arises, however, concerning the actual deposit of the waste material into waters of the United States. Such a discharge could be treated as a discharge of pollutants requiring a Section 402 NPDES permit or as a discharge of dredged or fill material requiring a 404 permit.

Under previously issued regulations implementing the CWA (42 FR 37122), where the "primary purpose" of the discharge of waste material is for disposal, rather than for filling an area, the discharge is subject to the NPDES program.

Some commenters suggested a need for procedures establishing how NPDES permits will be applied to solid waste disposal. In response the Agency is developing policy guidance for this permitting process. As of this writing, a draft of this policy guidance, "NPDES Permits for Solid Waste Disposal Facilities in Waters of the United States—Policy Guidance Memorandum, August 23, 1978," has been distributed for external review. A public meeting for discussion of the draft policy guidance memorandum was held on December 11, 1978. EPA is currently reviewing the public comments submitted on this issue. EPA is also considering whether solid waste disposal in wetlands is more appropriately handled under the Section 404 permit program. EPA intends to explore this issue with the Corps of Engineers.

EPA has dropped any reference to a presumption against issuance of an NPDES permit for discharge of solid waste into wetlands. That reference, contained as a comment in the proposed regulation, reflected EPA's general belief that disposal activities should not be conducted in wetlands if other alternatives exist. The NPDES permit, however, will define the legal responsibilities of parties engaging in disposal of solid waste near or in waters of the United States. If the requirements of an applicable NPDES permit can be *satisfied, then there will be no added* "presumption" against the facility or practice.

Commenters raised concerns over the ability of NPDES permitting agencies to process applications and issue permits or point source discharges of pollutants rom solid waste disposal facilities. It was noted that not many NPDES ermits have been issued to such ischarges.

It has been Agency policy to prioritize ssuance of NPDES permits based on the otential adverse environmental impact f the discharge However, all lischarges require NPDES permits, and t is incumbent on the discharger to apply for the NPDES permit. Generally, no enforcement action is taken if application for an NPDES permit has been made, but the permit has not yet been issued. Upon issuance, the discharger must maintain compliance with the NPDES permit. Upon denial or revocation of a permit, the discharge must be discontinued.

In using the 208 planning program, EPA has dropped the proposed requirement to "prevent or minimize" nonpoint source pollution from solid waste disposal activity Several commenters were concerned that such a requirement might duplicate or conflict with provisions developed to implement a State water quality management plan. EPA shares that concern and, therefore, has made the changes described above However, EPA is also aware that not all 208 plans will have addressed the non-point source pollution problems presented by solid waste disposal EPA intends to explore this problem further to determine whether uniform national guidance is needed and can be given on how to handle this type of pollution problem If a set of standards can be devised EPA will consider amending these criteria

Not all portions of a 208 plan will necessarily be applicable to solid waste disposal activities, and it will be up to officials implementing the criteria to make the appropriate determination The criteria are linked only to those portions of the plan that have been translated into legal requirements (i e statute, regulation, ordinance, administrative orders) This assures clarity on what is required, avoiding questions about how to comply with broadly-stated policy statements

G Ground Water (Section 257 3-4)

Ground water, generally a high quality, low cost, readily available source of water, is the drinking water source for at least one half of the population of the United States, often it is the only economical and high quality water source available Ground water is generally suitable for human consumption with little or no treatment necessary.

Ground water has been contaminated by solid waste disposal on a local basis in many parts of the nation and on a regional basis in some heavily populated and industrialized areas, precluding its use as drinking water. Existing monitoring of ground-water contamination is largely inadequate, many known instances of contamination have been discovered only after ground-water users have been affected The Act and its legislative history clearly reflect Congressional intent that protection of ground water is to be a prime concern of the criteria.

The proposed criteria established requirements for ground-water protection based on the utilization of the ground water. Ground-water utilization was divided into two categories: Case I addressed ground water currently used or designated for use as drinking water supplies or ground water containing 10,000 miligrams per liter (mg/l) total dissolved solids or less; and Case II addressed ground water designated for other uses

For Case I, the proposed criteria required that the quality of ground water beyond the disposal facility be maintained for use as a drinking water supply. The proposed criteria were based on the "endangerment" approach adopted from previously proposed regulations for the Underground Injection Control Program (41 FR 36726). "Endangerment" was defined to mean introduction of a contaminant that would require additional treatment of current or future drinking water supplies or would otherwise make the water unfit for human consumption. The proposed criteria required that the disposal facility not "endanger" Case I ground water beyond the property boundary (Comments were specifically requested on the use of other distances in lieu of or in addition to the property boundary) For Case II, States could, where consistent with their authority, designate ground water for uses other than drinking water and would establish the quality at which the ground water was to be maintained consistent with the designated use

In order to predict, as early as possible, the potential for ground-water endangerment, the proposed criteria required that ground water be monitored so as to indicate the movement of contaminants from the disposal facility where endangerment was likely. Contingency plans were required for corrective actions to be taken in the event that an adverse impact was indicated by the monitoring

For sole source aquifers, the proposed criteria required that facilities not be located in the recharge zone unless alternatives were not feasible and unless "endangerment" was prevented

Under the final ground-water criteria, the facility or practice must not *contaminate* an *underground drinking water source* beyond the *solid waste boundary or an alternative boundary* set by the State Contamination occurs when leachate from the disposal activity causes the concentrations of certain pollutants in the ground water to either (1) exceed the maximum contaminant level (based on the primary drinking water standards) specified for that pollutant, or (2) increase at all where the background concentration of the pollutant already exceeds the applicable maximum contaminant level An underground drinking water source is an aquifer currently supplying drinking water for human consumption or an aquifer in which the concentration of total dissolved solids is less than 10,000 milligrams per liter (mg/l) Generally, the existence of contamination is determined at the waste boundary However, States with approved solid waste management plans may establish an alternative boundary if, after thorough examination of the site-specific situation, a finding is made that an adjustment of the boundary would not result in contamination of ground water needed or used for human consumption

(1) *Approach to Ground-water Protection* A few commenters suggested that the proposed regulation was beyond EPA's authority becaue it allegedly involved the establishment of ambient ground-water standards. This charge reflects a misunderstanding of the approach taken in the proposed, as well as the final, regulation EPA is not regulating ground water with these criteria, rather, EPA is setting standards applicable to disposal of solid waste In defining the unacceptable effects of such disposal on ground water, EPA has concluded that solid waste activities should not degrade ground water beyond levels established to protect human health The criteria are designed to achieve that objective

EPA recognizes that ground-water quality is important for other purposes (e g for irrigation of plants, for its effect on fragile ecosystems) Differing standards may be appropriate to protect its usefulness for these other purposes. At this time, however, EPA has decided to define "contamination" in terms of the water's use as a drinking water source EPA believes that the prevention of adverse human health effects from direct consumption of ground water, should be the first among several objectives in protecting ground-water quality. Moreover, the Agency has developed standards for drinking water but has not established standards for other uses

These criteria reflect EPA's concern for both present and future users of ground water A significant number of people in the country take their drinking water directly from ground-water resources EPA expects that such direct use will continue in the future In defining unacceptable solid waste disposal activities, these criteria cannot be based only on current patterns of ground-water use. Potential future users of the aquifer must be considered.

EPA believes that solid waste activities should not be allowed to cause underground drinking water sources to exceed established drinking water standards. Future users of the aquifer will not be protected unless such an approach is taken. Where maximum contaminant levels have already been exceeded due to other conditions or actions affecting the aquifer, solid waste activities should not be allowed to increase the risk of damage to present or future users of the aquifer

(2) *Contaminants of Concern.* Commenters stated that the "endangerment" standard in the proposed regulation was vague, especially since it did not specify contaminants that would make more extensive treatment necessary or otherwise make the water unfit for human consumption Some felt this approach would allow too much contamination, given the lack of certainty regarding toxicity of many contaminants and the state-of-the-art of monitoring and water treatment. Others stated that it would require facility operators to demonstrate protection from a myriad of substances, that the levels to which those substances should be tolerated was not defined, that the standard was based on unspecified treatment and changing technology, and that the capability of existing treatment is a function of too many parameters In order to respond to these comments the Agency explored various lists of contaminants upon which to base the criteria

Several reviewers supported the proposed criteria's use of the National Interim Primary Drinking Water Regulation (NIPDWR) in the definition of "endangerment". Some reviewers pointed out, however, that the list of contaminants in the NIPDWR (40 CFR Part 141) was not created to serve as ground-water quality standards, and that it does not include all potentially harmful substances which might be associated with leachate from solid waste

EPA recognizes that the NIPDWR lists only those parameters commonly found in public drinking water supplies Other substances which may be harmful to human health were not included in Part 141 due to their relatively rare occurrence in drinking water systems, the unsuitability of analytical methods, the high costs of monitoring, or the lack of toxicity data For example, cyanide was not listed in the NIPDWR because of its low rate of occurrence Several potentially dangerous substances which were excluded from the NIPDWR are present in leachate from waste disposal.

There is no doubt, however, that the contaminants identified in the NIPDWR are appropriate for consideration in the criteria. Generally, no commenters opposed the inclusion of any listed contaminant in this regulation. The one exception is the manmade radionuclides identified in the NIPDWR. These substances fall within the class of radioactive substances excluded from the Act's definition of solid waste and, thus, the leaching of these materials into ground water should not be addressed by these criteria.

EPA has evidence that all of the contaminants identified in the NIPDWR have been in wastes covered by these criteria and that such materials are likely to enter ground-water supplies. Therefore, while it may be advisable to expand the list of contaminants covered by the criteria as new information is developed by the Agency, it is certainly appropriate to use the contaminants identified in the NIPDWR in the criteria at this time

The Agency has also explored the use of the National Secondary Drinking Water Regulations (NSDWR) in defining maximum contaminant levels The NSDWR (40 CFR Part 143) represent the Agency's best judgment on the standards necessary to protect underground drinking water supplies from adverse odor, taste, color and other aesthetic changes that would make the water unfit for human consumption. EPA believes that this is a serious concern which deserves consideration in the criteria. In addition, many of the substances listed in the NSDWR often occur together with other substances in leachate which can be injurious to health

However, EPA has decided not to include the contaminants identified in the NSDWR in the criteria at this time It was not clear in the proposed regulation that EPA was considering their use for purposes of the criteria To avoid any question about the adequacy of opportunity to comment on the use of the NSDWR in the criteria, EPA has decided to specifically seek public comment on this issue. Thus, EPA is also issuing today a proposed amendment to the criteria which would add the maximum contaminant levels in the NSDWR to the definition of ground-water "contamination."

Two other sets of pollution parameters were considered for inclusion in these criteria the *Quality Criteria for Water* (EPA 1976) and the list of toxic pollutants referenced in Section 307(a)(1) of the Clean Water Act, as amended

The publication *Quality Criteria for Water* recommends levels for water quality in accord with the objectives in Section 101(a) and the requirements of Section 304(a) of the Clean Water Act. The primary purpose of that publication is to recommend levels for surface water quality that will provide for the protection and propagation of fish and other aquatic life and for recreation. Although recommended levels are also presented for domestic water supply, and for agricultural and industrial use, ground water was not a major consideration.

Quality Criteria for Water lists most of the substances in Parts 141 and 143. Several of the additional parameters listed are only of interest in surface water protection, such as mixing zones (one third the width of a stream, 10 percent of the area of a lake, etc), temperature, and suspended solids While several health related substances that could be present in leachate are listed (e.g., boron, beryllium, cyanide, nickel and several insecticides and other organics), the recommended limits are specified for aquatic life protection and these are not appropriate for ground water. Furthermore, the recommended limits were written to be guidance in developing standards, not to be used as standards themselves Therefore, EPA decided that this list was inappropriate for these criteria.

Under Section 307 of the CWA the Agency may establish either technology-based or stricter health-based standards for toxic pollutants identified under Section 307(a)(1) EPA is investigating the appropriateness of using the health-based standards in the criteria Such substances as aldrin/dieldrin, DDT, endrin, toxaphene, benzidine and polychlorinated biphenyls (PCB's) are now subject to section 307 standards. EPA may be establishing such standards for other pollutants some time in the future At this time, however for purposes of these criteria, EPA will rely only on established drinking water standards

(3) *Levels of Contamination* While the design of the ground-water criteria is similar to the "endangerment" approach

of the Underground Injection Control Program under the Safe Drinking Water Act, it provides for greater specificity and does not use the exact wording of that program or statute Therefore, to avoid confusion the term "endangerment" is no longer used in the criteria Instead, the word "contaminate" has been employed A facility "contaminates" ground-water if it introduces a substance that would cause·

(a) The concentration of that substance in the ground water to exceed specified maximum contaminant levels, or

(b) An increase in the concentration of that substance in the ground water where the existing concentration of that substance exceeds the specified maximum contaminant level

The first part of the above definition is intended to protect water that can be used as drinking water without treatment. The second part is intended to protect ground water already at or above the maximum contaminant level by preventing introduction of substances that would exacerbate the problem

Many comments were received on levels of contamination. Some suggested using the maximum contaminant levels (MCL's) in the National Primary and Secondary Drinking Water Regulations, others suggested using higher limits or using lower limits Some reviewers suggested varying the levels with the background quality or the potential use of the ground water.

The reasons given for adopting higher allowable levels, or more lenient standards, (than the MCL's) included contention (1) that the increased cost of land disposal would be greater than the value of the threatened resource, (2) that the more efficient approach for some of the substances was to remove them from the water supply by treatment after contamination, and (3) that some of the Secondary MCL's are commonly exceeded in ambient or native ground water, thereby effectively resulting in a non-degradation standard for those aquifers EPA sees no reason to doubt that some people will continue to consume ground water directly without treatment That portion of the public should be protected from adverse effects (as defined by the drinking water standards) caused by solid waste leachate entering their drinking water In some situations protection of the public will require non-degradation of an aquifer The Act does not call for a balancing of the costs of disposal against the "value" of ground-water resources EPA believes that this criterion represents a reasonable approach to ground-water protection It allows for the use of natural mechanisms (e g soil attenuation, diffusion of contaminants in the aquifer) to reduce the risk of adverse health effects without compromising the general objective of protecting drinking water supplies

The reasons given for more stringent limits included· (1) Land disposal facilities are but one of several sources of ground-water contamination, and each source contributes to the overall rise in contaminant levels, (2) future research may find that lower levels are necessary to adequately protect health, (3) some agricultural, industrial and other important uses of ground water may be impaired, and (4) since ground water is often consumed without treatment, more stringent limits would require less reliance on programs to monitor and to require treatment before domestic usage

Generally, EPA has not written more stringent standards because existing information does not indicate that such standards are needed to protect public health Future research results might, of course, justify changing the criteria As discussed earlier EPA does not now have the scientific basis for setting stricter standards designed to protect ground-water's use for non-drinking water purposes The standard does recognize that an aquifer may be polluted by several sources Where existing ground-water quality levels exceed the MCL's, the solid waste activity may not degrade ground-water quality at all No matter what the standard, the need for monitoring must be determined on a case-by-case basis, and it seems doubtful that differing standards would change that need

Some reviewers mentioned that relying only on upper water quality limits results in more stringent requirements for protection of contaminated water than for uncontaminated water (i e. facilities over uncontaminated waters could introduce substances up to the maximum contaminant levels while facilities over contaminated waters could not introduce any substance that would increase contaminant levels) While this is a possible result of the standard, EPA does not believe that the health risk justifies a complete non-degradation standard

In adapting the NIPDWR for the criteria a few modifications were necessary As indicated earlier the standards for man-made radionuclides were not included because the statutory definition of solid waste excludes such materials from the Act's scope The contaminant level for coliform bacteria had to be modified because under the NIPDWR the MCL varied somewhat depending on sampling frequency and community size EPA assumed that sampling of ground water around disposal sites would be less frequent than in a public water system, and so the NIPDWR coliform standard related to the least frequent sampling regimen was selected for the criteria Also, the criteria do not include the NIPDWR limit for turbidity, since that limit was established for surface water supplies

(4) *Where the Standard is Applied* Another concern regarding the ground-water criterion is the issue of where the standard is to be applied (i e at what point in the aquifer does contamination from the facility or practice constitute non-compliance) In the proposed criteria, the point of application was at the facility property boundary The rationale for applying the standard at the property boundary was that it would provide for protection of off-site ground water while affording the opportunity for natural soil attenuation and dispersion and dilution of leachate in ground water underlying the area designated for waste deposition (i e within the facility)

However, the proposed criteria recognized that monitoring and control of leachate within the property boundary would generally be necessary in order to assure that the standard at the property bountary would be met Therefore, there also were proposed operational requirements including monitoring of ground water, prediction and control of leachate migration, collection and removal of leachate and prevention of water infiltration.

Commenters indicated two potential shortcomings of the facility property boundary approach (1) That future owners of the facility property might use contaminated ground water underlying the facility as drinking water and (2) that if the facility property were very large, great expanses of ground water could be contaminated and purchase of additional property could be used to circumvent the intent EPA agrees that such results could occur.

Commenters also expressed concern that the operational controls and monitoring provisions were vague and could be meaningful only if specified on a site-by-site basis, rather than generally prescribed in a regulation of national applicability. Commenters also described these operational provisions as inappropriate to a regulation which must delineate acceptable performance levels

The Agency considered use of other distance specifications in lieu of the property boundary in order to try to respond to reviewers' concerns about the potential for contamination of large expanses of ground water The proposed criteria requested comments on alternative distances and the rationale for specification of such distances. Various distances were suggested in the public comments; however, there was no basis presented for selection of one distance over another While there is a rationale for limiting migration of contamination to within the areas to be used for waste disposal in order to protect neighbors who may use the ground water untreated as a drinking water supply, there is no rationale for limiting migration to any *particular* distance

In evaluating this issue EPA recognized that the point of application of the standard must be mindful of the ability to monitor at that point. Ideally, the best way to protect present and future users of an aquifer is to assure that drinking water standards are not violated anywhere in the aquifer, including the area immediately under the waste material

However, any attempt to monitor directly under the waste presents two major difficulties. First, an environmental risk may be posed by the installation of monitoring wells through the waste material or in areas where waste will be deposited. These wells may become conduits for direct flow of waste constituents (e g leachate) into the aquifer While it may be theoretically possible to construct a well that doesn't allow such infiltration, the technology for this has not been sufficiently demonstrated that EPA would want to encourage this practice on a national scale Secondly, the immediate proximity of waste to the well, in conjunction with the "conduit" phenomenon, would undermine the utility of the monitoring well. Samples extracted would not be likely to be representative of the aquifer; rather, they would be likely to contain concentrated leachate, overestimating the contamination of the aquifer.

EPA also examined the possibility of other fixed distances from the center of the waste area This approach was rejected because it was impossible to establish a uniform distance that would be meaningful for the vast number of situations to which this standard applied. In some instances a fixed distance would mean that monitoring wells would still be placed through waste material. A longer distance might, in some cases, put the point of measurement beyond the area of likely placement of drinking water wells.

After examining all of these approaches EPA concluded that the *solid waste boundary* is the appropriate point for application of the standard The solid waste boundary is intended to be taken as the outermost perimeter of the solid waste as it would exist at completion of the disposal activity. With that as the point of measurement, ground-water contamination will be detected as soon as possible without presenting the risks inherent in monitoring under the waste Likewise, it avoids the problem of guessing the distance at which a potentially affected party is likely to put a drinking water well (The only assumption is that drinking water won't be taken from wells drilled directly through the area of solid waste deposition)

In most cases, for disposal facilities, the solid waste boundary would be the boundary of the solid waste as shown on the design and operating plans which are provided to and approved by the State agency as part of the State's facility permitting or certification program Where such plans do not exist to designate the perimeter at completion, especially for the practice of indiscriminate or unauthorized disposal, the perimeter at completion can only be taken as the current boundary of the deposited waste

With this approach to the point of application for the MCL's, the monitoring requirements are relatively clear. Monitoring wells should be placed so as to avoid their becoming conduits for waste materials Unsaturated and saturated zones underlying the area of the facility designated for waste deposition (i.e. within the solid waste boundary) may be employed for attenuation or control of leachate migration, but contamination of underground drinking water sources outside of these zones constitutes non-compliance with the criteria.

The point of application of the MCL's may be modified under certain circumstances. EPA recognizes that hydrogeological conditions, property rights or legal arrangements concerning an aquifer may limit the ability of the public to directly use some or any part of a particular aquifer as a drinking water source EPA believes that some flexibility is needed in the criteria to provide for such situations. Therefore, the criteria allow the State to modify the point for application of the MCL's.

To prevent this from becoming a major loophole, the criteria establish limits to this flexibility. Only States with approved solid waste management plans may modify the point of measurement. This may only occur where the State has conducted a thorough examination of the site-specific situation and has made a specific finding that establishment of the alternative boundary would not result in contamination of ground water needed or used for human consumption The examination leading to the finding should include the opportunity for public participation The criteria specify the key factors that must go into this determination.

The proposed criteria would have allowed a State to designate an aquifer as a Case II aquifer (an aquifer designated for use other than as a drinking water supply). For an aquifer so designated, the proposed criteria required the ground water to be maintained at a quality as specified by the State Several commenters challenged the use of this approach. Some argued that, given the uncertainties in future drinking water needs, all potentially usable drinking water should be conserved They also pointed out that there was inadequate data on ground-water quantity, quality and use projections to make such designations and that institutions and authorities to make such trade-offs are non-existent Commenters also suggested that it was improper for the criteria to defer totally to State standards for designated aquifers

EPA generally agrees with the comments. These and other factors lead EPA to drop the aquifer designation provision and rely on the alternative boundary approach as the means for allowing flexible application of the criteria.

(5) *Underground Drinking Water Source* The final criteria maintain the general approach found in the proposed regulation The reference to aquifers that "may be designated by the State for future use as a drinking water supply" has been deleted EPA concluded that this was unnecessarily vague Any future drinking water source would be likely to fall within the second portion of the definition (aquifers in which ground water contains less than 10,000 mg/l total dissolved solids)

Some commenters questioned the use of the 10,000 mg/l total dissolved solids measure for usable aquifers It is the Agency's general policy that ground-water resources below that concentration be protected for possible use as a drinking water source. This policy is based on the Safe Drinking Water Act and its legislative history which reflects clear Congressional intent that aquifers in that class deserve protection

(6) *Sole Source Aquifers* These aquifers are those which the Administrator specifically designates under authority of Section 1424(e) of the Safe Drinking Water Act (Pub L 93-523, 42 U S C. 300f, 300h-3(e), 88 Stat. 1660 et

seq) This provision of the Safe Drinking Water Act is administered through regulations proposed as 40 CFR Part 148. As applied through RCRA, the Agency's concern for the impact of disposal facilities on these aquifers is not different from that for other underground drinking water sources as defined in the criteria. Therefore, for clarity and consistency, this area of the proposed criteria has now been incorporated into the ground-water section. Rather than addressing the location of facilities in recharge zones of such aquifers (an operational standard), the criteria apply the performance standard described above for all underground drinking water sources, including sole or principal drinking water sources, regardless of location

H Application To Land Used For The Production Of Food-Chain Crops (Section 257 3-5)

The conservation of the nation's natural resources is one of the Agency's highest priorities The application of sewage sludge, as well as other solid wastes, to the land surface or incorporation within the root zone of crops may provide significant benefit through the addition of organic matter, nitrogen, phosphorus and certain other essential trace elements to the soil Specifically, land application of solid waste coupled with good management techniques for enhancement of parks and forests and reclamation of poor or damaged terrain is a desirable land management technique

Application of solid waste to agricultural lands may also be an environmentally acceptable method of disposal However, when improperly managed, the application of solid waste to agricultural lands can create a potential threat to the human food chain through the entry of toxic elements, compounds, and pathogens into the diet (It should be noted that pathogens are covered under the Disease section of the criteria) In developing these criteria, the Agency attempted to achieve the benefits of resource conservation while at the same time providing for protection of public health and the environment. In recognition of the above public health concerns, the Agency prefers the application of solid waste to non-food-chain land rather than to agricultural lands However, the Agency believes that food-chain land application practices which comply with these criteria will pose no reasonable probability of adverse effects on public health or the environment

This section is only concerned with disposal activities affecting food-chain crops. The other sections of the criteria apply to all disposal activities, including those occurring on lands producing food-chain crops However, solid waste facilities and practices are only affected by this section if the site of disposal is also a field for production of food-chain crops.

In their role as guidelines under Section 405 of the Clean Water Act the criteria define the responsibility of owners and operators of POTW's when they apply sewage sludge directly to the land In an effort to encourage the beneficial use of sludge in small communities EPA is concerned that these criteria could present an unwarranted administrative burden upon such communities Therefore, EPA will explore the possibility of reducing monitoring and recordkeeping requirements for those POTW's with small design capacity which do not have significant industrial inflow and which generate a sludge with a low contaminant level Such reduced requirements for facilities which apply sludge to land used for the production of food-chain crops would be a part of future regulations or guidance designed to implement Section 405 EPA is considering using a design capacity of 1 0 million gallons or less per day to define "small" facilities and cadmium concentrations of less than 25 mg/kg (dry weight) to define "low-contaminant" sludge.

This section of the criteria is being issued today as an "interim final" regulation This means that, while the regulation is "final" and legally enforceable, EPA is seeking further public comment on the regulation If changes are warranted by suggestions or new information generated during the public comment period, EPA is quite willing to modify this section

The "interim final" approach has been recognized by the courts as a permissible means for EPA to use when trying to satisfy the competing demands placed on its rulemaking efforts Particularly where EPA is under court order to issue regulations by certain dates, this approach has been used to satisfy the spirit of the court's order without curtailing opportunity for additional public participation in the rulemaking process.

These criteria are subject to the mandate of the U S District Court for the District of Columbia in *State of Illinois v Costle* No 78-1689 (D D C Jan 3, 1979) Under the order of that court the criteria were to be issued by July 31, 1979, and EPA intends to satisfy the spirit of that order EPA believes that the standards established in this section provide a reasonable approach to the environmental problem at issue However, the public has not had a full opportunity to comment on some of the technical data and analyses supporting this portion of the regulation The "interim final" approach is appropriate because it allows the Agency to accommodate these two competing interests It achieves substantial compliance with the court mandate while allowing full public participation in the rulemaking effort.

As proposed, this section of the criteria addressed four general categories of pollutants (1) Cadmium, (2) pathogens, (3) pesticides and persistent organics, (4) ingestion of toxic organic chemicals and heavy metals (especially PCB's and lead). In the final regulation this section addresses cadmium and PCB's Pathogens are considered under the disease criterion (§ 257.3-6) Lead, pesticides and persistent organics will not be addressed at this time because current information available to the Agency is inadequate to support specific standards EPA will investigate the possibility of adding more pollutants to the criteria at a later date.

(1) *Cadmium.*—The proposed criteria included two approaches for the land application of solid wastes containing cadmium The first approach incorporated four site management controls Control of the pH of the solid waste and soil mixture, annual cadmium application limits that were reduced over time, cumulative cadmium application limits based on soil cation exchange capacity (CEC); and a restriction on the cadmium concentration in solid wastes applied to facilities where tobacco, leafy vegetables and root crops are grown The second approach required comparability of the cadmium content of crops and meats marketed for human consumption to the cadmium content of similar crops and meats produced locally where solid waste had not been applied Also, a contingency plan was required which identified alternative courses of action that would be taken if the cadmium levels were not found to be comparable This approach was only available to facilities possessing the necessary resources and expertise to adequately manage and monitor their operations to assure such comparability.

In the final regulation, application of solid waste to land is specified as a disposal practice in which the solid waste is applied to within one meter (three feet) of the surface of the land. That distance was selected to represent the root zone of food-chain crops, where uptake of cadmium by plants is likely to occur.

The final regulation maintains the same general approach as the proposed regulation. Under the first option controls are placed on both annual application rates and maximum cumulative loadings The provision mandating that the pH of the mixture of soil and solid waste be maintained at 6 5 has been changed to a requirement that the pH be at 6 5 or more at the time of each solid waste application (except when cadmium concentrations are 2 mg/kg or less in the solid waste).

While the annual application rate limits are basically the same as those in the proposed regulations, two changes have been made. The limit for annual cadmium application to "accumulator" crops is now 0.5 kilograms per hectare/yr. (In the proposed regulation the limit was expressed in milligrams per kilogram dry weight of waste) In addition, the annual application rate limit for all other crops will be phased in over a slightly longer time period than that which was proposed.

The limits on cumulative loadings are also basically the same as those in the proposed regulation. However, they have been modified to account for pH effects. Where natural soil background pH is at 6.5 or greater, or where the natural soil background pH is less than 6.5 but safeguards exist at the site which will assure that the soil pH will be maintained at 6 5 or greater for as long as food-chain crops are grown, the maximum limits contained in the proposed regulation are applicable. In all other situations maximum cumulative loadings may not exceed 5 kg/ha.

As in the proposed regulation, there is a second approach that would allow unlimited application of cadmium providing that four specific control measures are taken· First, the crop grown can only be used as animal feed Second, the pH of the soil must be maintained at 6 5 or above for as long as food-chain crops are grown Third, a facility operating plan must describe how the animal feed will be distributed to prevent human ingestion. The plan must also describe measures that will be taken to prevent cadmium from entering the human food-chain due to alternative future land uses of the site Fourth, future owners are provided notice (through provisions in land records or property deed) that there are high levels of cadmium in the soil and that food-chain crops should not be grown

EPA received many comments on the cadmium controls in the proposed regulation In order to clearly explicate the final standard and respond to major public comment, this preamble will discuss the issues under five headings: (a) Health effects; (b) trace amounts of cadmium; (c) maximum cumulative loadings; (d) annual rates of application; and (e) closely controlled facilities.

(a) *Health Effects of Cadmium.*—The comments that were received exhibited widely divergent views on the health implications of cadmium contained in solid waste. As a result, the Agency reexamined the available scientific data and reached the following conclusions

A variety of adverse health effects have been documented in humans and experimental animals under conditions of acute as well as chronic exposure to cadmium. While acute health effects in humans are generally caused by high-level occupational exposure through inhalation, chronic health effects may result through the diet and cigarette smoking, which are the major routes of cadmium intake for most people. The kidney is considered the main target organ for chronic exposure to cadmium, although chronic respiratory effects have been observed in long-term occupational settings Upon ingestion or inhalation, the metal gradually accumulates in the kidney cortex. According to both clinical-epidemiological and model-calculation data, the critical concentration of cadmium in the kidney cortex is approximately 200 micrograms per gram (ug/g), wet weight, in the average human At that level, renal tubular dysfunction, characterized by proteinuria, is expected to occur This condition is manifested by the excretion of B_2-microglobulin, which is the earliest discernible laboratory evidence of organ damage. Although mild or moderate increases in excretion of B_2-microglobulin, per se, are not life-threatening, the condition is often irreversible, and continued excessive exposure to cadmium can lead to other renal function abnormalities (such as glycosuria, amino-acid uria, and phosphaturia)

Several autopsy studies have been performed to determine the cadmium content of various types of body tissue, such as the kidney and the liver These studies confirm that the kidney is the organ which contains the highest concentration of cadmium and that the concentration of the metal increases with age. Further, the autopsy data indicate that for the general United States population (smokers included) the mean cadmium levels reached in the kidney cortex are in the range of 20–35 micrograms per gram wet weight Smoking would tend to raise the mean cadmium concentration since the data also show that smokers have approximately double the concentration of non-smokers. There were significant individual variations from the mean value, with some concentrations over 60 micrograms per gram.

Various models have been established to calculate the daily level of exposure which will result in a cadmium concentration of 200 ug/g in the kidney cortex, i e , the concentration at which tubular proteinuria can be expected to occur. EPA scientists reviewed these models and have reached the following consensus. Ingestion of 440 micrograms of cadmium per day over a 50-year period is a reasonable estimate of the amount of cadmium necessary for 50 percent of the individuals within the population to develop proteinuria It is significant to point out, however, that there are many individuals who may develop proteinuria at lower exposure levels The metabolic model, developed by Friberg, shows that ingestion of about 200 micrograms per day over a 50-year period is the level at which most sensitive individuals accumulate 200 ug/g cadmium in the kidney cortex. The dose-response model, developed by Kjellstrom and Nordberg, reflects a non-threshold dose-response Using this model, daily cadmium exposures in the range of 100 to 125 micrograms would produce renal dysfunction in about 5 to 8 percent of the population after some 50 years of exposure

These model calculations are based on the assumption that all cadmium intake is through the diet Therefore, allowances are necessary for non-dietary routes of cadmium intake, such as smoking or occupational exposure (The contribution of smoking to cadmium intake is readily quantifiable. Available data show that smoking one pack of cigarettes a day is roughly equivalent to cadmium retention in the body resulting from a dietary intake of 25 micrograms.)

In 1972, the World Health Organization (WHO) used a model such as the ones referred to above to arrive at a recommended maximum cadmium intake level through the diet Employing a margin of safety to allow for non-dietary intake sources and for sensitive individuals, the WHO recommended that human exposure to cadmium should not exceed 57 to 71 micrograms per day from the diet

There is no general consensus on the current dietary cadmium levels in the United States, but there is wide agreement that the daily intake levels vary significantly according to individual dietary habits. Based on annual market basket surveys conducted by the Food and Drug Administration (FDA), the median ingestion level is about 39 micrograms per day and the mean ingestion level is about 72 micrograms per day for male teenagers, who have the highest per-capita food intake among any age group Any average value as an estimate for cadmium intake through the diet has the shortcoming that it does not represent those individuals with unusual dietary habits, such as the heavy consumption of cadmium-rich foods (e g , leafy vegetables), and the available evidence shows that there is a wide range of dietary cadmium exposure among the population

One other source for estimating cadmium intake levels in the human body was reviewed by the Agency This comprises chemical analysis of fecal excretions The fecal excretion studies are based on the experimental finding that only about 6 percent of ingested cadmium is retained in the body, while the rest is excreted. Three recent fecal excretion studies derived the daily mean dietary cadmium intake estimate of about 20 micrograms for American teenage males The reasons for the significant differences between the results of the fecal excretion studies and the FDA market basket surveys are not yet understood The fecal excretion studies also showed significant individual variations in derived cadmium ingestion levels. Thus, five percent of the population appeared to exceed 30 to 40 micrograms per day intake, and one percent appeared to exceed 50 micrograms per day intake

There are population groups for whom an increase of cadmium levels in the diet may be more significant than for the average population Among these are the smokers, who are known to receive an added body burden of cadmium via inhalation Vegetarians also may be experiencing higher cadmium intake than the average population, since certain vegetables contain significantly more cadmium than other food items. Also, the scientific literature indicates that certain nutritional deficiencies, such as low calcium, zinc, or protein, result in a marked increase in cadmium absorption through the gastrointestinal tract, while individuals with vitamin D deficiency are more susceptible to injury by a given level of cadmium in the body.

Both the FDA approach and the fecal study approach are legitimate means of estimating current average intakes of cadmium However it is also clear that "sensitive" individuals may be experiencing much higher absorption of cadmium Since under this regulation higher estimates of current intake will mean that lower levels of cadmium will be allowed to be added from solid waste disposal, EPA believes that it should use the higher estimate of current diet levels in order to provide greater protection for sensitive individuals Therefore, as will be explained later, the criteria will rely on the FDA estimate of 39 ug/day as the median level in the diet, which was derived by averaging the median levels over several years

In addition to the concerns over renal toxicity, several commenters raised questions over potential oncogenic, carcinogenic, mutagenic and teratogenic effects of cadmium Based on an evaluation of the currently available scientific data, the Agency has concluded that the evidence that cadmium may cause these effects in man is suggestive but not decisive enough to serve as the basis for this regulation. Consequently, the limitations on cadmium incorporated in the criteria are based on the substantial evidence of that metal's impact on the kidney, specifically the renal cortex, which the Agency considers to be the main target organ for chronic environmental exposure However, if cadmium is determined to cause the aforementioned effects in humans, the Agency will reevaluate the regulations and establish appropriate new limits

The Agency is concerned over the conduct of any practice which could significantly increase the amount of cadmium in the diet beyond current levels Therefore it is the intent of this rulemaking to minimize the movement of cadmium into the human food chain from solid waste applied to the land After an evaluation of the full range of scientific information concerning cadmium, EPA has decided to make the following assumptions to serve as a basis for setting limits on solid waste application

First, the Friberg model, which defines 200 ug/day as the "danger level" in the human diet, is most appropriate for regulatory purposes There is more data to validate that approach than there is for the Kjellstrom dose-response model.

Second, to provide an adequate safety margin in defining the risk from solid waste applied to food-chain crops, the criteria should be concerned about daily dietary intake of 70 ug/day of cadmium

Third, for analytical purposes, EPA will assume a maximum increment of 30 ug/day in conjunction with high risk diet assumptions In order to relate the health effects analysis to the diverse and complicated data that exist on crop uptake, it is necessary to make a judgment about the incremental cadmium ingestion that must be prevented by this regulation Clearly, this is a difficult task in light of the various sensitivities of particular individuals, the long-term nature of the health risk and the various dietary patterns which may occur.

In using this assumption, EPA is not stating that such an increase in the diet of the average American is acceptable. An increase of that magnitude in the *average* diet would clearly be unacceptable For the average to increase by this increment, many individuals would be experiencing much higher cadmium intakes

It must be emphasized that the 30 ug/day figure will be used in an analysis of a high-risk situation. That high-risk situation is one where an individual receives 50% of his vegetable diet from sludge-amended soils for a period of 40 to 50 years. While such a situation could occur, due to a wide variety of other mitigating factors most people will experience much smaller exposures to cadmium.

Realizing that any numerical expression of unacceptable health risk can only be an approximation, EPA used the 30 ug/day as a reasonable assumption for this analysis The Agency's Office of Research and Development determined that daily cadmium intake of about 200 ug/day could lead to serious health effects To provide a margin of safety, that office suggested that a limit of 150 ug/day from all sources of exposure be considered for regulatory purposes EPA is also concerned about the added cadmium which may enter the human body due to smoking Heavy smokers (those smoking 3 packs of cigarettes per day) can expect to add the equivalent of 75 ug of cadmium to their daily intake

Reducing the 150 ug/day by that figure gives an estimate of the "danger level" for dietary intake The result of that calculation (75 ug/day) is close to the World Health Organization's recommendation of 57–71 ug/day EPA decided that a level of 70 ug/day represented a reasonable limit on the maximum acceptable daily dietary intake of cadmium. The FDA's estimate of current levels of cadmium in the median American is 39 ug/day Therefore the 30 ug/day assumption would keep cadmium ingestion within the limit of 70 ug/day

(b) *Trace Amounts of Cadmium* —Where the cadmium content of sludges is quite small the likelihood of a significant uptake in plants is also relatively small Several commenters suggested that the requirement for pH control (6 5 at time of waste application) should not apply to those solid wastes which contain only trace amounts of cadmium EPA agrees with this comment and, therefore, has exempted wastes with cadmium concentrations of 2 mg/kg (dry weight) or less from the pH control provision. This modification would allow such wastes as food processing residuals to be landspread without unnecessary pH control measures.

(c) *Maximum Cumulative Loadings of Cadmium.*—Comments received on the cumulative cadmium application limits, soil pH, and soil cation exchange capacity (CEC) are interrelated and, therefore, will be discussed concurrently. In general, commenters felt that varying degrees and combinations of the three aforementioned parameters will limit the uptake of cadmium by food-chain crops.

Most commenters agreed that it is necessary to control the pH of the solid waste/soil mixture to minimize the uptake of cadmium by food chain crops. The final regulation recognizes that need by requiring that the pH of the soil/solid waste mixture be 6.5 at the time of application. The proposed regulation required that pH be maintained at 6.5 for as long as food chain crops were grown. Several commenters pointed out that such a provision would be difficult to implement or enforce in many situations. The Agency agrees that this may be true in some instances but did not want to preclude the application of solid waste to food-chain crops where soil pH can be maintained at acceptable levels.

These considerations prompted EPA to modify the standard for cumulative loadings to delineate three soil categories based on pH: (1) Those with natural pH of 6.5 or above; (2) those with natural pH below 6.5, and (3) those with natural pH below 6.5 but where pH will be maintained at or above 6.5 for as long as food-chain crops are grown. The criteria establish the same set of standards for categories (1) and (3) but tighten the standard for soils with the more dangerous condition reflected in category (2).

The prime data base for the calculation of acceptable cumulative loadings was a set of field studies on former landspreading sites where crops were grown at least two years after application of solid waste. This approach was appropriate for setting maximum cumulative limits because such standards are primarily concerned with future uses of landspreading sites for home gardening or commercial agriculture.

These data correlated cumulative loadings of solid waste in the soil to plant uptakes of cadmium in representative leafy vegetables. From existing data comparing uptakes of leafy vegetables to other basic food classes, EPA calculated the ratio of uptakes in leafy vegetables to those in other classes. The ratios were then applied to the field data to predict what uptakes would have been if other types of crops had been grown on former landspreading sites. This gave an estimate of cadmium uptakes that would be likely to occur in fields with differing cumulative levels of cadmium.

EPA then used a "diet scenario" analysis to translate the plant uptake levels into predictions about the amount of cadmium entering the human food chain. The Agency's assumptions about intake of the various food classes followed that of the U.S. Food and Drug Administration's 1974 Total Diet Studies. From this, EPA calculated the additional cadmium entering the human diet, assuming varying levels of dependence on crops from waste-amended fields. (EPA calculated intakes for situations where 100%, 50%, 25% and 10% of the diet come from such fields.)

The 5 kg/ha limit for acid soils (below 6.5 pH) was established by relating the diet scenario analysis to the health effects analysis. The diet scenario analysis indicated that on mildly acid soils (pH = 5.8) 5 kg/ha of cadmium only increased dietary cadmium by 22 ug/day (making the assumption that no more than 50 percent of one's vegetable diet is derived from sludge fields). However, a cumulative loading of 7 kg/ha on very acid soils (pH = 4.9) increased the dietary level by 211 ug/day. This marked increase in dietary cadmium may be attributed to both the increase in the cumulative cadmium application rate from 5 kg/ha to 7 kg/ha and the drop in pH from 5.8 to 4.9. Such an increase is far above the acceptable level in the diet. Therefore, EPA has established the maximum cumulative limit at 5 kg/ha for acid soils.

Soil cation exchange capacity was also utilized in calculating the permissible loadings for soils with pH of 6.5 or greater. The evidence available to EPA indicates that CEC is an important index of soil factors in limiting uptakes in high-pH soils. However, in highly acidic soils, pH becomes the dominant factor affecting plant uptake.

Soil CEC is an easily measured index of those properties, particularly the nature and content of clay and organic matter, that affect the soil's ability to adsorb cadmium. High CEC levels mean that a soil has a greater capacity to adsorb cadmium and thus prevent that cadmium from entering plants grown in the soil. Several studies have *demonstrated the inverse relationship* between CEC and plant uptake of cadmium.

The proposed cadmium standard recognized the importance of CEC and established differing limits depending on CEC levels in the background soil. The actual numbers selected were based on recommendations from recognized agricultural research groups (including the North Central Regional Extension Services and the U.S. Department of Agriculture). Several commenters supported the selected levels as providing adequate protection against excessive uptake of cadmium.

Where possible, EPA also used existing field studies on former landspreading sites to validate those recommendations. An application of the *diet scenario analysis to available data* on high-pH soils with mid-range CEC's supports the conclusion that the levels established in the recommendations provide adequate protection to the public. As an example, again assuming that half of the vegetable diet comes *from sludge-amended fields,* the data show that a cumulative level of 7 kg/ha could result in an 11.9 ug/day dietary increment, while a level of 15 kg/ha could result in a 39.2 ug/day increment. Using the 30 ug/day increment assumption discussed previously, the 15 kg/ha loading is too high, while the 7 kg/ha loading is well within the acceptable range. EPA believes that this analysis supports the selection of 10 kg/ha is an appropriate standard for soils with a mid-range CEC. In light of the other clear evidence of the role of CEC in limiting uptake EPA believes that it is, therefore, appropriate to use the limits recommended by the research community.

The Agency recognizes that there are some facilities with naturally acid soils where land management practices can be implemented with adequate safeguards to assure that the soil pH will be maintained at 6.5 or higher for as long as food-chain crops are grown. Where such safeguards exist, the criteria provide an option to permit such facilities to use the CEC based cadmium loading rates. However, the Agency is concerned that the application of up to 20 kg of cadmium per hectare may result in significant cadmium uptake by crops if the pH is not controlled for as long as food-chain crops are grown. Therefore, unless the facility can clearly demonstrate long-term control over pH, the Agency strongly recommends that those facilities having naturally acid soils select the option which limits the cumulative cadmium application rate to 5 kg/ha.

The Agency considered establishing even lower cumulative cadmium application rates on soils with a natural pH that is very highly acidic (including prohibition on landspreading on soils with very low pH) While it is clear that leafy vegetables, root crops and tobacco tend to accumulate cadmium in their tissues and, therefore, are more sensitive to high soil cadmium concentrations under acid soil conditions, insufficient data exist to establish more restrictive cumulative levels for such soils The Agency is continuing to examine this situation and will, upon development of additional data and information, propose new cumulative limits for highly acidic soil *However, in recognition of the higher* uptake of cadmium by these crops, the Agency recommends avoiding the application of solid waste containing cadmium (e g , sewage sludge) on very acidic soils used for the production of leafy vegetables, root crops and tobacco and discourages the application to agricultural land which is likely to be converted to production of such crops

The Agency also considered requiring a soil analysis for total cadmium prior to the application of solid waste and adjusting the cumulative limit for cadmium additions downward to account for soils with high background cadmium concentrations However, the Agency was not able to justify the use of a background correction factor since there is a paucity of data concerning the relationship between naturally occurring cadmium and solid waste-added cadmium, with respect to crop uptake. Until these questions are resolved, the Agency recommends that a soil test be performed prior to initiating landspreading, in order to establish the background conditions at the site Further, for those facilities which have unusually high background cadmium soil concentrations, the Agency recommends that consideration be given to reducing cadmium application

(d) *Annual Cadmium Application Limit* —Comments received on the proposed annual cadmium application limits were widely divergent Several commenters stated that the proposed cadmium limitation of 0 5 kilogram per hectare (kg/ha) per year was unnecessarily restrictive. The indicated *reasons were primarily that the* reduction in solid waste application would result in increased costs and that the potential risk to human health was not sufficient to justify that reduction A second group of commenters suggested that the annual limitations on cadmium application were not sufficiently protective of public health and should be reduced much further or the application of cadmium-containing solid waste to agricultural lands be prohibited altogether, since the proposed limits would permit the entry of significant quantities of cadmium into the human diet.

Comments were also received on the proposed cadmium concentration limit of 25 mg/kg for solid wastes applied to facilities where tobacco, leafy vegetables or root crops are grown for human consumption Some commenters viewed the proposed limit as being overly restrictive, while others recommended that cultivation of those crops which tend to accumulate cadmium to relatively high levels should *not be allowed on waste-amended soils.*

EPA believes that annual cadmium application limits are particularly important on those active sites which are nearing the cumulative cadmium application limits As the total amount of soil cadmium at such sites begins to reach the cumulative loading limits, both the cadmium previously applied to the soil and new additions of cadmium from solid waste will affect crop uptake of cadmium. In setting annual application rates EPA must account for this factor.

Available research indicates that there are significant differences in uptake among crop species. It would, however, be impossible to write specific cadmium limits for each crop type based on the available data Moreover, such an approach would complicate the regulation, making implementation confusing and impractical.

In looking at individual crop uptakes, however, EPA determined that there is a set of "accumulator" crops which tend to absorb very large quantities of cadmium as compared to all other crops. Tobacco, leafy vegetables and root crops constitute the "accumulator" class In order to provide an adequate margin of safety EPA believes that the annual application rates should be based on data from representative "accumulator" crops This assures that when a mix of crops is grown on sludge-amended fields no crop will have dangerous up takes of cadmium

The available data indicates that significant increases of cadmium occur even with small applications of waste. For example, annual rates of *approximately 0 7 kg/ha* applied to soils which have not received sludge previously have been shown to triple the amount of cadmium in lettuce leaves Using the diet scenario analysis it can be demonstrated that application rates of 0 8 kg/ha can lead to dietary increases of 10 3 ug/day from leafy vegetables alone Other data indicate that this level may be even greater where cadmium from *landspreading in* previous years is already in the soil Under these circumstances EPA concluded that an annual limit of 0.5 kg/ha is necessary to provide adequate protection to the public health.

EPA recognizes that not all crops will present the same risk as accumulator crops, particularly in the first few years of landspreading However, due to the factors discussed above, applications of solid waste should eventually be limited to 0 5 kg/ha for all food-chain crops. Therefore, the Agency has decided to distinguish between accumulator and non-accumulator crops in the annual limits. When wastes are applied to accumulator crops the annual limit will be 0 5 kg/ha immediately For all other crops a phased reduction will be allowed.

The criteria limit additions to 2.0 kg/ha until June 1984 and 1 25 kg/ha until December 1986 This gives communities and industry the time necessary to implement programs, such as cadmium source control and pretreatment of *industrial discharges, to reduce current* cadmium concentrations in their wastes or to develop alternative disposal practices. The schedule has been slightly relaxed from the proposed criteria in order to make it compatible with the Agency's pretreatment program schedule. The Agency believes that allowing higher cadmium application rates than 0 5 kg/ha through 1986 will have a negligible human health *effect* because the health impacts from cadmium are long-term and cumulative in nature Based on assumptions similar to those used in the "diet scenario" analysis (see the discussion of cumulative loading limits), it can be shown that during this initial period applications of 2 0 kg/ha do not present significant health risks

The proposed regulation also distinguished between accumulator and non-accumulator crops, and that approach is being maintained in the final criteria. However, the proposed limit for accumulator crops was expressed in terms of sludge quality (cadmium concentration in the waste not to exceed 25 mg/kg dry weight). Calculations show that a cadmium concentration limit of 25 mg/kg in the solid waste will not necessarily preclude application rates above 0 5 kg/ha, the level which EPA believes is more directly related to the human health risk.

For example, some solid wastes are often applied to the land as soil conditioner or mulch Such a solid waste (e g , composted sewage sludge), at a cadmium concentration of 25 mg/kg, would contribute cadmium to the soil at *the rate of about* 1 5 kg/ha when applied 1 3 cm (0.5 inch) thick to the land surface. Therefore, EPA decided to integrate this standard with the rest of the section and express the limit in kg/ha

(e) *Closely Controlled Facilities.* Substantial public comment was received on the second major approach proposed for controlling dietary intake of cadmium via the application of solid waste to land This approach required cadmium levels in crops or meats produced from solid waste-amended soils to be comparable to cadmium levels in similar crops or meats produced locally where solid waste had not been applied Several commenters stated that this approach would be very difficult to implement because of problems in establishing an effective system to monitor and control agricultural products Moreover, terms such as "local market" and "comparable levels" are vague and, therefore, subject to varying interpretations

Commenters suggested two major alternatives to the proposed approach; both of these were considered by the Agency. They were dilution of cadmium-containing crops and meats in the market place, and establishment by the FDA of maximum permissible levels of cadmium in food products Dilution in the market place was not selected as a control option, partly because of the difficulty of implementation More importantly the dilution of a toxic contaminant into the food chain is an unacceptable long-term policy because it could, over a number of years, significantly increase the total body burden in humans

The FDA indicated that the alternative approach of establishing a tolerance level for cadmium in food products is not possible at this time because of insufficient data A nationwide survey is being conducted currently by the EPA, FDA, and USDA on cadmium levels in raw agricultural commodities, however, several years will be required to obtain the statistically meaningful data necessary to establish tolerance levels in agricultural crops

Based on the public comments received, the proposed criteria have been modified to simplify implementation yet still provide adequate health protection. As promulgated, this cadmium management approach sets forth four requirements which will serve to minimize the increase of cadmium in the human food chain

First, only animal feed may be grown under this option Research data show that animals excrete most of the ingested cadmium, the small amount that is absorbed is accumulated in viscera such as the kidney and the liver The likelihood of significantly increasing individual or general dietary cadmium levels through animal feeds is negligible. Several commenters suggested that the Agency consider prohibiting the marketing of livers and kidneys of such animals for human consumption There is some question whether such an approach is within EPA's authority under the Act Moreover, control of distribution in this manner is unnecessary because the marketing of organs from such animals would not result in a significant increase of cadmium in an individual's diet

The second control to assure proper management of the facility is the requirement that the solid waste and soil mixture have a pH of 6 5 or greater at the time of solid waste application or at the time the crop is planted, whichever occurs later The Agency believes that maintaining the soil pH at a near-neutral level is particularly important under this cadmium management approach where the cadmium application rate is unrestricted

The third requirement calls for the development of a facility operating plan. The purpose of this plan is to demonstrate how the animal feed will be distributed and what safeguards are utilized to prevent the crop from becoming a direct human food source. EPA is primarily concerned about crops such as corn, wheat and soybeans which may be used for animal feed or direct human ingestion In addition, the facility operating plan should describe the measures that have been taken to safeguard against possible health hazards resulting from alternative future uses of the land Some future land uses, such as the establishment of vegetable farms or home vegetable gardens, could result in significant dietary increases of cadmium. Such provisions in the facility operating plan could cover a range of options, such as dedication of the facility as a public park, placement of fresh top soil over the site, or removal of the contaminated soil

The fourth requirement is 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 foodchain crops should not be grown, due to a possible health hazard.

(2) *Poly-chlorinated Biphenyls (PCB's)* The proposed criteria required that solid waste containing pesticides and persistent organics, when applied to land used for the production of food-chain crops, not result in levels of these substances in excess of the tolerances set pursuant to the authorities of the Federal Food, Drug and Cosmetic Act. The proposed criteria also required that solid waste of concern due to its toxic organic chemical or heavy metal content (e g , PCBs and lead) not be applied to a site so that the freshly applied solid waste may be directly ingested by animals raised for milk or by humans

At this time, EPA has decided not to establish tolerances for pesticides and persistent organics in solid waste They were not developed because there were no adequate data on the amounts of these substances in solid waste to demonstrate a public health risk An ongoing study is expected to obtain information on the amount of pesticides and persistent organics in sewage sludge to help develop a standard relating to this subject After reviewing existing FDA tolerance limits for such substances, EPA has determined that they are impractical as a basis for standards for solid waste application to food-chain lands, because those tolerance limits are based on food contamination from pesticide application At this time there is almost no information available indicating the relationship between the level of such substances in solid waste and the resulting food contamination Direct application of the FDA tolerance limits would require extensive chemical analysis for a very large number of pesticides and toxic organic substances that might be present in the solid waste in trace amounts Other data sources also did not provide an adequate basis for setting standards The Agency will continue to evaluate data on this subject and explore this problem with the FDA and other interested parties It is possible that standards on this subject could be part of pending sewage sludge disposal guidelines under Section 405 of the Clean Water Act, as well as future amendments to the criteria

While EPA is concerned about the health problem posed by ingestion of lead, the Agency is not aware of any evidence that increased lead ingestion by dairy animals results in elevated lead levels in milk Consequently, the Agency is not able to promulgate a standard for lead based on ingestion of solid waste by dairy animals, as was suggested by some commenters. While direct ingestion of lead by children, which may occur when they play in areas where sludge has been applied, may also be a concern, there is limited data available to establish a standard for this situation. The Agency intends to explore this potential problem further in the pending sewage sludge disposal guidelines under Section 405 of the Clean Water Act.

In establishing the standard for PCB's, the Agency looked to tolerance levels established by the FDA to define the health risk The FDA has established maximum tolerance levels of 0.2 mg/kg (actual weight) for animal feeds and 1 5 mg/kg (fat basis) for milk. The standard promulgated in the criteria is designed to prevent PCB levels from exceeding these levels due to application of solid waste to fields growing animal feed When solid wastes are applied to the land surface so as to allow direct contact between the solid waste and the crop, the animal feed can become contaminated By incorporation of the solid waste beneath the soil surface (generally below the root zone of pasture grasses), the amount of ingested PCB's is greatly reduced Therefore, EPA has concluded that the proper regulatory strategy is to require incorporation of the solid waste into the soil when the PCB level in the waste material is so high that direct contact between the crop and the soil could cause the FDA tolerances to be violated

Based on assumptions recommended by FDA, EPA calculated the concentration level of PCB's in solid waste which might cause the FDA tolerances to be violated These calculations established the PCB *concentration threshold at 10 mg/kg* Generally, then, any sludge which exceeds that level of PCB's must be incorporated into the soil when applied to land used for the production of food-chain crops

There is, however, one exception to that requirement Wastes which exceed 10 mg/kg of PCB's may be applied to fields without incorporation if testing of the animal feed grown on the field demonstrates that the FDA standards will not be violated If such testing indicates that the FDA standards have been violated, then the solid waste disposal activities leading to the contamination have violated the criteria.

It should be noted that the calculation of the 10 mg/kg level for PCB levels in the waste is based on the assumption that the only way PCB's enter a grazing animal is through the adherence of *waste material to the vegetation eaten* EPA recognizes that a certain amount of PCB's may enter the animal due to direct ingestion of soil. At this time, however, EPA does not have sufficient data to know how that factor should be used in the analysis Moreover, the recommendations from FDA did not take that factor into consideration

As discussed earlier this portion of the regulation is being issued as "interim final", which means that further public comment is solicited EPA encourages the public to provide suggestions and data that would help the Agency to account for the direct ingestion of soil in setting a PCB standard

I. Disease (Section 257.3–6)

Solid wastes can contain pathogenic bacteria, viruses and parasites which can infect both humans and animals. Wastes can provide food and harborage for rodents and flies which are capable of transmitting these disease organisms to humans and animals Other routes of disease transmission to humans and animals include direct contact with wastes during landspreading operations, contact with soil or plants which have been contaminated with wastes, or ingestion of food and water contaminated with wastes

The proposed criteria required protection of public health by control of disease vectors This requirement was to be met through minimizing the availability of food and harborage for disease vectors or through other techniques where appropriate. In another section, the proposed criteria required stabilization of solid waste of concern due to its pathogen content when applied directly to the surface of land used for the production of food-chain crops In addition, a one-year waiting period was prescribed before *growing human food crops which are* normally eaten raw In yet another section, the proposed criteria required controlled access to solid waste disposal facilities so as to minimize exposure of the public to exposed waste

The final disease criterion combines provisions concerning vectors and pathogens The provision concerning vectors calls for the minimization of on-site populations of disease vectors Periodic application of cover material (usually at the end of each operating day) or other appropriate techniques should satisfy the performance standard

Sewage sludge and septic tank pumpings are the solid wastes which are generally applied to the surface of the land and are of concern due to their pathogen content To protect public health, the criteria provide for control of *pathogens in disposal of these wastes* by one of several operational approaches as described below.

Sewage sludge applied to the land surface or incorporated into the soil must be treated by a Process to Significantly Reduce Pathogens Aerobic digestion, air drying, anaerobic digestion, composting, lime stabilization, or other similar techniques will satisfy this requirement In addition, public access to the site must be controlled for at least 12 months, and grazing by animals whose products are consumed by humans must be prevented for at least one month.

Septic tank pumpings must be treated by one of the Processes to Significantly Reduce Pathogens, unless 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 Neither set of provisions for sewage sludge or septic tank pumpings apply where these wastes are disposed of by a trenching or burial operation

Further public health protection is required when sewage sludge or septic tank pumpings are applied to land where crops for direct human consumption are grown less than 18 months after waste application In these instances, the waste material must be treated, prior to application, by a Process to Further Reduce Pathogens Beta ray irradiation, gamma ray irradiation, pasteurization or other equivalent methods will satisfy this requirement if performed after a Process to Significantly Reduce Pathogens High-temperature composting heat drying, heat treatment and thermophilic aerobic digestion will satisfy this requirement without prior treatment A Process to Further Reduce Pathogens is not required if there is no contact between the solid waste and the edible portion of the crop, as long as the solid waste is treated by a Process to Significantly Reduce Pathogens prior to application In addition, public access to the facility must be controlled for at least 12 months after solid waste application, and grazing of animals whose products are consumed by humans must be prevented for at least one month

Like the portion of the criteria concerning application of solid waste to food-chain crops (§ 257 3–4), the sewage sludge and septic tank pumpings provisions of the disease section are being issued as an "interim final" regulation While there was extensive public review and comment on the proposed regulation, the public has not had a full opportunity to examine and analyze the new data and technical *support for this section At the same* time EPA believes that it must promulgate this portion of the regulation in order to satisfy the spirit of the court order mandating issuance of the criteria. EPA will fully review all comments and make changes in the regulation if such modifications are warranted by the data

(1) *Disease Vectors* Some commenters sought a more specific statement of the performance objective of this provision EPA explored the possibility of developing a numerical performance objective, but determined that such a standard would not be meaningful While the risk from disease vectors is very real, the risk cannot be translated into a measure of "rats per square meter" or "flies per cubic foot of air space " Moreover, such performance

standards could not be measured with any accuracy. Therefore, EPA made the standard more specific by requiring minimization of on-site populations of disease vectors. This statement of the standard leaves no question that the facility must not be a breeding ground, habitat or feeding area for vector populations. At the same time, it provides some flexibility in the implementation of the standard.

Several commenters indicated that, since there are a number of techniques to protect public health from disease vectors, the phrase "minimizing the availability of food and harborage for vectors through periodic application of cover material" should be deleted. EPA agrees and has done so.

At most facilities which dispose of putrescible wastes, the most effective means to control rodents is the application of cover material at the end of each operating day. Other means include composting or processing the waste, so as to render it unattractive to rodents, or using rodenticides. At some facilities, disease vectors such as flies may be more difficult to control than rodents, but certain practices, such as the periodic application of cover material, can help alleviate the problems. Mosquitoes can be controlled by eliminating stagnant water for breeding, by predatory or reproductive control and, if necessary, by spraying with insecticides or repellants.

Cover material also serves other purposes: (a) It helps contain odor, litter, and air emissions, thereby improving the facility's aesthetic quality, (b) it reduces the potential for fires, (c) it reduces rainwater infiltration, thereby decreasing leachate generation and surface and ground-water contamination, and (d) it improves the facility's appearance and enhances utilization after completion.

Since periodic application of cover material is an effective, widely used and generally preferred means of controlling vectors, EPA believes that it is appropriate to specify it in the criteria. It is impractical, however, to cover some wastes. Moreover, cover material is not generally necessary for wastes which are non-putrescible, relatively stable or inert. The criteria allow for other techniques to be employed in these situations.

EPA has not included the phrase "minimizing the availability of food and harborage" in the final standard. That language would not cover such control measures as repellants, insecticides and rodenticides, which could be effective in meeting the objective of this section.

Commenters also requested a definition of the term "disease vector." Disease vectors are rodents, flies and mosquitoes, since these are the known organisms common at disposal facilities that are capable of transmitting disease.

(2) *Sewage Sludge and Septic Tank Pumpings.* In establishing regulations to protect public health from pathogen-induced disease, it must be recognized that there is a distinction between being exposed to disease-producing organisms and actually acquiring a disease. Healthy humans and animals can tolerate small numbers of pathogenic organisms without acquiring a disease. Disease normally occurs when the body's immune system is impaired, or the dose of pathogens is so great that it overwhelms the body's defense mechanism. In setting these criteria, the goal is to prevent human exposure to large numbers of pathogenic organisms due to solid waste disposal activities.

Commenters requested specification of which solid wastes are of concern due to their pathogen content. The criteria have been modified to specify sewage sludge and septic tank pumpings as the wastes which are generally applied to the surface of the land and are of concern due to their pathogen content. Although little information is available on septic tank pumpings, the relatively long residence time of the bulk of the waste material in a septic tank should reduce the density of pathogenic organisms. Therefore, the Agency has tentatively concluded that septic tank pumpings have the same general characteristics with regard to land application as partially treated municipal sewage sludge. The public is invited to submit pertinent data on this subject, the Agency will review any new information and reassess these regulations accordingly.

Sewage sludge and septic tank pumpings contain various types of pathogenic bacteria, viruses and parasites. While bacteria are greatly reduced by sunlight and drying, viruses may persist in soils and on vegetation for several weeks or months. Parasitic ova and cysts are quite resistant to disinfectants and adverse environmental conditions. Many, in fact, require a period of free-living existence in the soil before becoming infectious to man. Therefore, a major reason for requiring the control of pathogens is the potential for human ingestion of soil or plants contaminated with such wastes containing ova or cysts.

Some commenters suggested that the criteria require a "pathogen-free" sewage sludge. EPA does not believe that such regulation is necessary to avoid a reasonable probability of adverse effects on the population that may come in contact with sludge-amended fields. A greater degree of protection is needed for certain solid waste disposal practices (i.e., application to land where food-chain crops are grown), and this section provides for such protection.

The proposed regulation relied on stabilization as the principal treatment technique to reduce the risk of pathogen-induced disease. However, because the term "stabilization" conventionally related to odor control and to a lesser degree pathogen reduction, this term is no longer used in the criteria. The criteria have been revised to require that sewage sludge and, under certain conditions, septic tank pumpings be treated by a Process to Significantly Reduce Pathogens. These processes include aerobic digestion, air drying, anaerobic digestion, composting (three techniques), lime stabilization or other equivalent techniques.

EPA recognizes that not all of these processes achieve exactly the same level of pathogen reduction. Variations in weather, residence times, temperatures and other factors will influence the effectiveness of each process. The Agency also recognizes that different processes may be more or less effective in destroying certain types of pathogens (i.e., bacteria, viruses or parasites). Each process, however, has been shown to achieve a significant reduction in pathogen levels. Therefore, EPA believes that they are appropriate to achieve the objectives of this section.

The proposed regulation required controlled access to disposal facilities so as to minimize exposure of the public to hazards posed by exposed waste. The final regulation seeks to minimize exposure of the public to pathogens in the upper layers of waste-amended soils. Since pathogens in the surface soil are generally reduced to insignificant levels within 12 months of application, the criteria require that public access to the facility be controlled for that period of time. "Controlled" does not mean that all entry on the site be precluded. The term "controlled," rather than "prevented," was chosen for regulating public access, because with proper precautions there appears to be no health hazard. However, there would be a health hazard if, for example, children were permitted to play on the waste amended soil. Therefore, fencing would be necessary if these wastes were applied to areas frequented by the general public (e.g., park lands) but fencing would not be necessary on farm land which was not available for use by the public.

This section also includes a limit on animal access to the fields for grazing for one month after sewage sludge is applied. This is appropriate for several reasons. First, the animal acts as a first line of defense against human contact with pathogens The products derived from the animal (meat or milk) will not contain the same level of pathogens as might enter the animal due to grazing on waste-amended fields. Second, in many cases rainfall in the one-month period after application will wash the sludge off the crop Third, available evidence indicates that where sludge does remain on the crop, a one-month period should be sufficient for natural weather conditions (e g, sunshine, wind) to destroy most pathogenic organisms.

The access restrictions described above are required for all facilities receiving sewage sludge, even after the waste has been treated by a Process to Significantly Reduce Pathogens. For septic tank pumpings, the access restrictions may be used as an alternative to such a Process. This is due to the fact that containment in a septic tank will result in partial pathogen reduction in the waste and should diminish its attractant potential to disease vectors such as flies and mosquitoes However, septic tank pumpings do not undergo the kind of pathogen destruction that can occur with anaerobic digestion, because the waste is being continually reinoculated with fresh waste material. Therefore, EPA concluded that such wastes should be treated with a Process to Significantly Reduce Pathogens or be subject to the access restrictions.

As indicated earlier, special treatment is necessary for food-chain crop cultivation, where the risk of direct human consumption of crops contaminated by pathogens is higher. To provide protection, the proposed regulation relied on a one-year waiting period between waste application and use of that land for food-chain crops. The regulation now calls for the use of a Process to Further Reduce Pathogens if crops for direct human consumption are grown within 18 months of application or incorporation of the sewage sludge or septic tank pumpings If no such crops are grown within 18 months of application, treatment by a Process to Further Reduce Pathogens is not required.

The processes chosen should essentially destroy all bacteria and viruses and greatly reduce the number of parasites in the waste material. Two sets of processes are permitted—those which are sufficient in themselves and those which must follow a Process to Significantly Reduce Pathogens in order to be effective Processes which are adequate in themselves are high-temperature composting, heat drying, heat treatment and theromophilic aerobic digestion. Processes which must follow a Process to Significantly Reduce Pathogens are beta ray irradiation, gamma ray irradiation and pasteurization. This sequence of processes is necessary to assure that the waste is not an attractant to vectors. Irradiation or pasteurization, while effective against pathogens, do not provide the volatile solids reduction necessary to prevent a vector problem.

Based on available data, the Agency concluded that a Process to Further Reduce Pathogens is not necessary when there is an 18-month interval between land application of solid waste and the growing of crops for direct human consumption. EPA recognizes that there is some uncertainty about the life expectancy of pathogens in wastes applied to croplands. Bacteria and viruses persist for only a few months, but parasites, particularly resistant species such as *Ascaris lumbricoides*, may last much longer. Reports range from "no survivors" after a few months to "some survivors" (not necessarily viable) after ten years for such organisms.

Survival is most likely in the soil below the top five centimeters of soil. Field conditions such as sunlight, desiccation, freezing, heat and freeze-thaw cycles are effective at reducing survival times in the upper layer of the soil EPA selected the 18-month period because within that period most of the waste-amended soil will be exposed to the hostile environment found at the soil surface. Agricultural soils are typically plowed or cultivated at least annually. Thus, an 18-month waiting period assures that soil which was previously below the surface will be exposed to the harsh surface conditions for at least six months before planting. The growing period will provide additional exposure of the pathogens before harvest EPA believes that this will provide a reasonable probability that pathogen levels will be greatly reduced. Since this is an "interim final" regulation, EPA encourages public comment on the appropriateness of this rationale.

EPA recognizes that for some crops (e g, citrus fruits, corn) the edible portions are not exposed to nor are likely to come in contact with, the sewage sludge or septic tank pumpings. Therefore, there is no need to use a Process to Further Reduce Pathogens when such a crop is grown. However, in this case the waste must be treated by a Process to Significantly Reduce Pathogens, public access to the facility must be controlled for at least 12 months, and the grazing of animals prevented for at least one month after application of the waste. The Agency chose the more conservative approach of requiring significant pathogen reduction and controlled access for both sewage sludge and septic tank pumpings because even where direct contact appears unlikely, the quality of crops which are directly consumed by man must be assured.

In examining the health risk presented by pathogens, EPA determined that pathogens are not likely to migrate in the soil. Pathogens tend to remain intimately associated with the waste material and are often too large to move through soil pore systems Also, soils have been reported to be effective in removing viruses and bacteria from water. Surface erosion with the resultant water runoff seems to be the only route for movement of pathogens Based on these findings, the Agency concluded that sewage sludge and septic tank pumpings that are placed underground by a trenching or burial operation should not be subject to this section. Under such circumstances there will be minimal movement of the organisms through the soil, and the risk of erosion is slight because the wastes are completely covered

J Air (Section 257.3-7)

Open burning is the uncontrolled or unconfined combustion of solid wastes Open burning is a potential health hazard, can cause property damages, and can be a threat to public safety. Smoke from open burning can reduce aircraft and automobile visibility and has been linked to automobile accidents and death on expressways. The air emissions associated with open burning are much higher than those associated with incinerators equipped with air pollution control devices.

The proposed criteria provided for control of air emissions through three stipulations. First, the facility was to control air emissions so as to comply with Federal, State, and local air regulations. Second, all open burning of residential, commercial, institutional, and industrial solid wastes was prohibited Third, open burning of other solid wastes could be permitted if in compliance with State and local air regulations.

This final air criterion has two components. First, there shall be no open burning of residential, commercial, institutional or industrial solid waste. (This provision does not apply to infrequent burning of agricultural wastes, silvicultural wastes, land-clearing debris, diseased trees, debris from emergency clean-up operations and ordnance) Second, air emissions caused by solid waste disposal activities shall not violate applicable requirements developed for State implementation plans (SIP's) under Section 110 of the Clean Air Act.

While several commenters suggested that a ban on open burning is unnecessary, EPA has decided to retain that provision for residential, commercial, institutional or industrial waste The ongoing open burning of these wastes presents significant hazards to human health, and no health or environmental benefit is derived from the practice Several commenters suggested allowing open burning with a variance. There is no environmental rationale for such a variance because open burning does not lessen the need for disease vector control or leachate control for maintaining surface and ground-water quality Moreover, variance procedures for this situation would be particularly difficult to administer because of the dynamic nature of the many variables involved (existing air quality, wind speed, humidity, mixing and vertical dispersion, efficiency of the burn, amount and type of waste, etc)

EPA decided to exempt from the open burning prohibition those wastes which are typically burned infrequently The burning of agricultural wastes in the field, land-clearing debris, standing trees in a forest, diseased trees, debris from emergency clean-up operations and ordnance is not typically an ongoing practice and, thus, does not present a significant environmental risk In addition some of these practices, particularly the destruction of disease-carrying trees or debris from emergency clean-up operations, provides an added environmental benefit in preventing chances of disease or accident. It should be noted, however, that the criteria assure that the conduct of these infrequent acts of burning must be in compliance with applicable requirements developed under the State SIP

In requiring compliance with the SIP, EPA is seeking to coordinate the criteria with the Clean Air Act, as mandated in Section 1006 of the Act The regional health concerns addressed through the SIP's are clearly of concern under the Act as well The prohibition of open burning should prevent most air quality problems Where such concerns are not covered by the open burning ban, EPA believes that it is unacceptable for solid waste disposal activities to cause violations of SIP requirements

EPA has eliminated that part of the proposed regulation that required compliance with "all applicable Federal, State and local air regulations" and the reference to protection of public health and welfare. Some commenters said that the proposed criteria "federalized" State and local air regulations, EPA is not federalizing any such regulations in the final criteria In tying the criteria to the SIP's, EPA is assuring that, at a minimum, solid waste activities that undermine Congressionally-established Federal environmental air quality objectives will not be considered adequate under the Act.

Several commenters requested clarification regarding the impact of the criteria on the use of pit or trench incinerators Emission factors (i e , particulates) for such incinerators equal or exceed those for open burning dumps. Since such devices do not control emissions, they fit the definition of open burning Thus, for purposes of the criteria, combustion in a trench incinerator constitutes "open dumping "

Comments were requested in the Preamble of the proposed regulation on the advisability of including in the final promulgation specific air quality limits which would be based on Occupational Safety and Health Administration (OSHA) air quality standards Several commenters noted that since OSHA air quality standards are based on workplace exposure and not ambient air quality, the inclusion of these standards would be inappropriate and possibly confusing Air quality standards based on OSHA regulations have not been included in the final promulgation

Commenters also suggested that the content of the air criteria be moved to the safety criteria (§ 257 3–8) since many of the dangers of open burning relate directly to public safety The Agency considers the problems of open burning to be broader than just public safety; thus, this change was not made However, the safety criteria have been revised to reference the air criteria

K Safety (Section 257 3–8)

This portion of the criteria addresses a set of adverse effects involving potential accidents which could be caused by solid waste disposal activities The legislative history of the Act indicates that in passing the provisions authorizing these criteria the Congress was concerned about all of the effects addressed in this section The safety hazards addressed in the final regulation include explosive gases, fires, bird hazards to aircraft and public exposure to wastes due to uncontrolled access to disposal sites

The proposed regulation also contained a provision for toxic and asphyxiating gases While EPA is quite concerned about the emission of such gases from solid waste, EPA was unable to identify sufficient information on the nature of this problem to support the setting of particular standards The existing data on the generation of toxic and asphyxiating gases in solid waste is quite limited. In particular, it is difficult to define a set of gases generated in solid waste disposal that present a public health hazard. Even if such a set of gases could be identified it is difficult to determine, on the basis of data currently available to EPA, what levels of such gases may be tolerated without a substantial risk to public health or the environment EPA will continue to explore this problem However, at present there is insufficient information to support particular limits on toxic and asphyxiating gases.

(1) *Explosive gases* Solid waste disposal activities may produce explosive gases In particular, methane gas is a product of solid waste decomposition. The accumulation of a sufficient concentration of methane gas in disposal facility structures or nearby off-site structures may pose a serious threat to the health and welfare of facility employees, users of the disposal site, and occupants of nearby structures Explosions resulting in injury and death have been caused by gases from solid waste disposal.

The proposed criteria required that the concentration of explosive gases in facility structures and in soil at the facility property boundary not reach the lower explosive limits (LEL) for the gases The final regulation is essentially the same except that concentrations in facility structures will not be allowed to exceed 25 percent of the lower explosive limit for the gas In addition the final standard, which could potentially be applicable to several explosive gases, will only be concerned with methane at this time.

Commenters suggested that the gas criteria be deleted and that control be left to the Occupational Safety and Health Administration (OSHA) Following consultation with OSHA, the Agency rejected this suggestion because the jurisdiction of OSHA does not include all solid waste disposal facilities and practices of concern to the Act, nor does it include off-site residences to which gases can migrate.

The Agency has decided to adjust the standard for facility structures to provide a margin of safety Several commenters suggested such a change, since allowing explosive gas to accumulate in concentrations just under the lower explosive limit would be extremely dangerous and would not provide for a reasonable probability of avoiding adverse effects In selecting the 25% figure EPA is using a safety factor recognized by other Federal agencies as being appropriate for similar situations.

EPA also concluded that such a safety factor was unnecessary at the property boundary Gases at or below the LEL at the property boundary will necessarily become somewhat diffused before passing into a structure beyond the property boundary Thus, in assuring that the LEL is not exceeded at the boundary EPA has provided a margin of safety against an off-site explosion

EPA has selected methane as the single gas of concern The information available to EPA indicates that build up of methane gas has been the principal source of explosions associated with solid waste disposal Other gases may be added to the list as new information develops

Commenters recommended that disposal facilities not in close proximity to off-site structures be exempted from the gas criteria Considering that gas production in disposal facilities is a long-term process continuing for decades, the Agency rejected this recommendation Facilities which are remote today may be surrounded by extensive development in the future, especially after completion of disposal operations

(2) *Fires* Fires at solid waste disposal facilities pose the threat of property damage and injury or death to facility employees, users, and nearby residents Examples of circumstances which can lead to fires associated with disposal facilities or practices are Vandalism, carelessness, spontaneous combustion, open burning of wastes, and disposal of hot ashes.

The proposed criteria required that all fires be extinguished expeditiously and that fire hazards be minimized through proper site construction and design and periodic application of cover material where appropriate

According to the final regulation, the facility or practice shall not pose a hazard to the safety of persons or property from fires This objective can be served by compliance with the air criterion (§ 257 3-7), particularly the open burning ban, and through periodic application of cover material

Commenters objected to the vague nature of this provision as originally proposed While some level of flexibility is necessary, EPA has tried to make this standard as specific as possible The reference to "expeditious" extinguishing of fires was eliminated EPA also specified types of operational practices to accomplish the goals of this section

Commenters suggested that, due to the relationship between open burning and potential fire hazards, the prohibition on open burning be incorporated into this section. As explained previously the safety criteria now reference the air criterion (which contains the prohibition of open burning)

(3) *Bird Hazards* Many reports and investigations show that disposal facilities and practices involving putrescible wastes often attract birds, in spite of vector control efforts (compaction and cover of wastes, etc) When solid wastes are disposed in the vicinity of airports, the birds attracted to the area can present a significant risk of accidents due to collisions between birds and planes The Federal Aviation Administration (FAA) has issued FAA Order 5200 5, "FAA Guidance Concerning Sanitary Landfills on or Near Airports" (October 16, 1974) The order states that solid waste disposal facilities have been found by study and observation to be artificial attractants of birds and, therefore, "may be incompatible with safe flight operations" when located in the vicinity of an airport

The proposed criteria required that disposal facilities not be located within the two distance limits (10,000 feet for turbojets and 5 000 feet for piston-type aircraft) specified in FAA Order 5200 5 unless the facility was found to not pose a bird hazard to aircraft For facilities beyond the specified distances, but within the conical surface described by FAA Regulations (FAR), Part 77, facilities were to be reviewed on a case-by-case basis for a potential bird hazard

The final regulation retains the basic approach but clarifies several terms, including "airport" and "bird hazard " The provision for case-by-case analysis of facilities within the conical surface has been dropped

Some commenters questioned whether the Act provides authority to control solid waste disposal on the basis of bird hazards to aircraft They claimed that the FAA has adequate authority to prevent bird hazards to aircraft, concluding that this section of the criteria is not necessary

The criteria are required to address the prevention of adverse effects on health and the environment from solid waste disposal facilities The legislative history (H R Rep No 94-1491) cites an aircraft crash resulting from birds attracted to a disposal facility as one example of adverse effects of open dumps There are also many other examples of such hazards from disposal facilities Therefore, the Agency has concluded that this issue is clearly within the scope of this regulation

Although the FAA is authorized to control airport operations to reduce bird hazards to aircraft, its authority does not extend to disposal facilities outside airport boundaries which may pose such hazards It should be noted, however, that EPA is not "enforcing" the FAA order The selection of the distances specified in that order is merely a recognition that they represent a reasonable determination of the danger zone around an airport Likewise, it should be made clear that neither this regulation nor the proposed standard prohibited the disposal of solid waste within the specified distances Instead, the distances define a "danger zone" within which particular care must be taken to assure that no bird hazard arises

Some commenters challenged the relevancy of the 10 000 foot (for turbojets) and 5,000 foot (for piston-type aircraft) distances for defining the danger zone for bird/aircraft collisions. The distances cited were derived from FAA Order 5200 5 The distances are based on the consideration that over 62 percent of all bird strikes occur below altitudes of 500 feet (150 meters), and that aircraft are generally below this altitude within the distances specified

Some commenters emphasized that bird strikes do occur outside the distances established in the regulation Consultation with FAA personnel and other experts in the field of bird/aircraft hazards has revealed that, even when disposal facilities are located beyond the distances specified, hazards can exist where an airport is situated between a disposal facility and bird feeding roosting, or watering sites The hazard arises as birds traverse the airport in flying between the disposal facility and watering, feeding or roosting areas However, EPA does not have sufficient information to indicate how serious this problem is Moreover, the available data is insufficient to support the setting of national regulations to cover such contingencies At some point it becomes difficult to isolate the independent effect of solid waste disposal activities on the bird hazard problem.

EPA has also decided to give a clearer definition of some key terms The definition of "Airport" includes those airfields currently defined by the FAA as public-use airports The regulation applies to that set of airports because existing data indicates that the preponderance of bird strikes occur at public-use airports For example, 120 of the 121 airports reporting strikes in 1977 were public-use airports, and 220 of the 223 airports reporting strikes in 1978 were public-use airports The FAA agrees with this approach EPA, in consultation with the FAA, may broaden the class of airports of concern if it receives information demonstrating that a similar bird hazard exists at other fields.

In defining the airports of concern EPA has also eliminated the proposed criteria's reference to "runways planned to be used." As several commenters pointed out, such a reference would not be workable because it would require speculation about future siting of airports

EPA also makes it clear that the "bird hazard" of concern is "an increase in the likelihood of bird/aircraft collisions." Solid waste disposal within the danger zone may continue as long as it can be shown that the operation can be managed in such a way as to not increase the risk of collision within the specified distances

After considering public comments, EPA has deleted portions of the proposed standard Several commenters stated that the use of the conical surface in the criteria was ambiguous and not applicable to this standard The conical surface is an imaginary plane delineating an airspace segment 150 feet above the established airport elevation. The FAA prohibits stationary objects in this space because they might interfere with approaching and departing aircraft. This is inapplicable to solid waste disposal activities for two reasons, (1) Birds, the "obstructions" of concern in this regulation, are hardly stationary, and (2) solid waste disposal activities are typically low-profile operations (below 150 feet) and are not likely to constitute obstructions into the conical surface

Commenters asked who was responsible for determining whether a facility posed a bird hazard to aircraft. The Act and the CWA create the implementing mechanisms for these criteria. However, in this instance consultation with the FAA and the Fish and Wildlife Service would be very helpful Furthermore, actions at *both* the airport and the disposal facility can reduce or eliminate hazards Therefore, where appropriate this determination should be made in consultation with these agencies, as well as with the owners and operators of the airport of concern

(4) *Access.* Materials and activities associated with solid waste disposal facilities can cause injury or death to persons at the facilities Potential causes of such harm include

(a) Operation of heavy equipment and haul vehicles,

(b) Hazards associated with the types of waste, including sharp objects, pathogens, and toxic, explosive, or flammable materials, and

(c) Accidental or intentional fires

The proposed criteria required that entry to the facility be controlled in order to minimize exposure of the public to hazards of heavy equipment operation and exposed waste.

The final criteria call for control of access to protect the public from on-site exposure to health and safety hazards.

The importance of access control cannot be overstated, since persons have suffered injury and even death at uncontrolled waste disposal facilities. Furthermore, in most cases, there is little economic impact on solid waste disposal operations in accomplishing such control.

During normal operating hours, proper management controls can minimize safety hazards. For example, potential harm to facility operating personnel can be reduced through proper training, use of safety equipment, control of waste types, and other practices. The most effective means of minimizing the risk of injury to other persons is by complete prohibition of access to the site by non-users (e g. by suitable fencing) and strict control of users while on the site. For individuals disposing of small amounts of wastes, storage or special disposal facilities can be provided at the entrance to the facility or away from the area being utilized by professional solid waste management personnel.

The principal change from the proposed regulation is the broadening of the regulation's coverage Accidents at solid waste disposal sites are not limited to hazards caused by heavy equipment operation and exposed waste EPA believes that particular types of hazards should not be specified in the regulation, thereby allowing for flexibility in how the standard is applied. Therefore, the criteria seek to avoid public exposure to all potential health and safety hazards at solid waste disposal sites

Two commenters stated that the proposed requirement for fencing was unreasonable It should be noted that the Agency did not propose a requirement for fencing At many facilities natural barriers exist which make public access very difficult, however, even if the criteria were complied with through the installation of a fence around the entire property the cost would be relatively insignificant when compared to the other costs required to properly operate a disposal facility.

V. Environmental and Economic Impacts

Voluntary environmental and economic impact analyses onthis regulation have been performed and are presented in the "Final Environmental Impact Statement on the Criteria for Classification of Solid Waste Disposal Facilities". These analyses are not required by the National Environmental Policy Act but provide information pertinent to the development and use of this regulation Copies of this two-volume report may be obtained on request from. Solid Waste Information, U S EPA, 26 West St Clair, Cincinnati, Ohio 45268.

EPA has also prepared a number of background documents that respond to public comments not addressed in the Preamble These documents may be examined at E.P A , 401 M Street, S.W , Washington, D C. 20460 in room 2632. If there are apparent inconsistencies between these documents and this Preamble, the latter shall represent the Agency's position.

Dated September 10, 1979

Douglas M Costle,

Administrator

Title 40 CFR is amended by adding a new Part 257 to read as follows:

PART 257—CRITERIA FOR CLASSIFICATION OF SOLID WASTE DISPOSAL FACILITIES AND PRACTICES

Sec

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), 6944), sec 405(d), Pub L. 95-217, 91 Stat 1591, 1606 (33 U S C 1345).

§ 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 probability of adverse effects on health or the environment.

(1) Facilities failing to satisfy these criteria will be considered open dumps for purposes of State solid waste management planning under the Act.

(2) Practices failing to satisfy these criteria 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 facilities 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

§ 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 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

§ 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.

§ 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) A facility or practice 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) A facility or practice 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*)

§ 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) Only a State with a solid waste management plan approved by the Administrator pursuant to Section 4007 of the Act may establish an alternative boundary to be used in lieu of the solid waste boundary A State may specify such a 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.

(1) The hydrogeological characteristics of the facility and surrounding land,

(2) The volume and physical and chemical characteristics of the leachate;

(3) The quantity, quality, and directions of flow of ground water,

(4) The proximity and withdrawal rates of ground-water users,

(5) The availability of alternative drinking water supplies,

(6) The existing quality of the ground water including other sources of contamination and their cumulative impacts on the ground water, and

(7) Public health, safety, and welfare effects

(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/1 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

§ 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 5 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 <6 5	Background soil pH ≥ 6 5
<5	5	5
5-15	5	10
>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)
< 5	5
5 15	10
> 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)

§ 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.

§ 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) The facility or practice shall not violate applicable requirements developed under a State implementation plan approved or promulgated by the Administrator pursuant to Section 110 of the Clean Air Act

(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

§ 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. 662-688, and using a Standard sample, each portion being one fifth of the sample:

(1) If the standard portion is 10 milliliters, 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 days 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 13 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.

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ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 257]

[FRL 1234-2]

Criteria for Classification of Solid Waste Disposal Facilities and Practices Amendment

AGENCY: Environmental Protection Agency.

ACTION: Proposed Rule.

SUMMARY: This proposed amendment would expand the list of maximum contaminant levels (MCL's) used in the ground-water quality standard of the Criteria for Classification of Solid Waste Disposal Facilities and Practices (40 CFR Part 257) The criteria were developed and issued as a regulation under the authority of the Resource Conservation and Recovery Act of 1976. The purpose of the criteria is to provide the basis for determining whether solid waste disposal facilities or practices pose no reasonable probability of adverse effects on health or the environment.

The ground-water quality standard which has been promulgated in the criteria contains maximum contaminant levels for health-related parameters (specific inorganic and organic chemicals, coliform bacteria, and radioactive contamination). This amendment proposes limits for the following additional eleven contaminants. Chloride, color, copper, foaming agents, iron, manganese, odor, pH, sulfate, total dissolved solids, and zinc These additions are designed to *protect ground water from odor,* discoloration, and taste-causing contaminants

DATES: Comments are due November 13, 1979 One hearing will be held; it will be on November 1, 1979 at 9 00 AM. Registration for the hearing will begin at 8 30 AM

ADDRESSES: The official record for this amendment (Docket No 4004 2) is located in room 2107, 401 M Street, SW, Washington, D.C 20460 The record is available for viewing from 9 00 AM to 4 00 PM Monday through Friday, excluding holidays

The public hearing will be held in room 3906, 401 M Street, SW, Washington, D.C. Persons wishing to make oral presentations are requested to restrict their presentations to less than ten minutes

Written comments may be submitted at the hearing or mailed to. Comments Clerk, Amended Criteria, Office of Solid Waste (WH-564), EPA, Washington, D C 20460.

FOR FURTHER INFORMATION CONTACT: Mr. Truett V DeGeare, Jr , P E, at the above address or at (202) 755-9120.

SUPPLEMENTARY INFORMATION:

Authority

The statutory authorities for this proposed amendment are Sections 1008 (a)(3) and 4004 (a) of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (42 U.S.C. 6907(A)(3) and 6944(a)), later referred to as RCRA or the Act; also, Section 405(d) of the Clean Water Act, as amended (33 U S C. 1345).

Discussion

This action proposes to amend the Criteria for Classification of Solid Waste Disposal Facilities and Practices (40 CFR Part 257) which has been promulgated pursuant to the above authorities.

The purpose of the criteria is to provide the basis for determining whether solid waste disposal activities pose "* * * no reasonable probability of adverse effects on health or the environment * * *" (RCRA, Section 4004). The criteria define an open dump (RCRA Section 4004), the minimum elements of prohibited open dumping practices (RCRA Section 1008(a)(3)), and the effects which must be avoided by POTW owners and operators (CWA Section 405). For a full discussion of the criteria's role see the Preamble to that regulation.

The criteria provide a ground-water quality standard consisting of specified substances or parameters. When a facility or practice causes protected ground water to exceed the contamination levels specified in that standard, the facility fails to comply with the criteria The standard which has been promulgated in the criteria contains maximum contaminant levels for health related parameters. This amendment proposes limits for the following additional eleven contaminants: chloride, color, copper, foaming agents, iron, manganese, odor, pH, sulfate, total dissolved solids, and zinc, in order to protect against malodorous, discoloring, foul-tasting substances in ground water.

The criteria provide that solid waste disposal facilities or practices shall not *contaminate* an *underground drinking water source* beyond the *solid waste boundary*. The italicized terms are specifically defined for their use in the ground-water section of the criteria.

Underground drinking water sources are aquifers supplying drinking water for human consumption or aquifers in which the ground water contains less than 10,000 mg/l total dissolved solids. *Solid waste boundary* is the outermost perimeter of the solid waste (projected in the horizontal plane) as it would exist at completion of the disposal activity. (There is a provision in the criteria allowing a State with an approved State solid waste management plan to establish an alternative boundary to be used in lieu of the solid waste boundary in accordance with specified procedures and conditions). *Contamination* is defined as the introduction of listed substances to ground water so as to cause (1) the concentration of the substance in the ground water to exceed the maximum contaminant level specified, or (2) an increase in the concentration of the substance in the ground water where the existing concentration of the substance exceeds the specified maximum contaminant level.

As promulgated, the criteria establish specified maximum contaminant levels which were designed to be protective of the health of persons consuming the ground water. It includes levels for ten inorganic chemicals, six organic chemicals, coliform bacteria, and radioactive contaminants These levels are based on the National Interim *Primary Drinking Water Regulations* (40 CFR Part 141).

The criteria were initially proposed for public comment at 43 FR 4942 on February 6, 1978. In that proposal, the water quality standard for ground water used or usable for human consumption was that the water not be made unfit for human consumption The maximum contaminant levels (MCL's) of the National Interim Primary Drinking Water Regulations were included for determining fitness. Commenters noted that the term "fitness" was too vague to be workable It was unclear whether foul-smelling, discolored, but not unhealthful water is "fit" for consumption Others noted that since the proposed standard did not specify the contaminants or the concentrations at which unfitness would be reached enforcement would be troublesome In considering the merits of these comments, the Agency decided that the ground water quality standard should be specific regarding contaminants and levels which represent adverse effects on public health and the environment. Since the maximum contaminant levels in the National Interim Primary Drinking Water Regulations were the only specific contaminants and levels which were contained in the proposed criteria, the Agency has decided to promulgate the criteria based only on those contaminant levels Before other contaminant levels are incorporated in the standard, public scrutiny and the opportunity for comment should be offered. Thus, this amendment is proposed for public review.

RCRA clearly provides that the criteria should address effects on the environment as well as on health. The House Report (No. 94–1491) instructs that the legislative standard for the Administrator in developing the Criteria is "no reasonable chance of adverse effects" on the environment The report defines an open dump as a land disposal site where discarded materials are deposited with little or no regard for pollution controls or aesthetics It provides specific examples of the impacts to be prevented, including 47 cases of recorded fishkills and 30 cases of recorded contamination of drinking water wells. The adverse impact on the ground water at most of the cited examples was principally due to high color and odor characteristics associated with iron, manganese and other contaminants not generally associated with direct health effects. It is thus evident that Congress intended to include foulsmelling, discolored ground water as an adverse environmental effect

The Agency has reviewed monitoring data from a number of facilities which indicates that about half of those monitored facilities have caused ground water to exceed the health-based maximum contaminant levels promulgated in the criteria An additional thirty percent of these contain unacceptable levels of other (non-health-related) contaminants Additional research is needed regarding the probability that disposal activities may cause adverse environmental effects without posing direct health threats Nevertheless, the existing literature does indicate that including malodorous, distasteful and discoloring contaminants in the ground-water quality standard might significantly increase the number of facilities in violation, and that unless these contaminants are included in the standard, a significant number of facilities which cause ground water to be foul-smelling and bad-tasting will not be classified as unacceptable

Therefore, the Agency has decided to propose an amendment to the criteria's ground-water quality standard which would include contaminant limitations protective against malodorous, distasteful, foaming, staining, corrosive and otherwise adverse effects on ground water In this proposed amendment, comment is being solicited on the use of the maximum contaminant levels published in the National Secondary Drinking Water Regulations (40 CFR Part 143) for that purpose Eleven contaminant levels were specified in 40 CFR Part 143 which are of significance in the classification of disposal activities; some discussion is provided below, giving rationale and potential problems for each of the eleven and pertinent comments received by the Agency when the National Secondary Drinking Water Regulations were originally proposed

A *Chloride* (250 mg/1). The proposed MCL for chloride is the level above which the taste of the water may become objectionable to the consumer. In addtion to the adverse taste effects, high chloride concentration levels in the water will contribute to the deterioration of domestic plumbing, water heaters, and municipal water works equipment. Higher concentrations may also be indicative of the presence of sodium and other contaminants commonly occurring in leachate, which are not listed in either of the national drinking water regulations and, thus, not directly a part of the ground-water quality standard.

Leachate commonly contains high concentrations of chlorides Since chloride ions are quite mobile in both saturated and unsaturated zones, isograms of chloride concentrations are particularly useful for inscribing leachate plume envelopes In most cases, the chloride concentration is a key parameter which will indicate the potential presence of any other leachate constituent

Comments received by the Agency on the proposed level for chlorides concerned the high costs of removal and consumer tolerance or acclimatization Neither of these issues is appropriate for consideration in the water quality standard for the criteria High removal costs support keeping the contaminant out, and leachate-caused concentrations are too unstable to allow acclimatization In regions where naturally occurring or background concentrations of chloride are consistently high, people can become tolerant of the taste well in excess of the MCL In such regions, the National Secondary Drinking Water Regulations suggest that States exercise discretion, establishing limitations commensurate with local conditions However, such discretion is inappropriate for a leachate induced violation of the water quality standard The concentrations of chloride often fluctuate widely in a leachate plume, and their introduction would represent a new condition to which acclimatization may take years, and increasing concentrations of chlorides is a harbinger indicating the likelihood of the presence of harmful constituents of leachate.

B *Color* (15 Color Units) Color may be indicative of the presence of a host of organic materials against which protection is not provided elsewhere in the ground-water quality standard. Many of these organic materials are of direct health concern and of indirect concern as precursers for the formation of trihalomethanes and other halogenated organic compounds

Experience has shown that changes in color levels will stimulate consumers' complaints more readily than a relatively high constant level. The MCL at 15 color units is set quite high; consumers of clear water would be immediately aware of the presence of leachate if it were to cause color to exceed that level The color standard is not redundant for the staining problems which are caused by iron or manganese, since these constituents are not visible until oxidation, usually only occurring after withdrawal of the water

The only comments rceived on the proposed color standard were that it was set too high Support for a lower MCL included the argument that protection from halogenated organic compounds would be enhanced. This argument is quite significant for solid waste purposes. Fifteen color units may allow quite a high level of contaminants to be present However, the Agency has proposed inclusion of these compounds directly in the Primary Regulations

(**Federal Register** notice, February 9, 1978, 40 CFR Part 141) The approach proposed herein, then, is to employ the higher color standard and wait for the specific MCL to be established for those compounds in the Primary Regulations.

C *Copper* (1 mg/l). Copper, in trace quantities, is an essential and beneficial element in human metabolism but imparts an undesirable taste to drinking water at the MCL. Small amounts are generally regarded as non-toxic, but large doses may produce emesis, and prolonged consumption may result in liver damage. Copper, in some soft waters, will cause staining at the MCL.

Copper is generally quite low in both native ground water and in leachate from mixed municipal refuse, it generally occurs at concentrations less than 20 micrograms per liter except at facilities receiving wastes from industrial sources The metal is used extensively in electroplating, chemical manufacturing and in oil refining, and the salts of copper are used in textiles, photography and pesticides The inclusion of copper in the standard should only affect the assessment of industrial waste facilities

High cost of removal was the basis for comments for relaxing the MCL for copper This comment supports maintaining stringent water quality standards for the criteria In responding to that comment, the Agency notes that the MCL was only exceeded in 1 6% of the samples in EPA's 1970 Community Water Supply Study, and that wherever high copper concentrations were observed the other heavy metals were also high. Consequently, the inclusion of the copper standard appears appropriate.

D. *Foaming Agents* (0 5 mg/l). Foaming is a characteristic of water which has been contaminated by the presence of detergents and similar substances Water which foams in excess of the MCL will exhibit undesirable taste and foaming properties Comments received suggested that the MCL was too stringent and that since the analytical procedure specified for the detection of foaming agents is the methylene blue test, the MCL should be stated in terms of methylene blue active substances.

The 0 5 mg/l limit for foaming agents is based upon the fact that at higher concentration levels the water may exhibit undesirable taste and foaming properties. Also concentrations above the limit may be indicative of undesirable levels of pollutants from questionable sources, such as infiltration by sewage. Because there is no standardized foamability test, this property is determined indirectly by measuring the anionic surfactant concentration in the water utilizing the test procedure specified for methylene active substances. Many substances other than detergents will cause foaming and interfere with the methylene blue test. Since most of these interferences are positive, the Agency believes that the MCL designated for foaming agents is the correct one.

E. *Iron* (0 3 mg/l). Iron is a highly objectionable constituent of water supplies. It imparts a brownish discoloration to laundry, a bitter or astringent taste to drinking water, and stains to clothing, dishes and plumbing fixtures However, in some areas of the country, the native concentration of iron well exceeds the MCL. The limit on iron may be one of the most frequently violated standards in the criteria. Iron is very common in leachate, quite mobile in most soils, and, significantly, the concentration may be further elevated due to the release of soil-fixed iron as an effect of pH and other changes caused by the passage of leachate through the soil

At 1 0 mg/l, a substantial number of people will note the bitter astringent taste of iron Also, at this concentration level the staining problems associated with iron will be pronounced, thus making the water unpleasant to the consumer and unsatisfactory for most industries. Therefore, the Agency believes that the proposed MCL of 0 3 mg/l) for iron is reasonable.

F. *Manganese* (0.05 mg/l). Manganese, like iron, discolors and imparts taste At concentrations exceeding MCL it can cause build-up in distribution piping which can slough off and cause laundry spotting and unaesthtic black precipitates. Relatively fewer regions have high native manganese than have high native iron; however, it is not unusual For instance, New York State Health Department surveys indicate that manganese is found in every public drinking water system, and exceeds the MCL in about 10%. The Agency received no comments on the proposed standard for manganese.

G *Odor* (3 threshold odor number) The principal reason for establishing this MCL at 3 Threshold Odor Number in the Secondary Drinking Water Regulations is that beyond that odor level, consumers would be tempted to avoid the public water system and choose alternative, possibly unmonitored, water sources. Thus, it is an odor level which is considered definitely unacceptable, particularly when newly or intermittently introduced, as may be the case from leachate.

Odor is due to the presence of a variety of substances. Most organic and some inorganic chemicals contribute taste and odor. Because odorous materials are detectable when present in only a few micrograms per liter and are often complex, it is usually impractical and often impossible to isolate and identify the odor-producing chemical. Although many of the odor-producing chemicals are not known to have other adverse effects, inclusion of odor in the standard has the additional advantage of warning of the presence of organic and inorganic pollutants often associated with municipal and industrial wastes but not otherwise listed in the standard

Comments received by the Agency on the proposed regulation suggested that the proposed MCL should be deleted from the regulations, arguing that the threshold odor number is an arbitrary value and the analytical results obtained vary greatly from person to person. On the other hand, one commenter suggested that the MCL should be lowered to one. The level of three was determined by the Agency to be appropriate because most consumers find the water at this limit unacceptable. Determination of odor at that level is considered reliable, but below the MCL it is difficult because of possible interferences from other sources and variation of the sensing capabilities of the personnel performing the test.

H *pH* (6.5—8 5) A variety of health and environmental effects are associated with the range of pH which could result from contamination by leachate pH is an important determinant of corrosivity; below 6.5, significant corrosion effects become noticeable. The treatability of many of the other parameters in the water quality standard is also dependent upon pH For example, while a facility might emit no selenium, the selenium treatment which would be required because of high background concentrations could be rendered ineffective due to the facility's effect on pH Also, pH can interfere with existing treatment because of its effects on the efficiency of chlorination and on the solubility of toxic metals.

Naturally occurring pH is found lower than two in some volcanic situations and nearly 11 in contact with some silicates in desert basins However, acidities and alkalinities of these magnitudes are quickly reduced by reaction with their environment. Most ground waters which lie subject to contamination by solid waste disposal activities are subjected also to atmospheric and other neutralizing influences A reasonable range of pH at the water table may be considered to lie between 4 and 9, numbers which also represent the reported range of the pH of leachate Naturally occurring pH in ground water is slightly basic in most regions of the country, with sufficient buffering capacity to withstand significant stresses associated with solid waste disposal activities. Leachate from mixed municipal wastes is quite erratic, varying by both age and constituents of the waste. The occurrence of contaminated ground water in which the MCL for pH is exceeded after a reasonable mixing zone is highly indicative of adverse health and environmental effects.

Most of the comments received by the Agency concerned the upper limit for pH. Since raw leachate seldom exceeds the upper limit, these comments are not applicable for the Criteria. The remainder of the comments concerned corrosivity. The Agency is still evaluating tests and maximum concentration levels for corrosivity, these comments and the issue of corrosivity in leachate will be addressed on conclusion of the evaluations.

I. *Sulfate* (250 mg/l) Sulfate is a commonly occurring natural constituent of ground water in many regions of the country. Some States report as much as 10 percent of the underground drinking water supplies exceed the MCL. Sulfate is listed in the Secondary Drinking Water Regulations principally because of its cathartic or laxative effect in humans and to a lesser extent because of taste considerations. Its presence in leachate is frequently attributable to industrial sources of refuse such as textile and paper industries Leachate analyses frequently report sulfate far below MCL, with occasional reports as high as 1500 to 2000 mg/l. For these facilities it is a good indicator of the extent of contamination, and its laxative and taste effects are useful indices of the adverse effects.

Comments received by the Agency were not appropriate to this amendment, considering the objectives of the criteria Cost of treatment, and long-term acclimatization do not suggest allowing greater concentrations to result from land disposal.

J. *Total Dissolved Solids (TDS)* (500 mg/l). Dissolved solids content is useful as the single parameter which most closely describes a given water in terms of usefulness of the native water and influence of a heterogenous contaminant source. It reflects the influence of all the dissolved constituents It reflects mineralization and, thus, the taste of water Additionally it accelerates deterioration of plumbing and water fixtures (One study finds a reduction of one year of water heater life per 200 mg/l TDS) Although it is a very non-specific indicator which may be difficult to isolate by source, it is useful for covering both hardness and corrosivity effects which are not otherwise a part of the water quality standard of the criteria.

In some regions of the country, particularly in the Southwest, the ground water commonly exceeds the MCL for TDS A dissolved solids limit (10,000 mg/l) is used as the demarcation in the criteria for water too contaminated to warrant protection. Leachate is high in TDS, commonly reported between 5,000 and 40,000 mg/l.

Excessive hardness, taste, mineral deposition and corrosion are among the associated adverse effects listed in the rationale for limiting TDS in the Drinking Water Regulations. Comments received on TDS were mostly requests for flexibility or for a higher limit from water suppliers in area of high background TDS levels. No comments of concern to the criteria addressed areas of low background TDS.

K *Zinc* (5 mg/l) Like copper, zinc is an essential and beneficial element in human metabolism, but it imparts an undesirable taste to water. It also can create a milky appearance in water and cause a greasy film on boiling In native ground water it is seldom found in concentrations exceeding 2 or 3 mg/l. Frequently, it is reported in leachate at concentrations below the MCL; however, in industrial areas zinc concentrations in leachate have been reported up to 370 mg/l. The Agency received no comments on the proposed MCL.

Key Issues

EPA believes that this list of eleven maximum concentration levels may be appropriate for addition to the criteria In order to properly solicit public comment, yet not delay State implementation of RCRA, the Agency is promulgating the criteria at the same time as this amendment is being proposed; the alternative of promulgating interim regulations, with the expanded ground-water quality standard in effect during the comment period, was rejected.

Several key questions are specifically highlighted for public comment First, are these eleven proposed contaminant levels appropriate for the objectives of the criteria? Are they characteristic of leachate? Are they too commonly present in ground water to serve the purpose? Secondly, are there additional contaminants or characteristics which should be used to determine adverse effects on health and environment? Thirdly, what effect will the expansion of the standard have on compliance with the criteria? Will only those facilities with impervious liners for the prevention of discharges be acceptable, or will there be only a small incremental increase in non-complying facilities consisting of sites which do cause adverse environmental effects?

We specifically highlight for comment the fact that several States have considered these contaminant levels as they were proposed in the National Secondary Drinking Water Regulations and have chosen to promulgate State drinking water regulations based on higher or lower levels. Should these criteria permit similar State-by-State variations in the ground-water quality standard? This question should be addressed considering that without State discretion, some State agencies may be in the awkward position of requiring facilities to close or upgrade for causing effects which the State considers acceptable in drinking water supplies Yet, on the other hand, in order to protect against the potential for inconsistencies and abuses, a flexible standard will require adding a justification and approval process This is a level of EPA oversight not otherwise needed in implementation of the regulation.

Comments are also requested on the practicality of implementation (such as replicability of taste and odor tests), potential impacts of this amendment on segments of society and the economy, and the adequacy of the amended regulation in providing for protection of the public health and the environment. Written public comment is invited on all issues raised by the proposal.

Dated September 10, 1979

Douglas M Costle,

Administrator

Appendix A [Amended]

Accordingly, 40 CFR Part 257 is amended by adding to Appendix A a paragraph 6 as follows.

* * * * *

6 *Maximum contaminant levels for other than health effects*

The following are the maximum levels for odor, taste and miscellaneous contaminants

Contaminant	Level
Chloride	250 mg/l
Color	15 Color units
Copper	1 mg/l
Foaming agents	0 5 mg/l
Iron	0 3 mg/l
Manganese	0 05 mg/l
Odor	3 Threshold odor No
pH	6 5–8 5
Sulfate	250 mg/l
TDS	500 mg/L
Zinc	5 mg/l

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APPENDIX B

METHODOLOGY FOR DETERMINING

ECONOMIC IMPACT ANALYSIS

APPENDIX

B. METHODOLOGY FOR DETERMINING ECONOMIC IMPACT ANALYSIS

Chapter III summarized the economic impacts of three regulatory approaches -- the final, a more restrictive, and a less restrictive -- identifying these as Federally induced costs, State-standard-induced, and combined (State-standard-induced plus Federally induced) costs for landfills, surface impoundments, and landspreading. Chapter IV briefly discussed the approach and methodology used in analyzing the economic impacts of the criteria, and outlined the major assumptions for each disposal method.

In this chapter the methodology underlying the economic impact analysis is discussed in greater detail, including: (1) an explanation of the methodology used to differentiate between State-standard-induced and Federally induced costs; (2) a summary of the analysis used to evaluate the final, more-restrictive, and less-restrictive alternatives, with the assumptions supporting this analysis; (3) information concerning the data base; and (4) methodologies used in developing the data base and costs.

A. ANALYSIS OF STATE STANDARDS VS. FEDERAL CRITERIA

The cost figures developed for the Economic Impact Analysis (EIA) represent the increments or additional cost above current disposal costs to bring existing facilities into compliance with the criteria. By comparing the criteria to existing State standards, it is possible to divide these incremental costs into two categories: State-standard-induced cost (cost to come into compliance with existing State standards) and Federally induced cost (costs beyond those needed to achieve compliance with State standards). This breakdown was necessary because a number of disposal facilities do not yet comply with existing State standards (corrective or compliance technologies and methods often take years to implement). Without the Federal criteria, facilities can be expected to eventually come into compliance with State standards. The combined costs demonstrate the total additional expenditures necessary to bring existing facilities into compliance with State standards and the criteria.

In order to determine State-standard-induced and Federally induced costs, State standards and regulations were reviewed and evaluated; State regulations were then compared with the criteria to establish their degree of conformance with the criteria.

This legislative analysis is summarized below and in Table B-1; the latter identifies the specific criteria addressed in the regulations of each State.

Floodplains. A review of State solid waste legislation shows that 23 States (46%) had regulations that are intended to avoid adverse impacts associated with the disposal of wastes in floodplains.

Endangered and Threatened Species. Only one State, California, addressed this criterion in its regulations, through a requirement for environmental impact reports which consider the impact of proposed actions on endangered and threatened species.

Surface Water. The surface water criteria address all water of the United States, including wetlands. Because of the unique nature of wetlands, State regulations were examined for specific reference to these areas. The surface water criteria were addressed in existing regulations in all but three States -- Kansas, Louisiana, and Mississippi. Eleven States make specific reference to wetlands.

Ground Water. The ground-water criteria include sole source aquifers and were determined to have been met in 37 States. Several of those States determined not to meet the ground-water criteria did make provision for some ground-water protection, usually expressing a minimum vertical separation between wastes and ground water.

Table B-1

ANALYSIS OF STATE REGULATIONS VS. FEDERAL CRITERIA
(X Indicates State Compliance)

STATE	CRITERIA											
	Flood Plains	Critical Habitats	Surface Water Gen'l	Surface Water Wetlands	Ground Water	Air	Disease Vectors	SAFETY Expl. Gases	SAFETY Toxic Gases	SAFETY Birds	SAFETY Access	SAFETY Fires
Alabama			X		X	X	X					X
Alaska			X		X	X	X				X	
Arizona			X		X	X	X					X
Arkansas	X		X		X	X	X				X	X
California	X	X	X	X	X	X	X	X	X	X	X	X
Colorado	X		X			X	X				X	X
Connecticut	X		X				X	X	X		X	X
Delaware			X	X	X		X	X			X	X
Florida	X		X		X	X	X	X	X	X	X	X
Georgia			X	X	X	X	X				X	X
Hawaii	X		X				X					X
Idaho			X		X	X	X				X	X
Illinois			X		X	X	X				X	X
Indiana			X			X	X	X	X		X	X
Iowa	X		X			X	X				X	X
Kansas						X	X				X	X
Kentucky	X		X		X	X	X				X	X
Louisiana					X		X					
Maine			X	X			X				X	X
Maryland	X		X	X	X	X	X	X	X		X	X
Massachusetts	X		X	X		X	X				X	X
Michigan			X		X	X	X				X	X
Minnesota	X		X	X	X	X	X	X	X	X	X	X
Mississippi	X					X	X				X	X
Missouri	X		X		X	X	X	X	X		X	X
Montana	X		X		X	X	X				X	
Nebraska	X		X		X	X	X				X	X
Nevada			X		X	X	X				X	X
New Hampshire	X		X	X	X	X	X	X	X		X	X
New Jersey			X	X	X	X	X	X	X	X		X
New Mexico			X		X		X				X	X
New York			X		X	X	X				X	
North Carolina	X		X		X	X	X				X	X
North Dakota			X				X				X	
Ohio			X		X		X				X	X
Oklahoma			X			X	X				X	X
Oregon	X		X		X	X	X				X	X
Pennsylvania	X		X		X	X	X				X	X
Rhode Island			X		X	X	X	X	X		X	X
South Carolina			X		X	X	X				X	
South Dakota	X		X		X	X	X				X	X
Tennessee	X		X		X	X	X				X	X
Texas	X		X		X	X	X	X	X	X	X	X
Utah			X			X	X					X
Vermont			X			X	X				X	
Virginia			X		X	X	X					X
Washington	X		X	X	X	X	X	X	X	X		X
West Virginia			X		X	X	X					
Wisconsin			X	X	X	X	X	X	X		X	X
Wyoming			X		X	X	X				X	X
TOTAL	23/50	1/50	47/50	11/50	37/50	42/50	50/50	14/50	14/50	5/50	42/50	42/50
% OF TOTAL	46%	2%	94%	22%	74%	84%	100%	28%	28%	10%	84%	84%

Air. The air criteria were addressed in 42 States (84%), through at least limited bans on open burning.

Disease. Control of disease was provided in all 50 States. This criterion was met largely because of provisions in each State for periodic cover of waste material.

Safety. The five components of the safety criteria were met in varying degrees by the States; 42 States (84%) required provisions for prevention and control of fires, while 42 States (84%) also included provisions for the control of facility access in their solid waste regulations. Safety provisions which address the problems of explosive and toxic gases were less common in State rules and regulations. Fourteen States (28%) required controls for toxic and explosive gases. The criterion which addresses potential bird hazards to airports was met in the rules and regulations of only five States.

B. METHODOLOGY FOR EACH DISPOSAL METHOD

The methodology for the economic impact analysis was developed with the aid of fairly complete data on the number of landfills and on State solid waste disposal regulations, but with limited data on the number of landspreading operations and surface impoundments and overall conditions or current impacts of all three types of land disposal facilities. In lieu of complete information on the number and condition of landspreading sites, substantial data has been collected on the amount and characteristics of municipal sewage which is landspread. Although some industrial waste disposal facilities may be regulated by the hazardous waste regulations of RCRA and not by these criteria, no attempt was made to estimate how many facilities may be so affected; therefore, criteria costs may include estimates for some facilities that are regulated by the hazardous waste regulations of RCRA.

Unfortunately, the inventory of disposal facilities to be developed under RCRA is to occur after the regulation is finalized. Consequently, a number of assumptions had to be made because the following information is sketchy or not well known:

(1) number and size of surface impoundments (an estimate -- considered to be incomplete or conservative -- is available on the number of surface impoundment sites. (Ref. 107);

(2) number and size of landspreading operations on food-chain cropland;

(3) the specific locations and conditions of all categories of solid waste disposal facilities.

In analyzing the economic impacts of the criteria, the basic method used on a State-by-State basis was fourfold:

(1) estimate the number of disposal facilities (by size and location); In addition to partial estimating of the number of landspreading sites, estimate the amount of municipal sewage sludge landspread nationally;

(2) estimate the condition (environmental impact) of existing facilities (by size and location);

(3) identify control technologies (by adverse effect and regulatory alternative) and estimate unit costs (based on facility size) to meet each criterion; and

(4) derive total control costs of closure or upgrading for the major regulatory alternatives by summing costs of each criterion for the three types of disposal for the total number of affected facilities.

All costs in this report are in terms of annualized 1978 dollars. The methodology for cost calculations is based upon three assumptions:

- facilities have a life of 10 years (a 10 year planning period was assumed to be appropriate in the landspreading analysis);
- interest is 10%; and
- inflation affects all variables equally.

Thus, costs were developed by calculating annual payment spread over 10 years.

For capital expenditures (A_k), the following calculation was used:

A_k = (K) (0.163) = cost spread over 10 years
where K = capital = present worth
0.163 = annuity factor to 10 years at 10%

The formula used for derivation of the .163 factor was:

$$A_k = k \frac{i}{1-(1+i)^{-n}} \text{ or } k \frac{i(1+i)^n}{(1+i)^n-1}$$

Where:

K = Capital Cost
A_k = Annualized capital cost
i = Interest rate, per year
n = Number of years

For operation and maintenance (O+M),
A_{o+m} = Annual operation and maintenance

Overall, the calculation used to develop total annualized unit costs, A, was

$$A = A_k + A_{o+m}$$

1. Methodology and Assumptions for Landfills

a. Data Source

The 1977 update to the 1976 Waste Age survey provided the initial data base for the economic impact assessment. Feedback was requested from the States on two occasions regarding the accuracy of the data, and updated numbers were obtained in some cases, as referenced in this final EIS. The Fred C. Hart Associates, Inc. study, "The Technology, Prevalence, and Economics of Landfill Disposal of Solid Waste," was used as the base source of information concerning the national prevalence of on-site industrial landfills (those landfills on industry-owned property) by size category for each two-digit SIC manufacturing industry group.

b. Assumptions and Other Data Considerations

(1) Impact Receptors

All known landfill facilities, whether "permitted," "authorized," or "illegal,"* as documented by the Waste Age survey, were considered to be affected by the criteria, as well as known on site industrial landfills. The degree of impact varied according to five factors: numbers of authorized facilities; numbers of illegal facilities; number of on-site industrial landfills; the degree to which State regulations met the requirements of the criteria; and the location of facilities based upon the percentage of total population within a given State that could be classified as residing in a wetland or floodplain.

(2) Applicable Criteria

All criteria were considered to have the potential to generate economic impacts except the point-source requirements of surface

*These are assumed to be open dumps and thus require closing under RCRA within five years.

water, land application, endangered and threatened species, and bird hazards to aircraft. The following assumptions were made:

- Land application was not considered for landfills because traditional landfill wastes are usually not spread on land for beneficial utilization.

- Bird hazards to aircraft and endangered and threatened species do not have cost impacts, but these impacts are considered minimal due to the small number of disposal sites affected by these criteria.

(3) Regulatory Alternatives

Table B-2 shows, on a criterion-by-criterion basis, which regulatory alternatives were considered in analyzing the economic impacts of the criteria on landfills.

The following assumptions were made in regard to the regulatory alternatives:

- For ground water, the regulatory alternatives are a function of State regulations and potential for adverse impacts on ground water. Since required technologies are a function of the rates of infiltration in particular States, the final criteria considered ground-water technology with respect to those facilities in States with negative rates of infiltration versus those in States with net rates of infiltration. All facilities in wetlands received maximum technology. In net infiltration States, fifty percent of the authorized municipal landfills and on-site industrial landfills received maximum ground-water technology. Fifty percent of these facilities also were assumed to require ground-water quality monitoring. These same percentages were applied

TABLE B-2

REGULATORY ALTERNATIVES

CRITERION	PROPOSED	MORE RESTRICTIVE	LESS RESTRICTIVE
Floodplains	X	X	Not practical
Endangered & Threatened Species	N/A	N/A	N/A
Surface Waters			
- Point Source	N/A+	N/A	N/A
- Nonpoint Source	X	X	N/A
- Wetlands	X	X	N/A
Groundwater	X	X	X
Disease	X	Not practical	Not practical
Air	X	X	Status quo
Safety			
- Explosive and Asphyxiating Gas	X	Not practical	Not practical
- Fires	X	Not practical	Not practical
- Bird Hazards	N/A	N/A	Status quo
- Access	X	Not practical	Not practical

*Status quo refers to regulatory alternative which will not change current practices
+This is not applicable because point source regulation is the function of water programs

to permitted municipal landfills in States which had no standards equivalent to the Federal criteria. The regulatory alternatives considered these same facilities, but provided maximum technology in all States for the more restrictive and minimum technology in all States for the less restrictive.

- For safety, more- and less- restrictive alternatives were not considered feasible for gas, fire, and access because of the need to control these factors to ensure public safety.

- For surface water, the final criteria were considered to consist of two parts -- one part addressing surface waters in general, and the other addressing wetlands because of their unique nature. The regulatory alternatives considered the surface water criterion in the same manner by providing alternatives both for the general non-point-source provisions of the criteria and for wetlands.

  For the purpose of assessing costs, it was determined that the costs attributed to the surface water criteria should not be assigned to the total criteria costs, because the surface water criteria merely focuses existing Federal legislation -- the Clean Water Act -- to the operation of solid waste disposal facilities. Costs are more accurately a reflection of Sec. 103 of this Act.

- For air, the regulatory alternatives involved an assessment of increased land required as a result of restricted burning. The more restrictive alternative considered this, as well as additional land needs resulting from a total ban of burning. Under the final criteria, some burning is allowed on a site-specific basis by permit from individual States.

(4) Technologies and Cost Considerations

Applicable technologies and unit costs on a criterion-by-criterion basis are discussed in Chapter III. Costs were based upon three factors: numbers of facilities, facility size and quantity of control needed; and facility size was based upon a scenario of average conditions. Table B-3 summarizes the assumptions regarding facility size.

TABLE B-3

LANDFILL FACILITY SIZE DATA*

Facility category, (metric tons/day)		9.1	9.1	272
		(10)	(100)	(300)
Refuse Capacity,	m^3	39,800	397,800	1,193,400
	(yd^3)	(52,000)	(520,000)	(1,560,000)
	(tons)	(26,000)	(260,000)	(780,000)
Edge**	m	152	336	549
	(ft)	(500)	(1,100)	(1,800)
Area	Hectare	2.4	11.3	30.4
	(acre)	(6)	(28)	(75)
Refuse-to-Soil Cover Ratio (Daily and Intermediate Cover)		1:1	2:1	3:1

*Assumptions are as follows:

(1) Refuse is placed in 2 successive 2.43-meter (10') high lifts.
(2) 260 days per year
(3) Soil cover excavated on site
(4) In-place refuse density of 593 kg/m^3 (1000 lb/cy)
(5) Perimeter fill slopes are 3 horizontal to 1 vertical
(6) Facility service life of 10 years.

**Edge distance is based on a square facility, with a 30.5m(100') set-back from top of fill to property line.

The ground-water criteria had the most detailed cost considerations. Clay lining, monitoring wells, and leachate collection and treatment facilities were considered to be the best available technology for purposes of upgrading. Leachate removal and treatment was considered an operation and maintenance (O&M) cost, because of the likelihood that leachate would be discharged to a POTW; the assumptions to calculate costs for leachate were as follows:

- A surcharge would be collected annually and put in a trust fund. Funds accrued during the life of the landfill would be used for leachate removal and treatment during the last 5 years of facility service life and 10 years thereafter.
- Leachate infiltration is 6 inches/year and treatment costs are 2.5, 1.0, and 0.5 cents per gallon for 10, 100 and 300 ton per day facilities, respectively.
- Surcharge over a 10-year period is equal to annual expenditures over 15 years. Inflation is assumed to offset interest accrual, hence neither of these factors has been incorporated in the calculations.

c. Data Base

(1) Facility Conditions

Evaluation of municipal facility conditions was based upon categories of disposal facilities,as provided by the *Waste Age* survey, and an assessment of the stringency of State regulations, as discussed in Chapter VA.

Landfill facilities were divided into four categories: permitted, authorized, illegal, and on-site industrial. The following assumptions were made for municipal landfills:

- Permitted Facilities. The facility conditions are a function of the degree to which their States' solid waste regulations comply with the criteria. (This assumes that the permitted facilities comply with the State regulations.) Thus, for any given State, if the condition of their landfills can be said to be X1 and the Federal criteria mandate a condition of X2, then the difference between these two conditions is the amount of upgrading needed on a criterion-by-criterion basis.

State permitted facility condition	Federal criteria mandates
X1————————	————X2

- Authorized Facilities. An authorized facility, according to the Waste Age survey, is one which is not quite ready to be permitted. However, there is no available definition of "quite ready;" therefore, in order to maintain consistency it is necessary to define this condition with respect to the State regulations and the Federal criteria. For example, if authorized facilities are at condition XO, then they have to reach both conditions X1 (State regulations) and X2 (Federal criteria).

Authorized condition	State regulations condition	Federal criteria
	X1	X2
XO————————	X1————————	X2

In addition to being upgraded from State permit condition to Federal criteria (X2-X1), all authorized facilities need to be upgraded to the level of current State regulations (X1-XO) for ground-water and surface water criteria. With respect to all other disposal criteria, these authorized facilities were assumed to already meet current State regulations. The basis for this assumption is that it is relatively easy and inexpensive to comply with the other criteria; hence an assumption was made that authorized facilities are probably in compliance.

- Illegal Facilities. The remaining, or illegal facilities within a State will be assumed to be open dumps, which are mandated by RCRA to be closed within five years. In other words, illegal dumps meet none of the criteria, and consequently, costs for these facilities will be determined by costs for closure.

The 1977 update to the 1976 Waste Age survey provides the numbers of municipal landfills according to the above two categories, and by inference, a third category -- illegal facilities. For example, in a given State, there may be 300 known disposal facilities, of which 94 are permitted and 108 are authorized, leaving 91 facilities which are considered illegal. The formula for this computation is:

Illegal facilities = (known facilities) - (permitted facilities) - (authorized facilities)

However, the Waste Age Survey has several inconsistencies, resulting from differing reporting methods among the States. These inconsistencies are resolved as follows:

1. When the number of authorized facilities is less than the number of permitted facilities, it is assumed that the permitted facilities were not included in the authorized category,and therefore:

Total - (authorized + permitted) = illegal

2. When the number of authorized facilities is equal to the total number of facilities, it is assumed that there are no illegal facilities and the authorized category includes permitted facilities.
Therefore:

Total - permitted = true authorized

3. When the number of authorized facilities is equal to the number of permitted facilities, and the total of authorized + permitted exceeds the stated total, it is assumed that the authorized are the same as permitted. Therefore:

Total - permitted = illegal

4. When the total number of facilities is equal to both the number of authorized facilities and the number of permitted facilties and the number of permitted facilities (total = authorized = permitted), all facilities are assumed to be permitted and no facilities are assumed to be illegal. Therefore:

Total = Permitted

5. When the number of authorized facilities is greater than the number of permitted facilities, but the sum of permitted and authorized is less than the stated total, the difference from the total of this sum are assumed to be illegal. Therefore:

Total - (authorized + permitted) = illegal

6. When the number of authorized facilities is greater than the number of permitted facilities, but the sum of permitted and authorized is greater than the stated total, it is assumed that the authorized category includes both permitted and authorized facilities.
Therefore:

True authorized = stated authorized - permitted
Total - (true authorized + permitted) = illegal

7. When the number of authorized facilities is equal to the number of permitted facilities, but the sum of these is less than the stated total, it is assumed that there are an equal number of authorized and permitted facilities. Therefore:

Total - (authorized + permitted) = illegal

8. Number of authorized facilities is less than the number of permitted facilities and the total of authorized and permitted is greater than total number of facilities. It is assumed that the definitions of authorized and permitted facilities differ in these states. Therefore:

Actual permitted = given authorized
Actual authorized = given permitted - given authorized

In addition, it is assumed that the actual authorized include actual permitted. Therefore:

Total - (actual authorized + actual permitted)= illegal

For industrial landfills, the following assumptions were made:

- All industrial landfills will require upgrading, except for the gas component of the safety criteria, the groundwater criteria and disease criterion. This assumption was based on the presumption that industry would find it more cost-effective to upgrade their landfill disposal facilities, rather than close them and find alternative disposal methods.

- For the ground-water criteria, it was assumed that all on-site industrial landfills located in wetlands will be upgraded; fifty percent of those facilities located in net infiltration areas will be upgraded with maximum technology, and fifty percent in these same areas would require ground-water quality monitoring.

- For the gas criteria, 10% of the industrial landfills will require upgrading. This assumption is based on the fact that most industrial wastes are non-organic, and therefore not conducive to gas generation.

- For the disease criterion, 10% of the industrial landfills will require upgrading. This assumption is based on the fact that most industrial wastes are non-organic, and therefore not conducive to the support of disease vectors.

The Fred C. Hart Associates, Inc. study (Ref. 141) was used as the base source of information for determining the number of on-site industrial landfills by size category and State for each two-digit SIC industry group. The methodology is detailed in the Data Base Calculations Section.

In regard to closure, EPA is currently developing policy and procedural guidance on what constitutes closure of solid waste disposal facilities. The following assumptions were made:

- A closed facility by definition does not receive any more solid wastes.

- All closed facilities shall be "window dressed" or "topped off" (to minimize infiltration, disease vectors, bird attractions, and waste exposure). In regard to landfills and dumps, a minimum of 2 feet of cover material suitable to support vegetation, and vegetation adequate to prevent soil erosion is necessary.

- No open burning.

- One year after closure, the facility shall be inspected for settlement, vegetation, cover material, and effectiveness of vents.

- No other corrective actions.

These assumptions are based to a large extent on the following information: (1) corrective actions for ground-water contamination are very expensive and generally do not clean up the aquifer, but merely inhibit additional leachate migration, (2) revenue sources at closed facilities have ceased and the property may have changed hands so that the desired outcome of any suit for corrective action is doubtful, and (3) in general, it is better to concentrate on protecting ground water from damage than to dwell on corrective actions.

It is further assumed that closure requirements are the same for abandoned facilities and active facilities.

Since RCRA mandates the closure of all open dumps (illegal facilities) closure costs were considered to be Federally induced.

(2) Facility Location

In order to assess the impact of the floodplains and the wetlands component of the surface water criteria, assumptions had to be made regarding the number of facilities located in wetlands and floodplains. The basic assumption is that:

- The number of facilities located in wetlands and floodplains is a function of the percentage of each State's population living in wetlands and floodplains, since waste generation and industry activity are generally correlated with population centers or concentrations.

Thus, if 30% of the population within a given State lives in floodplains and wetlands, then the assumption was made that 30% of the landfills in that State were located in floodplains and wetlands. In each State, the number of facilities in floodplains was determined as follows:

Number of facilities in floodplains =

$$\frac{\text{(State Floodplains Population)}}{\text{(Total State Population)}} \times \text{Total number of facilities}$$

For each State, the number of facilities in wetlands was determined as follows:

Number of facilities in wetlands =

$$\frac{\text{(State Wetlands Population)}}{\text{(Total State Population)}} \times \text{Total number of facilities}$$

The methodologies for determining the State floodplains and wetlands population is given in the Data Base Calculations section.

(3) Facility Size

The Waste Age survey breaks facility sizes into six categories. For ease of computation, these facility sizes were grouped into three categories and a modal value chosen for each category, as follows:

Waste Age Categories (tons/day)	New Categories (tons/day)	Modal Value in TPD
0-50	0-50	10
50-100) 100-200	50-200	100
200-500) 500-1000) 1000)	200	300

(4) Data Base Calculations

Data base calculations were designed to provide information on a State-by-State basis for a number of facilities by category (permitted, authorized, illegal); by size (10 TPD, 100 TPD or 300 TPD); by type (industrial or municipal): and by location (in or out of floodplains and wetlands). Once these calculations were made, they were used for determinations of cost. The following steps detail the methodological approach.

- Facilities by Location

  The number of facilities located in or outside of floodplains and wetlands was based on the assumption that the number of facilities located in floodplains and wetlands is a function of the percentage of each State's population living in floodplains and wetlands. The following methodologies were to determine the State population in these areas:

For floodplains:

1. Determine urban floodplains land area by multiplying 19.8% (Schaeffer and Roland, Inc., Ref. 151) by the total urban land area by State as provided by 1972 Bureau of Census data.

2. Multiply urban floodplains land area by the urban population density as determined from census data, to obtain urban floodplains population.

3. Determine rural floodplains land area by subtracting urban floodplains land area from total floodplains land area.

4. Multiply rural floodplains land area by rural population density as determined using census data to obtain rural floodplains population.

5. Add rural and urban floodplains populations to obtain national floodplains population.

6. Use State populations as provided in 1972 Bureau of the Census data to determine the percentage of the national population in each State.

7. Use floodplains land area for each State (as provided by Federal Insurance Administration data) to determine the percentage (for each State) of the national floodplains land area.

8. Find average of the #6 and #7 above for each State.

9. Apply average in #8 to national floodplains population to determine State floodplains population.

10. Determine percent of total State population in floodplains.

11. Apply percentage to total number of facilities in State to determine number of facilities in floodplains.

For wetlands, a similar approach was taken:

1. Determine urban wetlands land area by multiplying 19.8% (Schaeffer and Roland, Inc., Ref. 151) by the total urban land area and by .5 (to account for the floodplains/wetlands overlap).

2. Multiply urban wetlands land area by urban population density (as determined using 1972 Bureau of the Census data) to obtain urban wetlands population.

3. Determine rural wetlands land area by subtracting urban wetlands land area from ½ the total wetlands land area as provided in the 1954 National Wetlands Inventory of the U. S. Fish and Wildlife Service.

4. Multiply rural wetlands land area by rural population density to obtain rural wetlands population.

5. Add total and urban wetlands populations to obtain national wetlands population.

6. Use State populations as provided in the 1972 Bureau of Census data to determine the percentage of the national population in each State.

7. Use the wetlands land area for each State as provided by the 1954 National Wetlands Inventory of the U.S. Fish and Wildlife Service to determine the percentage (for each State) of National Wetlands land area.

8. Find average of #6 plus #7 for each State.

9. Apply average in #8 to national wetlands population to determine State wetlands population.

10. Determine percent of total State population in wetlands.

11. Apply percentage to total number of facilities in State to determine number of facilities in wetlands.

For example, the following data are provided:

- Total land area in U.S. = 3,536,855 sq. mi.
- Urban land area in U.S. = 55,047 sq. mi.
- Rural land area in U.S. = 3,481,808 sq. mi.
- Total population in U.S. = 203,211,926
- Urban population in U.S. = 149,324,930
- Rural population in U.S. = 53,886,996
- Floodplains land area in U.S. = 148,985 sq. mi.
- Wetlands land area in U.S. = 117,574 sq. mi.

Therefore,

- Urban population density = 2,713 per sq. mi.
- Rural population density = 15 per sq. mi.

Using the given data and methodology:

- Urban floodplains land area in U.S. = 10,899 sq. mi.
- Urban floodplains population in U.S. = 29,568,987
- Rural floodplains land area in U.S. = 138,086 sq. mi.
- Rural floodplains population in U.S. = 2,071,290
- Total floodplains population in U.S. = 31,640,277
- Urban wetlands land area in U.S. = 5,450 sq. mi.
- Urban wetlands population in U.S. = 14,785,850
- Rural wetlands land area in U.S. = 53,337 sq. mi.
- Rural wetlands population in U.S. = 800,055
- Total wetlands population in U.S. = 15,585,905

For States A and B, the following data are given:

- Population in State A = 3,000,000
- Population in State B = 15,000,000
- Floodplains land area in State A = 5,000 sq. mi.
- Floodplains land area in State B = 3,000 sq. mi.
- Wetlands land area in State A = 700 sq. mi.
- Wetlands land area in State B = 1,000 sq. mi.

Applying all data provided, the following figures are derived using the above methodology:

State	% of U.S. Population	% of U.S. Floodplains	% of U.S. Wetlands	State Floodplains Population	State Wetlands Population
A	1.5	3.4	1.2	791,007	218,203
B	7.4	2.0	1.7	1,487,093	716,952

- Facilities by Location by Type

  To determine the number of on-site industrial landfills in each State, the following methodology was used:

The number of establishments for each two-digit SIC industry group for each State is available in the 1972 Census of Manufacturers, compiled by the U.S. Bureau of Census. These numbers are divided by the total number of establishments nationwide to yield the percentages of the total number of each industry group within each State. These percentages are applied to the total number of on-site industrial landfills by size, as determined in the Hart study, for each industry group to determine the total number of on-site industrial landfills by size and industry group for each State. For example, if the total number of on-site industrial landfills nationwide is 90,000 and the following information is provided by the Census of Manufacturers:

STATE	SIC GROUP	NO. OF ESTABLISHMENTS
National	20	8000
	21	1200
	22	3000
	23	2400
	Others	6000
XYZ	20	200
	21	30
	22	150
	23	300 300
	Others	78

Then, the percentages of the total number of establishments nationwide in State XYZ are:

SIC GROUP	PERCENTAGE
20	2.5
21	2.5
22	5.0
23	12.5
Others	1.3

Applying these percentages to the total number of on-site industrial landfills for each 2-digit SIC industry nationwide, yields:

SIC GROUP	NO. OF ON-SITE LANDFILLS, NATIONAL	%	NO. OF ON-SITE LANDFILLS IN STATE XYZ
20	6,186	2.5	155
21	60	2.5	2
22	1,584	5.0	79
23	5,376	12.5	672
Others	62,499	1.3	812
TOTAL	75,705		1,720

To determine the number of municipal landfills by State, the 1977 update to the 1976 Waste Age Survey was used. The survey lists the total number of facilities per State.

The next step was to allocate the municipal and on-site industrial landfills to wetlands and floodplains. This was done by applying the percentage of the State's population in these areas to each State's landfill data base.

Floodplains:

On-site industrial landfills x % State floodplain population = number of on-site industrial landfills in State's floodplains

Municipal landfills x % State floodplain population = number of municipal landfills in State's floodplain

TOTAL = Total number of State's landfills in floodplains

Wetlands:

On-site industrial landfills x % State wetlands population = number of on-site industrial landfills in wetlands

Municipal landfills x % State wetlands population = number of municipal landfills in State's wetlands

TOTAL = Total number of State's landfills in wetlands

- Facilities by Location by Type by Size

  Next, the number of industrial and municipal facilities both in and out of floodplains and wetlands, according to size, was determined. This was done using the *Waste Age* survey for municipal landfills and the Fred C. Hart Associates study (Ref. 141) for on-site industrial landfills.

  For example, for a given State, the *Waste Age* survey supplies the following numbers:

Distribution	0-50	50-100	100-200	200-500	500-1000	1000
Number of Facilities	255	25	15	4	1	0

Using the new facility size categories, the following data were generated:

Distribution	0-50	50-200	200
Modal Value	10	100	300
Number of Facilities	255	40	5

The number of landfills in and the number outside of the State's floodplains and wetlands were developed assuming 20% of the State's population lives in each of these areas;

Facility Size	10 TPD	100 TPD	300 TPD
Raw Data	255	40	5
Facilities in Wetlands	51	8	1
Facilities in Floodplains	51	8	1
Other Facilities	153	24	3

The Fred C. Hart Associates study (Ref. 141)supplies numbers of on-site landfills by size and by industry group. The Hart size categories, 0-50 TPD, 50-200 TPD, and 200 TPD, were converted to the modal values previously discussed, as follows:

		NUMBER OF ON-SITE LANDFILLS		
		0-50 TPD	50-200 TPD	200 TPD
SIC CODE	INDUSTRY	(10 TPD)	(100 TPD)	(300 TPD)
20	Food Processing	6,186	14	-
21	Tobacco	60	-	-
22	Textile	1,584	-	-
23	Apparel	5,376	-	-
24	Wood Products	7,466	3	-
25	Furniture	2,031	-	-
26	Paper & Allied Prod.	1,328	-	-
28	Chem. & Allied Prod.	4,527	43	-
29	Petroleum	403	-	-
30	Rubber & Plastics	-	-	-
31	Leather	160	-	-
32	Stone, Clay	3,518	5	-
33	Primary Metals	1,346	13	-
34	Fabricated Metals	6,479	16	-
35	NonElectrical Mach.	28,554	-	-
36	Electrical Mach.	-	-	-
37	Transportation Equip.	1,905	31	-
38	Prof. & Scientific Inst.	1,316	-	-
39	Miscellaneous Manuf.	3,341	-	-
	TOTAL	75,580	125	-

- Number of Facilities by Location, Type, Size and Category

  The next step was to determine the number of municipal landfills that are permitted, authorized, and illegal.

For a given State, the following were derived from the 1977 update to the 1976 Waste Age survey:

State XYZ - Permitted Facilities, 94
Authorized Facilities, 108
Illegal Facilities, 98

What was not known was how many of these types of facilities are in each category. This was determined by assuming that the type of landfill by size is a function of the percentage of landfill types divided by the total number of landfills, times the number of facilities by size. The computational formula for this is:

$$\text{Percentage of sanitary landfills or authorized or illegal} = \frac{\text{number of sanitary, authorized or illegal landfills}}{\text{total number of landfills}}$$

$$\text{Number of landfills by category and size} = \frac{\text{no. of sanitary, authorized, or illegal landfills} \times \text{no. of facilities by size}}{\text{total number of landfills}}$$

This was done for landfills located both in and out of floodplains and wetlands. Thus, for a given State, the following was generated:

Sanitary landfills = 31.3%
Authorized landfills = 36.0%
Illegal landfills = 32.7%

This information was used in conjunction with knowledge of the number of facilities by size to obtain:

Areas

All	Percentage	10 TPD	100 TPD	300 TPD
Sanitary	31.3	80	13	1
Authorized	36.0	92	14	2
Illegal	32.7	83	13	2
TOTAL	100%	255	40	5

Floodplains

Sanitary	31.3	16	2	-
Authorized	36.0	18	3	1
Illegal	32.7	17	3	-
TOTAL	100%	51	8	1

Wetlands

Sanitary	31.3	16	2	-
Authorized	36.0	18	3	1
Illegal	32.7	17	3	-
TOTAL	100%	51	8	1

- Cost Calculations

Cost calculations were based upon a State-by-State assessment of upgrading needs. For each criterion, unit costs for the best available technology were developed according to facility size. Cost calculations were based upon the following formula:

Costs = (quantity)x(price)x(applicable numbers of facilities by size)

In this formula, quantity refers to the amount of control technology needed (i.e., the square feet, cubic yards, lineal feet, etc.)

State costs were developed by summing costs for each criterion; national costs were developed by summing all State costs on a criterion-by-criterion basis.

- Combined Cost

Costs were assessed on the following basis:

$\Delta B1$ = Federal Costs (difference between State standards and Federal criteria)

$\Delta B2$ = Costs to upgrade or comply with State standards for surface water and ground water

$\Delta B3$ = Costs to close an illegal facility

N1 = Number of permitted municipal facilities

N2 = Number of authorized municipal facilities

N3 = Number of illegal municipal facilities, exclusive of those in floodplains and wetlands

N4 = Number of on-site industrial landfill facilities

- Permitted Facilities

Costs = $N1 (\Delta B1)$

- Authorized Facilities

Costs = $N2 (\Delta B2) + N2 (\Delta B1) = N2 (\Delta B1 + \Delta B2)$

- Illegal Facilities

  Costs = N3 (ΔB3)

- On-Site Industrial Landfill Facilities

  Costs = N4 (ΔB1) + N4 (ΔB2) = N4 (ΔB1 + ΔB2)

- Total Combined Costs

  N1 (ΔB1) + N2 (ΔB1 + ΔB2) + N4 (ΔB1 + ΔB2) + N3 (ΔB3)

- Federally Induced Costs vs. State-Standard-Induced Costs

  - When State standard meets Federal criterion:

    State Standard-Induced Costs = N2 (ΔB1 + ΔB2) + N4 (ΔB1 + ΔB2)

    Federally Induced Costs = N3 (ΔB3)
    (closure)

  - When State does not meet Federal criterion:

    Federally Induced Costs = N1 (ΔB1) + N2 (ΔB1+ B2)+ N4 (ΔB1+ΔB2)

    Federally Induced Costs = N3 (ΔB3)
    (closure)

2. Methodology and Assumptions for Surface Impoundments

   a. Data Source

This methodology is predicated on data from an EPA report, USEPA Contract No. 68-01-4342: Surface Impoundments and Their Effect on Ground Water in the United States (Ref. 107). In addition to the above, The Ground Water Report to Congress (Ref. 7) provided necessary information.

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*Closure costs are included in costs for floodplains and wetlands for facilities sited in these areas. Facilities which are closed but where not located in these areas were not attributed to any specific criterion but to the criteria in general.

b. Assumptions and Other Data Considerations

(1) Impact Receptors

For purposes of this analysis, the following types of surface impoundments were considered:

Municipal surface impoundments
Industrial surface impoundments
Agricultural surface impoundments

Information as to the number of facilities by State within each of these groupings came from the Surface Impoundments report referenced above (Ref. 107), as well as updates provided by the States through contacts made by the EPA regional offices.

(2) Applicable Criteria

Only the criteria for ground water, floodplains, surface water (wetlands), and the access component of the safety criteria were considered to have economic impacts. The following assumptions were made:

- Costs incurred for the point source provisions of the surface water criteria were more appropriately a function of the NPDES program. The nonpoint source provisions were more appropriately a function of groundwater considerations. For these reasons, only impoundments located in wetlands incurred any costs attributable to the the surface water criteria.

- No open burning at surface impoundments occurs on a regular basis as a means for volume reduction of waste.

- The disease aspects of these criteria were assumed not to be problems at surface impoundments.

- Not enough information exists on the land application of surface impoundment wastes. It was assumed that this was not a viable practice.

- The gas control, fire, and bird hazards to aircraft components of the safety criteria were considered to have a minimal economic impact on surface impoundments because these factors are more likely a problem with nonliquid organic wastes.

(3) Regulatory Alternatives

More and less restrictive alternatives were considered for the ground-water, surface water (wetlands), and floodplains criteria. No alternatives were considered practical by EPA for the access component of the safety criteria because of the need to ensure protection of the public.

(4) Technologies and Cost Considerations

To upgrade facilities to meet the ground-water criteria, facility lining with imported clay was deemed to be the most appropriate maximum technology. This technology represents a compromise between the costs of two other applicable technologies--lining with onsite clay, and lining with a synthetic membrane. Costs for ground-water quality monitoring were also considered. Access considerations were considered to be met through use of a minimal perimeter gate and fence.

Closure costs for the surface water (wetlands), ground water, and floodplains criteria included only costs for closure of the facility. This was based on the following assumptions:

- Facilities forced to close in wetlands and floodplains do so because of their location in these areas, and their inability to meet the costs for compliance in these areas.

- Facilities may be forced to close by the ground-water criteria because of the high cost of compliance in some cases.

- Technology costs for all other criteria will include those facliities located in wetlands and floodplains, inclusive of those facliities closed, because they will be relocated in an acceptable manner in wetland and floodplain areas.

For purposes of assessing costs, assumptions had to be made as to facility sizes and configurations. Table B4 summarizes the assumption regarding surface impoundment size. The following assumptions were made:

- 100% of all municipal and agricultural facilities, and 95% of all industrial facilities are 2.5 acres.

- 5% of all industrial facilities are 50 acres.

TABLE B-4

SURFACE IMPOUNDMENT SIZE DATA

Size:	Hectare	1	20
	(acre)	(2.5)	(50)
Edge*:	Meters	107	457
	(feet)	(350)	(1500)

*The impoundments are square and the edge distance is that used for fence and levy lengths.

The assumptions were based on the presumption that virtually all municipal and agricultural activities requiring the use of surface impoundments would be on a small scale. This same presumption was applied to industrial activity, however, there is a need in the industrial area for some large impoundments. No data exists which provides an accurate assessment of these groupings. Flow data alone is inadequate, as the size necessary to accomodate a particular flow is more appropriately a function of geologic conditions.

Furthermore, because no detailed accurate data exists on the condition of facilities, the following assumptions were made:

- To meet the alternatives for the ground water criteria, 50% of the facilities were upgraded with maximum technology; 50% also received ground-water quality monitoring. Five percent of the total were assumed to require closure.

This assumption was based upon an assessment of the industrial studies provided in Appendix C.

- To meet the alternatives for floodplains and surface water (wetlands), 2/3 were upgraded or closed; 5% were considered for closure. For the more restrictive alternatives, 100% were closed.

The assumptions for the final alternatives were based on a presumption that the same percentage of surface impoundments that were inadequate to effectively control groundwater contamination, would be inadequate to comply with the wetlands and floodplains criteria.

- To meet the access component of the safety criteria, which remains the same for all alternatives, 25% of the facilities were upgraded.

This assumption was based on the presumption that most surface impoundments located in populated areas would have controlled access in order to ensure against the likelihood of liability for damages resulting from uncontrolled access. Furthermore, it was presumed that many impoundments in unpopulated areas would not be required to control access at this time, given their limited or nonexistent exposure to unauthorized persons.

c. Data Base

(1) Facility Sizes, Conditions and Locations

Supplementing the above assumptions concerning facility sizes and facilities in need of upgrading, was information relating to the numbers of facilities by type, by State, and by location.

Information regarding the number of surface impoundment facilities by type was obtained from the Geraghty and Miller report (Ref. 107) and from updates provided by the States through the EPA regional offices.

The total number of surface impoundments in each State was determined by multiplying the number of facilities within each type (municipal, industrial, agricultural) by a factor of 2.5. This factor was chosen because most estimates place the actual number of impoundments as two or three times greater than the number of sites (Ref. 107).

The number of surface impoundments, by State, for each type that was apportioned to the average surface impoundment size categories, was determined by applying the estimated percentage of each type of surface impoundments which fall within each size category. For example, if it is determined that 95% of all industrial surface impoundments are two acres, and 5% are fifty acres, then 95% of the industrial impoundments in State A are 2.5 acres, 5% are fifty acres.

The total number of surface impoundments for each size category was determined by summing the size categories within each State for each type of impoundment. For example, the total of State A's five acre impoundments will be the sum of the five-acre impoundments in the municipal, industrial, and agricultural categories for that State.

The number of surface impoundments for each State by size located in floodplains was determined by applying the percentage of the State's population living in floodplains to the total number of surface impoundments by size, as discussed above. The percentage of those facilities which require closure was applied to the number of impoundments in floodplains to determine the number of surface impoundments in floodplains to be closed. The remainder required upgrading to comply with this criterion.

This same methodology was used to determine the number of facilities by size located in wetlands, and to determine the number requiring closure and upgrading.

The data base for determining compliance costs for all criteria, except floodplains and surface water (wetlands), was the total surface impoundment data base. For floodplains and wetlands, the data base was those facilities located in these areas.

d. Cost Calculations

Criteria costs were assessed on the following basis:

Cost = (number of facilities to be upgraded) x (cost to upgrade) + (number of facilities to be closed) x (cost to close)

e. Combined Cost

(1) Combined Costs = (number of facilities to be upgraded for ground-water criteria in wetlands) x (cost to upgrade) + (number of facilities to be upgraded for groundwater criteria in other areas) x (cost to upgrade) + (number of facilities to be upgraded for floodplains and surface water (wetlands) x (cost to upgrade) + (number of facilities to be closed for ground-water criteria) x (cost to close) + (number of facilities to be closed in floodplains and wetlands) x (cost to close) + (number of facilities to be upgraded for the access component of the safety criteria) x (cost to upgrade).

(2) Federally Induced Cost vs. State- StandardInduced Cost

In order to assess cost distributions, State solid waste regulations were analyzed; if the State's floodplains, surface water (wetlands), ground-water, and access component of the safety criteria regulations were as stringent as the Federal criteria, then costs were considered to be State-induced. All others are Federally induced.

3. Methodology and Assumptions for the Landspreading Analysis

The cost methodology used to develop the national costs of the regulation for landspreading is a step-by-step analysis which: screens for what categories of costs should be considered (e.g., going to alternative disposal methods, increased monitoring and surveillance); estimates, nationally, the number of facilities which landspread and the amount of sludge which these facilities landspread; and finally, factors these estimates to assess the incremental national costs (i.e., beyond current practice) which can be expected if either the proposed or selected alternative regulations are applied on a national scale.

NOTE: For simplicity, all final and interim final rules promulgated in the Federal Register on September 13, 1979 (44 Federal Reg. 53438) are identified in this EIS as "final" regulations. However, it should be noted that the criteria for Application to Land for the Production of Food-Chain Crops and Disease--Sewage Sludge and Septic Tank Pumpings (under Section 257.3-5 and 257.3-6(b), respectively) are of an interim final status.

As Figure B-1 indicates, the methodology is organized into five activities. Within each activity, simplifying assumptions have been made. An effort was made, however, to avoid assumptions which would understate nationwide costs. These five activities can be summarized as follows:

- Defining Cost Considerations. Segments of the environment were reviewed to see where the regulations would have cost impacts: environmentally sensitive areas (floodplains), surface water, ground water, air, land, safety, and health (disease). Only the costs of (1) protecting surface and ground water from excessive nitrogen contamination, and (2) protecting humans and grazing animals from excessive ingestion of heavy metals (cadmium) and organics (PCB's) were determined to have the potential to contribute significantly to the national cost of regulation.

- Developing Regulatory Alternatives. The final regulation and three alternatives were proposed to control sludge to food-chain land. Each alternative was designed to achieve a different degree of protection for the segments of the environment discussed above; the final regulations, a less restrictive alternative, a more restrictive alternative, and a most restrictive alternative. The requirements of the final regulation and the three alternatives are discussed in detail in Chapter III.

- Estimating Sludge Quantities and Qualities. For each regulatory alternative and the final regulation, the following parameters were calculated for publicly owned treatment works (POTW's) where data is available and where landspreading is currently practiced:

    - Total annual metric tons of sludge which are currently landspread

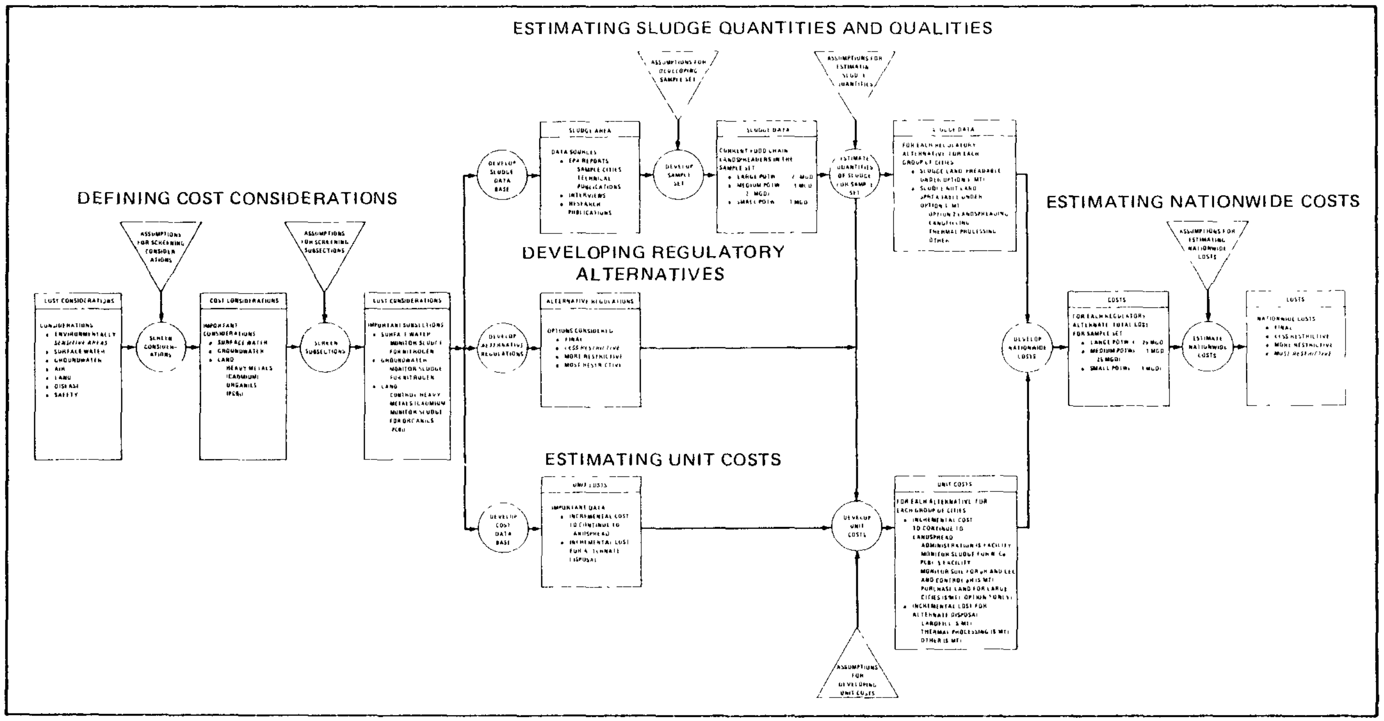
    - Total annual metric tons which are/are not landspreadable under the annual cadmium limitations of the alternative regulations

    - Projected life of disposal facilities used by POTW's under a worst-case cumulative cadmium limitation.

  Appendix F lists these POTW's.

- Estimating Unit Costs. The unit costs to comply with the regulations in order that landspreading may continue and the unit costs to select an alternative

FIGURE B-1
Methdology for Developing the Costs of
Landspreading Regulations



method where landspreading cannot continue were estimated. All unit costs were based on a cost per ton of disposed sludge or a cost per facility.

- Estimating National Costs. The final component of the cost methodology tied together the previous four components. Unit costs of disposal were applied to the quantities of sludge which could/could not be landspread under the mandates of each of the four alternatives. The results, a cost of regulation for the sample set of POTW's, was then extrapolated to the national level to produce national cost estimates. The national costs were further analyzed for their impacts on residential sewer charges.

The following discussion focuses on these five activities in sequence. For each activity, all assumptions are discussed in detail.

a. Defining Cost Considerations

Seven segments of the environment were screened to determine the relative cost impact of the landspreading regulations: environmentally sensitive areas (floodplains), surface water, ground water, air, land, safety, and disease. Only in the protection of surface water, ground water, and land were the costs of regulation nationally significant and quantifiable. Since the regulations do require measures to protect air quality and environmentally sensitive areas and to control pathogens, the result may be additional treatment costs incurred by certain facilities. However, in most cases no additional costs will be incurred, and thus their national impact will be insignificant. The regulations which protect human safety are being addressed in other sections of this environmental impact statement and are not included in the cost methodology.

In the second step of the screening, three subcomponents of surface and ground-water protection were evaluated for expected cost impacts: monitoring the sludge for nitrogen prior to land application, monitoring the surface and ground water after application, and controlling the movement of pollutants after application. Where high water tables or topographical features make adverse effects likely, the criteria require that best agricultural management practices are to be used to prevent ground- and surface water contamination. Facility operators in such cases will incur moderate additional costs. However, because the sludge is assumed to be applied at a rate necessary to satisfy the nitrogen demands of the crops, and because this application rate is generally quite low, water pollution from sludge application is unlikely. Therefore, costs for pollution control and water quality monitoring are assumed to be neglible nationwide and are not included in the analysis. However, the cost of monitoring the nitrogen in the sludge prior to application will be incurred by all municipalities and is quantifiable. This cost is included in the analysis.

Two subcomponents of land protection were also evaluated in the second screening; heavy metals and organics application. The methodology includes the costs associated with regulating cadmium additions to the soil and the costs for monitoring sludge for polychlorinated biphenyls (PCB's).

b. Developing Regulatory Alternatives

The final regulation and three alternatives were examined for regulating the application of sludge to food-chain land. Each alternative was designed to achieve a different degree of protection for the segments of the environment discussed above. The requirements of the final regulation and the three alternatives are discussed at length in Chapter III.

c. Estimating Sludge Quantities and Qualities

The estimation of sludge quantities and qualities is based on EPA case study data on sludge handling practices by POTW's across the nation. This methodology assumes that the sample set is representative of all POTW's landspreading sludge in the nation. The POTW's included in the sample set are listed in Appendix F.

For each regulatory alternative, for each POTW in the sample set, the following estimates were made:

- Tons of sludge which are currently being spread to food-chain land
- Tons of sludge which could/could not be spread to food-chain land under the annual cadmium limitations of the final regulation
- Tons of sludge which could/could not be spread to food-chain land under the annual cadmium limitations of the alternative regulations.

In order to reflect different operating characteristics and economics of scale, the sludge data were disaggregated according to POTW size:

- Small POTWs ($<$ 1 mgd)
- Medium POTWs ($\geqslant$ 1 mgd, $\leqslant$ 25 mgd)
- Large POTWs ($>$ 25 mgd)

Five key assumptions made in the analysis are discussed below:

(1) <u>Accounting for Changes in the Quantity and Quality of Sludge</u>

The methodology assumes that the quantity of sludge being generated remains constant throughout the planning period. Furthermore, the methodology assumes that, except for the effects of pretreatment, the amount of cadmium in the POTW influent remains constant. Both assumptions are not necessarily valid for all POTWs in the nation. As more secondary treatment is brought on line, and removal efficiency increases at a given POTW, more sludge will be generated. As process changes take place within an industry, the use of cadmium may decrease and a given POTW may experience a decrease in the amount of cadmium in its influent. The pending U.S. EPA-Department of Defense agreement for reviewing defense specifications on cadmium is an example of how the demand for cadmium may decrease in the planning period. At the present time, the net effect of changes in sludge generation and influent characteristics is difficult, if not impossible, to predict. Thus, the methodology made these two assumptions.

(2) Estimating the Effects of Pretreatment Guidelines

The analysis makes two key assumptions concerning the effectiveness of pretreatment in reducing cadmium in municipal sludge:

> In POTW sludge where cadmium levels are high, the cadium is assumed to be approximately 60% industrial in origin. Estimates of industrial cadmium origin reach as high as 90 percent, with the remainder attributed to residential and commercial discharges, urban runoff, and natural background concentrations. (Ref. 195) However, the data are limited and suggest a wide variance between sites. For the purpose of this analysis, a conservative estimate of 60 percent is employed to minimize the projected effects of industrial pretreatment, thereby maximizing the cost of the landspreading regulations.
>
> Pretreatment guidelines will reduce the industrial contribution by 80 percent beginning July 1, 1984. Pretreatment guidelines for the electroplating industry are expected to reduce cadmium from that industry by as much as 85 percent by July 1, 1984. While pretreatment guidelines for other key industries have not yet been developed, removal efficiencies could be in this same range for most industries and most metals (Ref. 196).

Assuming that a one percent reduction in influent cadmium corresponds to a one percent reduction in sludge cadmium content, these assumptions translate into approximately a 50 percent average reduction in cadmium in municipal sludge after industrial pretreatment (80% x 60% 50%).

(3) Selecting Appropriate Sludge Application Rates

The analysis was based on a sludge application rate of 10 metric tons per hectare (mt/ha) on the conservative assumption that this is the lowest economically viable rate. Should some POTW's spread at a higher rate, this assumption would overstate the cost of regulation.

(4) Estimating the Impacts of Cumulative Cadmium Limitations

This analysis assumed that the quantity of sludge being landspread would be unaffected by the cumulative limitations in the regulation. Rather, when the cumulative limit is reached at a given disposal facility, the methodology assumes that the POTW will continue disposing of sludge at an alternative facility at no additional cost. The validity of this assumption is supported in the results presented by the economic impact analysis.

(5) Defining Practical Alternate Methods of Disposal

The final regulation and the less and more restrictive alternatives permit POTW's to select either of two optional schemes for the application of sludge to food-chain land. (The most restrictive alternative requires the elimination of all food-chain landspreading.) The cost methodology assumes that if a large POTW is precluded from option 1 landspreading due to the high cadmium content of its sludge, it will elect to continue landspreading under option 2. The methodology assumes, however, that small and medium facilities will abandon landspreading altogether and select an alternative method of disposal. These assumptions are made because the option 2 landspreading regulations are tailored to large POTW's capable of developing and administering a responsible plan, and would be prohibitive for most small and medium facilities. Nevertheless, some of these smaller facilities may select option 2, and to this extent the cost of the regulation is overstated. For the purpose of this analysis, the sludge which can no longer be landspread is distributed among alternative disposal methods according to the proportions currently devoted to those methods by each plant size category. These percentages were derived from the data presented in Figure D-1 in Appendix D, and are presented in Table B-5.

d. Estimating Unit Costs

Unit costs are developed in Table B6 for two mutually exclusive costs incurred by a POTW because of the regulations:

TABLE B-5

Projected Disposition of Sludge Which is Precluded from Option 1 Landpsreading by Annual Cadmium Limitation

Disposal Option	Small POTW's (All Alternatives)	Medium POTW's (All Alternatives)	Large POTW's	
			Less, Final, More Restrictive Alternative	Most Restrictive Alternative
Option 2 (%)	0	0	100	0
Landfill (%)	87	65	0	47
Thermal Processing (%)	0	21	0	47
Other (%)	17	14	0	6

TABLE B-6
Annualized Unit Costs: Food-Chain Landspreading and Alternate Disposal

DISPOSAL METHOD	SMALL POTW (< 1 mgd)	MEDIUM POTW (≥ 1 mgd, ≤ 25 mgd)	LARGE POTW (>25 mgd)
OPTION 1 FOOD-CHAIN LANDSPREADING			
. Administration ($/facility)[1]	1296	1728	4320
. Sludge Monitoring ($/facility)[2]	120	120	530
. Soil pH Monitoring and Control ($/mt)[3]	5/10/15	5/10/15	5/10/15
PRECLUDED FROM OPTION 1 LANDSPREADING			
. Option 2 Food-Chain Landspreading			
- Administration ($/facility)[1]	N/A	N/A	4320
- Sludge Monitoring ($/facility)[2]	N/A	N/A	120
- Soil pH Monitoring and Control ($/mt)[3]	N/A	N/A	5/10/15
- Land ($/mt)[4]	N/A	N/A	24
. Landfilling ($/mt)[5]	50	37	24
. Thermal Processing ($/mt)[6]	N/A	79	47
. Other			
- Composting ($/mt)[7]	N/A	N/A	60
- Non-Food-Chain Spreading ($/mt)[8]	50	44	34
CURRENT LANDSPREADING PRACTICES[9]			
. Food-Chain Landspreading ($/mt)	51	46	36
DEWATERING[10]			
. With Landfilling, Thermal Processing, Composting ($/mt)	58	46	32

TABLE B-6 (Continued)

1. Unit Costs are based on:
   - Small plant - 3 days/month for 6 months, 8 hours/day, $9/hr.
   - Medium plant - 4 days/month for 6 months, 8 hours/day, $9/hr.
   - Large plant - 10 days/month for 6 months, 8 hours/day, $9/hr.

2. Cadmium, lead, nitrogen, pesticides and persistant organics are to be monitored at each facility. Monitoring requirements and associated unit costs for large and small and medium facilities are summarized in the following table. he frequency of monitoring for organics (PCB's) by large cities is assumed to be 1 sample every 5 years. (Monitoring for organics (PCB's) if only required under Option 2 of the regulations and only large cities select Option 2.)

SLUDGE MONITORING COST

Analysis	Unit Cost ($/Sample	Frequency of Sampling #1 Year	
		Large Cities	Small and Medium Cities
Cadmium	10	8	2
Lead	10	8	2
Nitrogen	40	8	2
Organics (PCBs)	250	1	N/A

3. Lime addition for pH adjustment based on 1.0 ton/acre of lime to raise pH from 6.0 to 6.5. (This is equivalent to 2.25 mt/ha.) Agricultural lime cost was assumed to be $49/mt, thus a cost of $87.70/ha. At a sludge application rate of 10 mt/ha, this is $8.77/mt of sludge. This value was increased to $10/mt to cover miscellaneous realted testing and sampling costs. The less restrictive requirement (pH from 6.0 to 6.2) was assumed as being .5 tons lime/acre or using the same procedure as above $5/mt. Similarly, the more restrictive pH adjustment (from 6.0 to 7.0) was assumed to cost $15/mt.

4. Land costs vary widely across the nation, and estimating an average cost per hectare is extremely difficult. However, for the purposes of this analysis, an average unit cost of $5000 per hectare was selected. Assuming that an average of 225 kg/ha of nitrogen can be used as fertilizer, and assuming one third of the nitrogen applied to the land is lost either to the atmosphere or elsewhere, an average of 336 kg/ha of nitrogen must be applied to the land to meet the needs of an average crop. Assuming that sludge is 1 percent plant available nitrogen, 1

hectare requires 33.6 mt of sludge to fulfill its nitrogen needs. Combining this requirement with the cost of $5000 per hectare, the annualized cost of land is $24/mt. Only cities selecting Option 2 of the regulations are assumed to purchase the land prior to the spreading of sludge. Since it was assumed that only large cities select Option 2, no land cost is presented for small cities.

5. Landfill estimates include transportation costs, and are based on the best available data, which is rpesented in Process Design Manual Municipal Sludge Landfill, U.S. EPA Technology Transfer, October, 1978, EPA 625/1-78-010. Errors in this document have been noted and compensations have been made in this cost methodology.

6. These estimates include the average cost of incineration and heat treatment. For incineration, the estimates assume a 20% filter cake, and do not include ash disposal. For heat treatment, recycle treatment and odor control are included. The estimates are based on the best available data presented in Effects of Thermal Treatment of Sludge on Municipal Wastewater Treatment Costs, Ewing, L. J., et. al., for the U.S. EPA Municipal Environmental Research Laboratory, Cincinnati, June, 1978, EPA 600/2-073.

7. For composting, no hauling costs are included. This data was taken from "Sewage Sludge Composting," Sludge Treatment and Disposal. Chapter 8, by G. M. Wesner, for U.S. EPA Technology Transfer, October, 1978, EPA 625/4-78-012.

8. Non-food-chain landspreading costs were assumed to be equal to food-chain landspreading costs with surface application with subsequent incorporation into the soil. See footnote 9.

9. Due to the large number of system variables and the wide range of values possible for each of these variables, single unit costs for land application of sludge are extremely difficult to obtain. Or rather, they are difficult to transfer from one system to another. These variables are as follows:

   Climate: Temperature, rainfall patterns
   Soils: Clay, loam, sand
   Type of Transport: Truck, pipeline, rail, barge
   Application Method: Injection, liquid spray (truck or sprinkler), dewatered
   Incorporation Method: None, disking, plowing, injection
   Distance from Plant to Site: Less than 5 miles to 100 miles
   Local Health Requirements: Restrictive loading rates, constraints on incorporation methods, treatment requirements prior to land spreading, etc.

TABLE B-6 (Continued)

Most equipment or processes used in wastewater and sludge treatment are mechanical and are not as susceptible to local conditions as transport and disposal systems.

For this study three types of land application systems were chosen: injection, surface spreading with incorporation into the soil, and surface spreading without incorporation into the soil. The unit costs presented in Table V-6 are a weighted average of the unit costs for these three systems, based on the following assumptions regarding current practices:

- 20% injection
- 40% surface application with incorporation into the soil
- 40% surface application without incorporation into the soil

The unit costs for a liquid injection system assume one-way transport distances of 5, 10, and 20 miles for the three size ranges of treatment plants. The small facilities' costs were based on using the same truck for hauling and injecting. The medium and large facilities costs were estimated with pipelines used for transport. The second set of unit costs are based on surface spreading liquid sludge at a high rate <u>with</u> incorporation by disking or plowing at a later time. The same assumptions are used for haul distances and modes of transportation. The third set of limit costs are based on surface spreading liquid sludge at a high rate <u>without</u> incorporation into the soil. Again, the same assumptions discussed above are used for haul distances and modes of transport. All costs are based on 1, 10, 25 mgd facilities to represent the three sizes of POTW's, under consideration:

- <u>Injection</u>
    - Small Facility: $38/mt injection plus $24/mt hauling = $62/mt (same truck to haul and inject, 6% solids "Big Wheels" type injection system)
    - Medium Facility: $16/mt injection plus $39/mt pipeline = $55/mt (6% solids, "Big Wheels" type injection system)
    - Large Facility: $16/mt injection plus $29/mt pipeline = $45/mt (6% solids, tractor-towed injection system)

TABLE B-6 (Continued)

. Surface Landspreading with Plowing or Disking After Spread

- Small Facility: $50/mt haul and spread with same truck
- Medium Facility: $5/mt spread/disk-in plus $39/mt pipeline
- Large Facility: $5/mt spread/disk-in plus $29/mt pipeline

Surface Landspreading Without Plowing or Disking After Spread

- Small Facility: $47/mt haul and spread with same truck
- Medium Facility: $3/mt spread plus $39/mt pipeline
- Large Facility: $3/mt spread plus $29/mt pipeline

Transport costs are from: Transport of Sewage Sludge, U.S. EPA Office of Research and Development, Cincinnati, December, 1977, EPA 600/2-77-2/6.

10. Dewatering Costs assume vacuum filtration. Estimates are based on data presented in Municipal Wastewater Sludge Alternatives, Prepared by G. L. Culp and D. J. Hinrichs, for the U.S. EPA Technology Transfer, National Conference on 208 Planning and Implementation, January, 1977, (1.25 multiplier used to convert to current dollars).

- Costs to comply with the regulations in order that landspreading activities may continue under Option 1

- Costs to utilize an alternate method of disposal if the annual cadmium limitations preclude continued landspreading under Option 1.

All values are based on 1978 dollars, and capital investments are included by assuming a ten year planning period and a ten percent interest rate.

The goal of the economic analysis is to define the incremental unit costs associated with the regulations. The incremental unit costs can be developed from Table B-6 for the three cases of concern as follows:

- Option 1 Landspreaders. The incremental unit costs incurred by a POTW which continues to landspread are those unit costs listed in Table B-6.

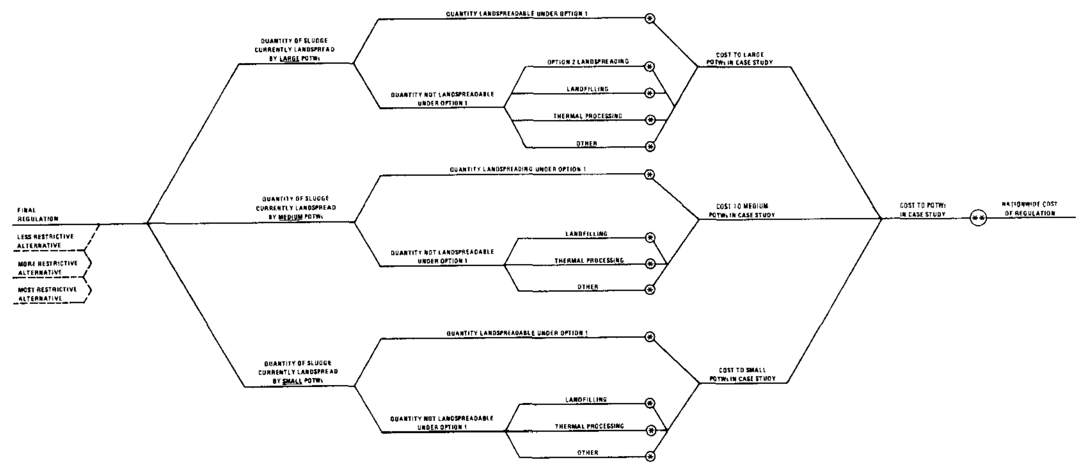
- Option 2 Landspreaders. The incremental unit costs incurred by a POTW which switches to Option 2 landspreading are those unit costs listed in Table B-6.

- Landfill, Thermal Processing, Other. The incremental costs incurred by a POTW which switches to an alternate method of disposal can be derived from the unit costs listed in Table B-6. The incremental unit cost associated with each alternative is the sum of the unit cost of the new disposal method plus the unit cost of dewatering minus the unit cost of the current landspreading practice. (The fact that a given POTW is forced to stop an existing practice results in an effective cost savings to that POTW. Hence, the cost of the current landspreading practice must be subtracted from the cost of the new disposal method.)

e. Estimating National Costs

The final component of the cost methodology ties together the previous four components and results in an estimate of the national costs of the final landspreading regulations and three alternate regulations. Figure B-2 illustrates the sequence in which these costs were developed.

FIGURE B-2
Sequence for Developing
The National Cost of Regulation



* Application of unit costs to calculate cost for the sample set.
** Application of scale-up factor to extrapolate to the nationwide cost.

The methodology assumes that, because the data base used in the analysis accounts for only 38 percent of all sludge estimated to be landspread, a national projection of costs could be derived by multiplying the cost to the sample set by a factor of 2.6 (100/38). National projections include a fixed cost per facility, multiplied by the number of facilities in the sample set, multiplied by the 2.6 scale-up factor. Although the numbers of large and medium facilities are fairly representative of their proportion of the national total, the projected number of small facilities currently food-chain landspreading is understated. Hence, while an attempt has been made throughout the analysis to forecast the maximum cost of the regulations, the cost to small facilities and to the nation may in this regard be understated by several hundred thousand dollars on a nationwide basis.

Unlike surface impoundments and landfills, landspreading is not yet subject to formal regulations in most States. For the purpose of this analysis, State-standard-induced costs were assumed to account for 10 percent of the total regulatory cost. The remaining 90 percent was assumed to be induced by the federal regulations, i.e., Federally induced.

The projected nationwide costs of the four regulatory alternatives were further analyzed for impacts on residential sewer charges. The results are based on a telephone survey of all POTWs in the sample set which are currently spreading sludge to food-chain land. The survey determined, for each POTW contacted:

- the existing residential sewage treatment charge
- the number of residential users
- the proportion of total wastewater influent generated by residential users.

For each regulatory alternative, the incremental costs to the POTW were calculated according to the post-regulatory disposal option, based on whether the POTW could continue landspreading under Option 1, or must adopt an alternative disposal method. Several critical assumptions were made in this analysis:

- If not precluded from Option 1 landspreading, a POTW will continue landspreading, but must bear additional administrative, monitoring, and soil pH control costs. If precluded from Option 1, the POTW must bear the additional costs of an alternate disposal method.

- The incremental unit costs presented in Table B-6 are applicable to the POTW's surveyed. Case studies of the incremental costs of disposal were not made for each POTW surveyed. The methodology assumes that case-by-case divergences will be offsetting in the aggregate.

- Incremental costs to a POTW are paid by households in proportion to the quantity of wastewater generated by all residential users served by that POTW. In practice, because utility rate structures often favor large industrial users by charging a lower average fee, residential users are likely to pay more than this proportion. The assumption of proportional payment is made here to simplify the analysis by avoiding detailed studies of industrial cost recovery systems on a case-by-case basis.

Based on the number of residential users supporting a given POTW, the proportion of wastewater generated by them, and the incremental unit cost data, a projected incremental cost per household was computed and compared to the existing charge per household to determine the percent increase.

4. Methodology and Assumptions for the Industry-by-Industry Analysis for the Manufacturing Industries

a. Data Source

The Fred C. Hart Associates, Inc. study, "The Technology, Prevalence and Economics of Landfill Disposal of Solid Waste", was used as the base source of data for industrial on-site landfills. In addition, the 1972 Census of Manufacturers, compiled by the U.S. Bureau of the Census, provided data on numbers of industrial establishments by two-digit SIC code. For data on industrial surface impoundments, the Geraghty & Miller report, Surface Impoundments and Their Effect on Ground Water Quality in the United States (Ref. 107) was used.

b. Assumptions and Other Data Considerations

(1) Impact Receptors

For purposes of this analysis, the following manufacturing industrial groups were considered:

	On-site Landfills	Surface Impoundments
SIC 20 - Food Processing	X	X
SIC 21 - Tobacco	X	-
SIC 22 - Textile Mill Production	X	X
SIC 23 - Apparel	X	-
SIC 24 - Wood Products	X	X
SIC 25 - Furniture	X	-
SIC 26 - Paper Products	X	X
SIC 28 - Chemicals Products	X	X
SIC 29 - Petroleum	X	X
SIC 30 - Rubber & Plastics	-	X
SIC 31 - Leather	X	X
SIC 32 - Stone, Clay	X	X
SIC 33 - Primary Metals	X	X
SIC 34 - Fabricated Metals	X	X
SIC 35 - NonElectrical Machinery	X	X
SIC 36 - Electrical Machinery	-	X
SIC 37 - Transportation Equipment	X	X
SIC 38 - Instruments	X	X
SIC 39 - Miscellaneous Manufacturing	X	X

This information was obtained from the above referenced reports.

(2) Applicable Criteria

The criteria which were determined to have economic impacts were the same as those considered relevant for the landfill and surface impoundment assessments discussed above. The assumptions for these criteria remain the same as well. For the ground-water criteria, because it affects disposal facilities differently based on the rate of infiltration in individual States, the following methodology was applied:

- The number of establishments of each relevant industry segment in each of the net infiltration States was totaled, as were those in the negative infiltration States.

- Each of these groups was expressed as a percentage of the national population.

- These percentages were applied to the landfills for each industry to determine the number of facilities affected by the ground-water compliance scenario.

(3) Technologies and Cost Considerations

For purposes of assessing the costs to the manufacturing industries, the following assumptions were made:

- All onsite industrial landfills required upgrading for compliance with each of the criteria, except for the disease criterion, the toxic and explosive gases components of the safety criteria, and the ground-water criteria.

- 10 percent of the on-site industrial landfills were upgraded for the disease vectors criterion and the gas components of the safety criteria.

- All wetlands facilities were upgraded for the groundwater criteria. Fifty percent of those landfills in net infiltration areas were upgraded; fifty percent of the total surface impoundments were upgraded.

- No on-site industrial landfills were considered for closure.

- Two-thirds of the industrial surface impoundments in floodplains and wetlands required upgrading or closure. Five percent of the total located in these areas were closed.

- Twenty-five percent of the industrial surface impoundments were upgraded for the access component of the safety criteria.

c. <u>Data Base and Costs</u>

(1) On-Site Industrial Landfills

The following methodology was used to determine the costs of upgrading all on-site industrial landfills on an industry-by-industry basis to meet the Federal criteria.

The Fred C. Hart Associates, Inc. study (Ref. 141) provides the number of on-site industrial landfills by size category for each relevant (as determined by the Fred C. Hart Study) two-digit SIC manufacturing industry.

Based on the assumption that all on-site industrial landfills need upgrading, the compliance costs for each industry may be found using the following calculation:

$$\text{Costs for Industry X} = (\text{number of facilities}_{10TPD} \times \text{upgrading costs}_{10TPD})$$
$$+ (\text{number of facilities}_{100TPD} \times \text{upgrading costs}_{100TPD})$$
$$+ (\text{number of facilities}_{300TPD} \times \text{upgrading costs}_{300TPD})$$

(2) Surface Impoundments

The Geraghty & Miller report (Ref. 107) provides, by industry, the total number of surface impoundments for each relevant industry. The percentage of the total number of industrial surface impoundments provided by this report was applied to the total number of industrial surface impoundments obtained through State revisions to provide a revised number of surface impoundments for each industry.

These impoundments were divided into the two size categories for each industry. Ninety-five percent were in the 2.5 acre size category, and five percent were in the 50 acre size category.

Costs were assessed based on the following, for each relevant criterion:

Cost for Industry X = (number of impoundments needing upgrading x cost to upgrade) +
(number of impoundments needing closure x cost to close)

(3) Total Costs

Total costs were assessed by adding the cost for landfills and surface impoundments for each industry. Further, these costs were expressed as a percentage of total annual sales for each industry, based on Bureau of Census (Ref. 150) data.

APPENDIX C

SELECTED INDUSTRIAL STUDIES

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C. INDUSTRY SPECIFIC STUDIES

The following chapter examines the cost impact of Section 4004 of the Resource Conservation and Recovery Act (RCRA) on three selected industries: 1) mining; 2) coal-fired utilities; and 3) iron and steel. These three sections were independently researched as part of ongoing EPA inhouse and contract efforts concerning nonhazardous waste generation by specific industry sectors. Major characterization efforts began in 1978 to provide the Office of Solid Waste with information on industry characterization, waste characterization, current and future treatment/disposal practices, and the cost impact of Section 4004.

These three industries are the largest volume waste producing industries. Table C-1 shows the most currently available non-hazardous waste quantities for these industries. A detailed breakdown by industry segment and type of waste is available in each specific industry section.

The inclusion of this chapter in the economic impact analysis is intended to give the reader more detailed information on the impact of RCRA Section 4004 on these three industries. The assumptions and unit costs used are based on specific industry considerations, including knowledge of current and planned disposal practices and alternative control technologies available to meet specific 4004 criteria. Where practical, assumptions and unit costs agree with those utilized elsewhere in this economic impact analysis. However, certain instances do occur where major assumptions regarding the impact of the Criteria and unit costs for compliance differ based on specific industry information. These differences vary with each industry and are outlined in each industry section.

It should be noted that the control technologies in each chapter which are assumed to meet the Section 4004 criteria are not required technologies rather a set of alternative disposal options which would meet the performance standards set forth.

TABLE C-I

ESTIMATED NON-HAZARDOUS WASTE QUANTITIES
(million metric tons)

	No. of Plants	Total Annual Waste Generation
MINING	14,187	1,295
COAL-FIRED UTILITIES	399	65
IRON AND STEEL	150	50

Those costs are maximum costs based on immediate full compliance of industrial open dumps. It has been concluded that States will move in a voluntary manner utilizing available Federal funds to implement the criteria. Because the total amount of Federal funds a State will receive will be small compared to the total financial requirements necessary to implement the criteria, and because most States do not currently have the legislative or regulatory authority to permit or classify industrial solid waste disposal facilities, it has been concluded most States will focus first on landfill facilities receiving general municipal waste. It appears that States will need approximately 3 years to make classification determinations on just these facilities. Based on this trend it is difficult to predict the exact year of compliance and the number of industrial facilities which will upgrade or close.

The annualized solid waste disposal costs are shown in 1978 dollars. Annualized solid waste costs include the amortized portion of capital expenses plus annual operation and maintenance costs. The annuity factor used to amortize the capital for each industry segment may vary due to different costs of capital and life of the disposal facility. For example, while the economic impact analysis has assumed a 10 percent cost of capital and 10 year life for a disposal facility, a 16 percent cost of capital and 30 year life for a new coal-fired utility disposal facility is more realistic for this analysis.

It currently costs the coal-fired utility industry approximately 16 percent to raise capital through common stock, preferred stock, and public bonds. The life of a utility plant is approximately 30 years and it is assumed capital costs for the disposal facility will be amortized over this life.

These costs have been broken down by each criterion for each industry and total costs have been further analyzed to show the cost of compliance with existing state solid waste, other Federal regulations, and the criteria. As stated previously, state-induced costs represent estimated costs of complying with existing state standards for the control of non-hazardous wastes. Other Federally induced costs represent costs of complying with existing Federal regulations other than Section 4004. Criteria-induced costs are those costs of complying with Section 4004 that exceed the compliance cost for state and other Federal standards. The individual capital as well as annual operating and maintenance costs which comprise the annualized solid waste cost are shown in each specific section. The results of these studies are summarized in Tables VII-2 through 4.

Table C-2 shows the cost impact of Section 4004 on these three industries by criteria. A range of costs may appear because in some cases, two scenarios were costed out for wetlands. One scenario assumed all facilities currently disposing of their wastes in wetlands would not be issued NPDES permits. In this case, closure of existing facilities and the establishment of new sites outside the wetland area were costed out. The second scenario assumed all facilities would be granted NPDES permits. Here, additional technical requirements were considered necessary to meet the ground-water and surface water criteria, but no costs were attributed directly to the wetlands criteria. It should be noted here that the approach utilized in these selected industry studies varies from that previously employed in this document. Because two of the three industries affected by the wetlands criteria, -- mining and coal-fired utilities -- handle their own disposal operations and cannot depend on municipal or private facilities for disposal, denial of a NPDES permit would require closure of the existing facility and establishment of a new facility outside the wetlands area. The economic impact analysis, however, covered all national disposal and assumed, if sites in wetlands were closed, wastes could be diverted to existing facilities meeting the criteria. It was not possible to predict either the alternative disposal options available to these facilities or the number of new facilities that would be required.

Table C-3 breaks these total national costs down and indicates what portion of the total costs are attributable to existing state and other Federal regulations, and what portion are Federally induced costs.

Table C-4 indicates the increase in disposal cost per metric ton of waste along with the increase in cost per unit of product.

MINING INDUSTRY

The mining industry produced an estimated total of 1.3 billion metric tons of non-hazardous waste in 1975. Ten industries generated 91% of all non-hazardous mining solid wastes (excluding coal mining wastes). These ten industries are: copper, iron ore, molybdenum, gold, lead, zinc, phosphate, clay, stone, sand, and gravel. Table VII-5 indicates non-hazardous waste quantities from each industry.

It is estimated that it will cost the ten largest waste producing mining industries between a total of 467 million and 928 million dollars in annualized costs to meet the combined state, Federal and Section 4004 criteria. Between 183 and 635 million of these costs are attributable to existing state and other Federal regulations. The Federally induced portion of these costs range between 284 and 293 million. These are costs which will be incurred by the mining industry beyond their current solid waste expenditures to meet the floodplains, wetlands, closure, surface and ground-water requirements of Section 4004 for all facilities. The major assumptions used to derive these costs are listed below according to criteria.

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TABLE C-2

ESTIMATED COMBINED COST OF COMPLIANCE WITH

STATE AND OTHER FEDERAL REGULATIONS AND SECTION 4004

(1,000,000 Dollars)

INDUSTRY	GROUND WATER	SURFACE WATER	WETLANDS	FLOODPLAINS	CLOSURE	TOTAL
MINING	116-123	35-41	133	133	226	523-1,010
COAL-FIRED UTILITIES	85-105		44-101	30-40		159-246
IRON AND STEEL	30.7			.24	5.3	36.3

TABLE C-3

TOTAL COMPLIANCE COSTS AS ATTRIBUTABLE TO

STATE AND OTHER FEDERAL REGULATIONS AND SECTION 4004 CRITERIA

(1,000,000 Dollars)

INDUSTRY	TOTAL COMPLIANCE	STATE AND OTHER FEDERAL REGULATIONS	FEDERALLY INDUCED COSTS
MINING*	467-928	183-635	284-293
COAL-FIRED UTILITIES	159-246	120-195	39-51
IRON AND STEEL	36	29	7

*These costs include only those for the ten major mining industries. "Others" are not included.

TABLE C-4

ESTIMATED COMPLIANCE COST PER UNIT BASIS

(1,000 dollars)

INDUSTRY	TOTAL COST OF COMPLIANCE	$/METRIC TON OF WASTE	$/UNIT PRICE
MINING:[1,2]			
Copper	$ 48,039	$ 0.0801	$11.32
Iron Ore	63,820	.275	0.80
Molybdenum	2,231	.1101	22.42
Gold	5,185	.28	151,520.00
Lead/Zinc	1,325	.28	0.078
Phosphate	416,430	1.96	9.33
Clay	18,841	.52	0.47
Stone	27,560	.42	0.03
Sand and Gravel	339,140	9.44	0.48
COAL-FIRED UTILITIES[1,3]			
New Facilities (on line by 1985)	116,000	7.48	.20
Existing Facilities	130,000	2.00	.22
IRON and STEELMAKING[4]	36,275	0.49	0.07

1 These costs represent the highest costs, assuming NPDES permits are denied for disposal in wetlands.

2 The $/unit price reflects $/metric ton of product. For current produce value see page VII-59.

3 The $/unit price represents mills/kwh

4 The $/unit price represents $/metric ton of iron and steel.

Costs attributable to Section 4004 Criteria and other state and Federal legislation were determined by using the concept of a model plant because a detailed site-by-site study was not possible. It is recognized that many mines will not meet the model plant specifications; however, the costs derived through the methodology are assumed to be reasonable averages. Model plants were developed for each of the 10 major mineral industries. These plants represent a typical production level, with typical quantities of tailings and mine wastes generated. Model plants also reflect any current control methods to the extent that they are practiced within the industry. Most mining industries are now using some control technologies to satisfy at least some portion of the Section 4004 criteria.

The copper, iron ore, gold, lead/zinc, clay, and stone industries have minimal diversion ditching to prevent surface waters from reacting with overburden piles. These industries also have minimal closure practices for overburden, usually involving grading and revegetation. Twenty percent of the facilities in these mining industries are assumed to use diversion ditching and ten percent are assumed to use closure practices. It is assumed 80 percent of the molybdenum industry makes use of diversion ditches and 80 percent of the molybdenum and 80 percent of the phosphate industry commonly grade and revegetate their overburden. Unlined ponds are assumed to be the baseline controls used by clay, sand and gravel tailings. Minimal closure of tailings ponds is practiced by 10 percent of the clay, sand, and gravel industry.

The additional control technologies necessary to meet the Section 4004 Criteria were formulated and are discussed below along with the corresponding costs.

TABLE C-5

ESTIMATED MINING INDUSTRY PRODUCTION AND NONHAZARDOUS WASTE QUANTITIES (1,000 metric tons/year)

Mining industry	No. of mines	Product§§	Nonhazardous wastes**		
			Tailings	Mine wastes	Total
Copper	61	4,237		627,900	627,900
Iron ore	68	80,160		234,800	234,800
Molybdenum	3	55		10,740	10,740
Gold	99	0.021	2,740*	8,408	11,148
Lead/zinc	33/36	16,840		4,778	4,778
Phosphate	47	44,600	62,500¶¶	150,200§	212,700
Clay	1,249	39,770	2,275	33,760	36,035
Stone	5,584	815,400	Negligible	66,160	66,160
Sand and gravel	7,007	718,000	35,900	Negligible	35,900
Coal	6,459	573,300		¶	¶
Other††		829,000	21,840†	97,730@	119,570
Total			125,255	1,234,476	1,359,731

*Represents tailings from gold placer mining. Other gold mining tailings are considered hazardous.

†Fifty percent of tailings from other mining industries are considered to be nonhazardous.

§Thirty percent of all phosphate mine waste in Florida is considered hazardous (i.e., thought to contain radium 226 that emits radioactivity in excess of a proposed 5 picocurie per gram standard) and thus is not included in this number.

¶Coal mine wastes are regulated by the Surface Mining Control and Reclamation Act and were not considered in this study. The March 13, 1979, Federal Register contains the Permanent Regulatory Program of Surface Coal Mining and Reclamation Operations. Estimated costs of control methods for nonhazardous wastes from coal mining are presented in a report entitled "Permanent Regulatory Program of the Surface Mining Control and Reclamation Act of 1977, Final Regulatory Analysis (OSM-RA-1), March 1979."

@All mine wastes from other mining industries are considered to be nonhazardous.

**The quantities shown were taken from "Study of Adverse Effects of Solid Wastes from All Mining Activities on the Environment." The quantities represent 1975 statistics based on Tables 2 and 11 of the preprint from the 1975 Bureau of Mines Minerals Yearbook.

††Includes more than 20 industries.

§§These quantities represent the final products from the mining industries (e.g., concentrate from beneficiation plants) with the exception of gold which represents the pure product.

¶¶Represents sand tailings.

Ground Water

It was assumed the construction of diversion ditches would be sufficient to direct water away from overburden and waste rock disposal areas and protect the ground water.

In order to determine the control technologies required for industries which generate non-hazardous tailings, an evaluation of the water table is necessary to determine whether leachate from existing unlined tailings ponds would adversely affect the quality of the ground water. Regional percentages were calculated which reflect the percentage of land with high and low water tables. The degree to which a tailings pond will have an adverse impact on the ground water was determined by the region in which the industry is located. Tailings ponds located in geographical regions with low ground-water tables were assumed to need no additional controls to protect ground water.

A site evaluation consisting of a hydrogeological survey, permeability tests, evaluation and report would be necessary to determine the actual impact on ground water for tailings ponds in areas with high water tables. It is estimated that 80 percent of the site evaluations would show an insignificant impact, with the accompanying recommendation that monitoring wells should be installed and data collected quarterly at these sites. These wells would be installed as a precautionary measure to insure that no contamination occurs at a later time. It is assumed the remaining 20 percent of the evaluations would indicate significant ground-water impact, with the result that these sites would be required to install collection wells for the leachate to prevent ground-water contamination, and install monitoring wells in appropriate locations to perform quarterly checks of the leachate collection system.

It is estimated the total annualized cost for the mining industry to meet the state and criteria ground-water requirements is 116-123 million dollars. The distribution of the costs among the 10 major mineral industries can be seen in Table C-6.

Surface Water

It is assumed that the same construction of diversion ditches around mine waste piles used to protect ground water would also prevent surface runoff from interacting with the wastes and carrying them as suspended solids into surface water. These costs have been equally divided between the two criteria.

An unlined tailings pond is the current control technology for all mining industries producing non-hazardous tailings with the exception of gold placer mines located primarily in California and Alaska.

The cost of complying with the surface water criterion includes the construction of tailings ponds for the placer mine industry as well as the construction of diversion ditches around existing ponds and the upgrading of the existing pond dikes by compaction, soil coverage, and revegetation. The diversion ditches would direct waters away from tailings ponds to prevent the dikes from being weakened or washed out and reduce the chances of overflow.

It is estimated that the total annualized cost for the mining industry to meet the surface water criterion is approximately 35 million dollars. All these costs are attributable to the Clean Water Act. The distribution of the costs among the 10 major mineral industries is shown in Table C-6.

TABLE C-6

ESTIMATED TOTAL BASELINE AND GOVERNMENT-INDUCED COSTS BY INDUSTRY AND BY CRITERION (1,000 dollars)

Mining industry	Baseline costs[+]	Ground water NPDES permit granted	Ground water NPDES permit denied	Surface water NPDES permit granted	Surface water NPDES permit denied	Wetlands NPDES permit denied	Floodplains	Closure	Total NPDES permit granted	Total NPDES permit denied
		Costs attributable to government regulations (above baseline)*								
Copper										
Total capital	94	185	185	185	185			181,300	181,670	181,670
Annual O&M	8,239	10	10	10	10			21,150	21,170	21,170
Total annualized	2,250	37	37	37	37			47,770	47,844	47,844
Iron Ore										
Total capital	134	384	264	264	264	26,700	4,500	187,900	193,048	219,628
Annual O&M	1,028	33	14	14	14	15,800	224	18,580	18,851	34,632
Total annualized	1,044	85	50	50	50	19,200	823	43,740	44,698	63,863
Molybdenum										
Total capital	1,960	3	3	3	3			4,960	4,966	4,966
Annual O&M	129	1	1	1	1			630	632	632
Total annualized	369	1	1	1	1			1,230	1,232	1,232
Gold										
Total capital	6	1,947	1,947	5,286	5,286		1,044	5,297	13,574	13,574
Annual O&M	39	208	208	265	265		54	610	1,137	1,137
Total annualized	39	628	628	1,042	1,042		110	1,388	3,168	3,168
Lead/Zinc										
Total capital	26	65	52	52	52	30	419	3,628	4,164	4,181
Annual O&M	43	8	4	4	4	30	22	532	566	592
Total annualized	48	17	13	13	13	35	95	1,174	1,299	1,330
Phosphate										
Total capital	59	1,338	119	119	119	137,000	2,828	24,860	29,145	164,926
Annual O&M	7,435	181	7	7	7	383,400	141	3,730	4,059	387,285
Total annualized	7,445	418	28	28	28	407,300	650	8,130	9,226	416,136
Clay										
Total capital	46,800	17,515	9,109	18,317	4,003	16,320	7,891	18,240	61,963	55,563
Annual O&M	2,485	1,431	923	291	201	2,977	397	3,259	5,378	7,757
Total annualized	9,355	3,955	2,861	1,739	1,040	5,743	2,050	7,081	14,825	18,775
Stone										
Total capital	1,300	16,630	2,500	2,500	2,500	10,840	16,350	37,330	72,810	69,520
Annual O&M	600	1,988	125	125	125	5,000	822	6,671	9,606	12,743
Total annualized	734	5,559	650	650	650	7,200	4,250	14,500	24,959	27,250
Sand and gravel										
Total capital	380,200	310,800	310,800	101,830	87,970	60,590	345,100	289,800	1,047,530	1,094,260
Annual O&M	17,800	34,300	34,300	5,092	4,399	3,030	17,300		56,692	59,029
Total annualized	87,900	101,100	101,100	33,336	28,800	15,530	113,000	80,390	327,826	338,820
Other										
Total capital	43,060	35,103	32,500	12,643	10,040	25,150	37,810	75,330	160,886	180,830
Annual O&M	3,180	3,727	3,560	671	503	41,020	1,896	6,966	13,260	53,945
Total annualized	10,920	11,123	10,540	3,750	3,166	45,500	12,100	20,540	47,513	91,846
Total										
Total capital	473,639	383,970	357,479	141,199	110,422	276,630	415,942	828,645	1,769,756	1,989,118
Annual O&M	34,978	41,887	39,152	6,480	5,529	451,257	20,856	62,128	131,351	578,922
Total annualized	120,104	122,923	115,908	40,646	34,827	500,508	131,078	225,943	522,590	1,010,264

*In columns where numbers are left blank, the industries are not affected by these criteria
These costs do not include nonhazardous waste control costs for the coal mining industry
Note: Some total annualized cost numbers in this table and those shown in Table 5 are slightly different due to rounding component costs.

[+]These costs include estimated expenditures for stabilization of overburden returned to the mine site.

Wetlands Portion of the Surface Water Criteria

Two scenarios are considered for tailings and other mine wastes located in wetlands. One scenario assumes that NPDES permits will be granted to all mining industries located in wetlands, allowing solid wastes to be disposed of within the area. The second assumes that no NPDES permits will be granted and that all mining wastes generated in wetlands will have to be transported out of the area.

The specific industries located in wetlands were calculated from the percentages presented in Table IV-27 (Volume I) of this Environmental Impact Analysis. If additional information was available regarding the locations of these mineral industry facilities relative to the wetlands, it was used. For example, although 46 percent of Florida is wetlands, the majority of the Florida phosphate industry is located in these wetlands; therefore, it was assumed 90 percent would be affected by the wetlands portion of the surface water criteria.

It was assumed that if facilities were permitted to remain in the wetlands (Scenario 1), additional monitoring wells would be installed around mining waste piles as a precautionary measure. Dikes around tailings ponds permitted to stay in the wetland would upgrade into a 3:1 slope structure. It is estimated Scenario 1 will cost the mining industry approximately 13 million dollars in annualized costs to install these additional control technologies.

If the NPDES permit was denied (Scenario 2), the mine would be required to close the existing site, and purchase land for the construction of disposal facilities for tailings and mine wastes outside the wetlands. It is assumed wastes from all mining industries located in wetlands would be trucked a distance of 16 km. A distance of 32 km was assumed for wastes from the Florida phosphate industry.

Due to the distance involved, the tailings slurry would require thickening to a 70 percent solid before it is transported by truck.

The estimated cost to the mining industry for Scenario 2 is 500 million dollars in annualized solid waste costs.

Floodplains

Diking is the principal method selected to protect both tailings ponds and mine wastes from washout by the 100 year flood. For mine wastes, a 3 meter high, 3:1 slope dike would be constructed around accumulated plus newly generated waste. Based on a national average, it was assumed that three sides of a mine waste pile would require diking with the fourth side of the pile located against a natural barrier.

Dikes are the current control technology for tailings ponds. Measures necessary to prevent washout by the 100 year flood include upgrading of existing pond dikes to a 3:1 slope, compacting, covering these dikes with 0.6 meters of soil and seeding and fertilizing to prevent erosion.

It was assumed that 5 percent of all mining industries are located in floodplains. This is based on the estimated average percentage of land in the United States that is within floodplains. This average percentage figure is considered adequate since the location of mining operations is based solely on mineral deposits rather than proximity to the population, transportation or process requirements (such as large sources of water).

It is estimated that it will cost the mining industry 133 million dollars in annualized solid waste costs to comply with the floodplain criteria.

Air Quality

Current disposal practices were assessed for their impact on air quality. It was assumed that no additional controls would be necessary to protect air quality.

Mine wastes are not likely to pose an air quality problem and closure requirements would satisfy long-term protection against fugitive dust.

Tailings from clay, phosphate, sand, and gravel industries and newly built gold placer mine tailings ponds are or will be contained in small ponds and are nearly all located in non-arid regions. As a result, the pond surface remains wet a majority of the time due to the addition of new tailings and the fact that the precipitation rate exceeds the evapotranspiration rate for these areas. Other tailings ponds containing hazardous waste may have a fugitive dust problem but are not addressed in this report.

Closure

It is assumed that accumulated and newly generated non-hazardous mine waste will be closed with 15 cm of soil cover and that the soil will be revegetated. Regrading, compaction, soil coverage, soil amelioration and seeding would be required for the accumulated mining waste. Newly generated waste would be spread out, compacted, covered with soil, and revegetated on a continual basis. It is recognized that arid, barren areas of the country would not require top soil and full revegetation. Sand or similar cover and scrub brush would be sufficient. It is assumed the 15 cm of soil is a reasonable average cost.

Closure of tailings ponds includes dewatering of the pond, soil coverage, compaction and revegetation.

The estimated cost of closure is 226 million dollars on an annualized basis. This cost is high due to the large number of accumulated mining waste piles.

Combined Cost of Criteria

As previously stated, the range of costs for the entire mining industry to meet the combined State, Federal, and Section 4004 criteria is 523 million to 1.0 billion dollars. These costs are considered to be the maximum costs of compliance with Section 4004.

Certain costs could be reduced depending on the enforcement approach taken by the States and the adopted compliance schedule. Approximately 120 million dollars was included in the floodplain criteria costs for protection of clay, stone, and sand and gravel wastes against the 100 year flood. Because these wastes are present as natural constituents of riverbeds, these costs may not be incurred. In addition, closure costs, one of the highest individual criteria costs could be reduced if certain mine waste piles were allowed to remain as is in isolated and barren areas.

COAL-FIRED UTILITIES

The coal-fired utility industry produces two major streams of waste: ash and flue gas desulfurization (FGD) sludge. In 1977, approximately 62 million metric tons of ash and 2.5 million metric tons of FGD sludge were produced by approximately 400 plants producing approximately 200,000 MW of power. It is estimated by 1985 that the 350 new plants coming on line will increase this national total to 70 million metric tons of ash and 10 million metric tons of FGD sludge.

It was estimated that the utility industry will incur costs between 159 and 246 million dollars in annualized solid waste costs to upgrade existing facilities and build new facilities to comply with combined state, Federal and Section 4004 standards. The three criteria having the greatest impact on this industry are ground water, floodplains, and the wetlands portion of the surface water criteria. It is assumed that the industry is currently practicing closure of existing disposal facilities which comply with the Section 4004 closure requirements.

These national estimates were extrapolated from unit costs derived from a model plant approach. A 1000 MW capacity was used for this purpose. Average dollar per kw capital investment costs for solid waste disposal and dollar per ton annual operating costs from these model plants were developed based on average annual quantity of 187,000 metric tons of ash and 162,000 metric tons of sludge.

A power-rating-size cost adjustment factor was used to offset any economies of scale which may exist for new 1000 MW plants coming on line but not for existing plants with an average capacity of 500 MW. It was assumed a capital cost of $1.00/MW for a 1000 MW plant would equal $1.32 and an annual operating cost of $1.00/ton of waste would equal $1.39 for a 500 MW plant. An average of $1.35 was applied to annualized costs to more accurately reflect costs.

Utility wastes are ultimately disposed of in ponds or landfills which can be lined or unlined. Four disposal methods are assumed to be representative of current disposal practices for disposition of ash alone and ash in combination with FGD sludge. For utilities generating only ash, it is assumed 35 percent pond the ash and 51 percent landfill it. The remaining 14 percent of the industry incurs no cost for ash disposal since resource recovery is practiced. For utilities generating ash and FGD sludge, 54 percent are assumed to pond the combination and 46 percent are assumed to landfill it.

National solid waste disposal costs for new plants coming on line through 1985 are broken down to show cost of disposal attributable to current practices, costs attributable to existing state solid waste and other Federal regulations, and compliance costs with the Criteria. It is assumed the new plant's disposal facility will be built for the entire 30 year life of the utility.

Existing facilities are examined based on available data regarding current disposal practices. Estimates are made for the number of facilities failing the Section 4004 criteria. Average costs for closing and upgrading are developed. It is assumed existing disposal facilities are built in 10-year cells and that utilities have utilized 5 years of this 10 year life.

Ground Water

The control technologies assumed necessary to meet the ground water criteria are clay lining (.6 meters), monitoring wells and leachate collection and treatment facilities. It is assumed that 67 percent of all new facilities will require liners while the remaining 33 percent will locate land where natural conditions provide sufficient protection. It was assumed existing facilities lining their disposal sites or chemically fixing their FGD sludge will meet the ground water criteria. The remaining facilities were subject to the same 67 percent failure, 33 percent compliance probability.

It is assumed that monitoring wells will be installed at all new and existing facilities. Due to the large volume capacity and area of utility disposal facilities seven sampling wells are assumed per site. Quarterly sampling costs are included as are annual operating and maintenance cost.

Upgrading these existing facilities failing the ground-water criteria entails removal and temporary storage of existing waste as well as the purchase and placement of liner materials.

Annualized ground-water costs for the coal-fired utility industry were assumed to be $48 to $53 million for new facilities and $37 to $52 million for existing facilities.

The range exists for ground-water criteria because three scenarios were tested for compliance with wetlands portion of the surface water criteria. All facilities located in wetlands were assumed to be a total subset of the sites affected by the ground water criteria; therefore, assumptions concerning different closure options affected ground-water costs. As the distance from the plant to the disposal facility increases, capital and operating expenses increase. In addition, it is assumed the farther the facility is located from the plant, the higher the probability is for locating impermeable soil. It is assumed that for facilities moving 8 km from the plant, 50 percent will locate land with indigenous clay soil and 50 percent will require lining. For plants moving 16 km from the plant, it is assumed only one out of three will require lining. The various wetlands options also affect the floodplain criteria costs. It is assumed sites five to ten miles from the facility will not require protection against washout.

Wetlands

The degree to which coal-fired utility disposal facilities would be likely to locate disposal facilities in wetlands and violate surface water criterion was determined by using the Wetlands Map by U.S. Water Resources Council. Based on sample testing, it was assumed all facilities located in Arkansas, Florida, Georgia, Louisiana, North Carolina, North Dakota, South Carolina, South Dakota, Texas and Wisconsin would be affected by the wetlands provision and facilities in the remaining states would not. Approximately 60 plants or 20 percent (25,500 MW) of capacity coming on line by 1985 were determined to be located in these twelve wetlands states. It was estimated that approximately 115 utilities or 25 percent (50,000 MW) of existing sites were in these twelve states.

The distances from the plant these disposal facilities must move are unknown and will vary. Where wetlands are highly dense, it is assumed the disposal facility will be relocated 16 km from the plant; other sites in less dense wetlands areas are assumed to be able to locate disposal sites 8 km.

Three scenarios were examined for wetlands.

The first case assumed all facilities in wetlands would be denied NPDES permits and forced to move their disposal facility outside of the wetland, with 50 percent of these facilities moving 8 km from the plant and 50 percent moving 16 km.

The second scenario assumed sites located in Louisiana, Texas, Florida, North and South Carolina would be granted NPDES permits due to the ubiquitous nature of wetlands in these states. In this case, 35 of the 60 new facilities and 30 of the 115 existing sites will be granted NPDES permits. The remaining facilities in each case are assumed to move 8 km.

The last scenario examines the costs were all facilities granted NPDES permits. In this case no costs are incurred for the wetlands criteria. Technical costs for upgrading facilities remaining in the wetlands appear under the ground water criterion.

The total annualized cost for compliance with the wetlands portion of the surface water wetlands criteria ranges between 14 and 39 million dollars for new facilities and 30 and 62 million dollars for existing facilities. These are all costs attributable to the Clean Water Act.

Floodplains

It is assumed that 100 percent of all coal-fired utility disposal sites will be or are located in floodplains. A 3 meter dike is assumed to be a sufficient average height to protect against the floodwaters.

It is assumed that landfill disposal sites do not employ any controls against wash out by the 100 year flood; therefore, the entire cost of the dike will be a compliance cost assigned to the floodplain criterion.

Surface impoundments, on the other hand, are normally built with 2:1 sloped dikes to contain wastes. It is assumed that these dikes will be upgraded to a 3:1 slope to prevent weakening and erosion of the dike. This incremental cost is attributable to the floodplain criteria.

Total floodplain compliance costs for new and existing facilities are $ 30 to $40 million.

Combined Cost of the Criteria

As previously stated, the combined cost for the coal-fired utility industry will be between $159 and $246 million dollars in annualized solid waste costs. These are reasonable maximum costs based on the assumptions regarding the technologies necessary to bring existing and new sites into compliance with the criteria. These costs are based on full compliance of all open dumps and may be reduced depending on State action and compliance schedules. No unusual circumstances exist, such as the accumulated waste piles in the mining industry, whose costs could be eliminated to reduce these estimated any further.

IRON AND STEEL INDUSTRY

The iron and steelmaking industry produces an estimated 50 million metric tons of non-hazardous solid waste per year. However, due to commercial sale and/or in-plant recovery of over 60 percent of these solid wastes the industry disposes of only 16.5 million metric tons. Table C-7 shows the estimated quantities of non-hazardous solid waste generated and disposed of by the iron and steelmaking industry.

There are currently over 150 iron and steelmaking plants in the United States. It is estimated that it will cost this industry approximately $36 million in annualized costs to comply with state, Federal and Section 4004 criteria. The two criteria responsible for these costs are the ground water and--to a much lesser extent--floodplain criteria.

These costs were estimated by using a model plant with an annual raw steel production of 2.5 million metric tons and annual waste generation of approximately 305,000 metric tons. A landfill design life of 5 years was chosen to provide a representative basis from which to extrapolate steel industry disposal costs on a national basis.

The most common disposal practice in current use is to dump/landfill the various wastes. It was assumed that sites will not be closed and relocated as a result of the criteria. Existing sites failing the criteria will be upgraded as necessary. It is also assumed that 50 percent of the sites will remain onsite (on or adjacent to the plant ground) and 50 percent offsite.

It was assumed that approximately 15 percent of offsite iron and steel disposal sites (or 8 percent of all iron and steel disposal sites) are presently designed and operated in a manner which meets the Section 4004 criteria. The remainder will require upgrading to meet the ground water and floodplain criteria as discussed below.

Ground Water

The ground-water criteria will have the greatest impact on the iron and steel industry. It was assumed 100 percent of onsite and 85 percent of offsite disposal areas will require additional site controls to provide for ground water protection. Site preparation, land clearing, surface runoff, ditching, clay lining, leachate collection, monitoring wells, closure and revegetation are the additional costs to prevent ground water contamination.

The annualized costs for the steel industry to meet the ground water criterion are $36 million.

TABLE C-7

ESTIMATED ANNUAL QUANTITIES OF NON-HAZARDOUS SOLID WASTES GENERATED BY THE IRON AND STEELMAKING INDUSTRY in 1977
(Based on Raw Steel Production of 114 Million Metric Tons)

WASTE	GENERATION FACTOR kg/MT of process	QUANTITY GENERATED Thousand Metric Tons	WASTE DISPOSITION % Recycled or sold	WASTE DISPOSITION % Land-filled	QUANTITY LANDFILLED Thousand Metric Tons	POTENTIAL LEACHING constituent of concern[1]
SLAGS						
Blast Furnace	282.0	20,850	95%	5%	1,043	----------------
Basic Oxygen Furnace	145.0	10,204	50	50	5,102	----------------
Electric Furnace	120.0	3,042	20	80	2,434	----------------
Open Hearth Furnace	243.0	4,428	25	75	3,321	----------------
		38,524	69%	31%	11,900	
SCALES						
Soaking Pit	10.0	1,003	--%	100%	1,003	Chromium
Primary Mill	44.9	4,604	80	20	921	Oil, grease
Continuous Casting	8.7	100	80	20	20	Oil, grease
Hot Rolling Mill	10.3	710	80	20	142	Oil, grease
Cold Rolling Mill	0.1	1	60	40	---	Oil, grease
		6,418	67%	38%	2,086	
SLUDGES						
Blast Furnace	24.4	1,804	75%	25%	451	----------------
Basic Oxygen Furnace[2]	17.3	791	25	75	593	----------------
Electric Furnace	8.7	22	--	100	22	Oil, grease
Primary Mill	1.9	192	--	100	192	Oil, grease
Continuous Casting	0.1	1	--	100	1	Oil, grease
Hot Rolling Mill	1.7	68	--	100	68	Oil, grease
Cold Rolling Mill	0.2	3	--	100	3	Oil, grease
Tin Plating	5.3	31	100	--	31	Oil, grease
Galvanizing	10.8	63	100%	--%	63	Oil, grease
		2,975	56%	44%	1,330	
DUSTS						
Blast Furnace	16.2	1,198	85%	15%	180	Chromium, Lead '
Basic Oxygen Furnace[3]	16.0	394	25	75	295	----------------
Electric Furnace	12.8	292	10	90	263	Chromium, lead
Open Hearth Furnace	13.7	250	15	85	212	----------------
		2,134	55%	45%	950	
MISCELLANEOUS (Non-Process)						
Flyash[4]	87.2	198	--%	100%	198	----------------
Bottom Ash[4]	21.8	50	--	100	50	----------------
Rubble (brick, lumber, dirt, etc.)[5]	30.0	3,420	--	100	3,420	----------------
		3,668	0%	100%	3,668	
	TOTAL	53,471	63%	37%	19,934	

FOOTNOTES

1 The Toxicant Extraction Procedure has not yet been performed on steel mill wastes. Therefore, testing as performed by Calspan Corp, the Pennsylvania Department of Environmental Resources and the American Society for Testing and Materials was used as a basis for determining these potential lacking constituents of concern.

2 64% of Basic Oxygen Furnaces utilize wet emission controls, 35% utilize dry controls. Dust in the form of kisk will be generated whichever device is utilized.

3 Since 90% of electric furnaces utilize dry controls, assume that dry controls are used solely.

4 Generation factor in terms of kg of flyash/bottom ash per metric ton of coal fired. Assume: 2.5 million metric ton of coal consumed; b) ash content of 12%; c) 80% of ash discharged as flyash, 20% as bottom ash.

5 Generation factor is in terms of kg of rubble/metric ton of raw steel produced.

Floodplains

The floodplain criteria is assumed to affect 15% of onsite disposal areas (8% of the entire industry). The control technology required to protect against inundation by the 100 year flood is a 3 meter dike.

National annualized costs for the steel industry to meet the floodplain criterion are $274,000.

Closure

The iron and steelmaking industry does not currently practice closure and revegetation. However, this practice was assumed to be necessary for land reclamation as well as final ground water protection. Of the $36 million shown for annualized ground-water protection costs, $5.3 million covers closure and revegetation requirements.

Combined Cost of the Criteria

The total costs of $36 million in annualized costs is a reasonable maximum cost based on the stated assumptions regarding technologies necessary to bring iron and steel disposal facilities into compliance with the Criteria. The $36 million assumes immediate upgrading of disposal sites and is subject to change based on State action and compliance schedules.

B. A STUDY OF THE COST IMPACTS OF SECTION 4004 OF THE RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) ON THE DISPOSAL OF NON-HAZARDOUS WASTES FROM MINING

1. Summary

The main objective of this study is to present estimated total capital and annual operating costs of solid waste disposal technologies for mining industries that will satisfy the criteria set forth in Section 4004 of the Resource Conservation and Recovery Act (RCRA). This study partially satisfies Section 8002(f) of RCRA, the requirements of which are delineated in the following excerpt from Section 8002(f):

> The Administrator, in consultation with the Secretary of the Interior, shall conduct a detailed and comprehensive study on the adverse effects of solid wastes from active and abandoned surface and underground mines on the environment, including, but not limited to, the effects of such wastes on humans, water, air, health, welfare, and natural resources, and on the adequacy of means and measures currently employed by the mining industry, Government agencies, and others to dispose of and utilize such solid wastes and to prevent or substantially mitigate such adverse effects. Such study shall include an analysis of -
>
> (1) the sources and volume of discarded material generated per year from mining;
> (2) present disposal practices;
> (3) potential dangers to human health and the environment from surface runoff of leachate and air pollution by dust;
> (4) alternatives to current disposal methods;
> (5) the cost of those alternatives in terms of the impact on mine product costs; and
> (6) potential for use of discarded material as a secondary source of the mine product.

This study essentially fulfills analyses (2), (4), and (5) above and completes the requirements of Section 8002(f) by augmenting a recently completed comparison study, currently under final EPA review, entitled "Study of Adverse Effects of Solid Wastes from All Mining Activities on the Environment," prepared under EPA Contract No. 68-01-4700.

The author of this report used professional judgment to determine the split between hazardous and non-hazardous wastes. Any assumptions and estimates made were not intended to reflect EPA decisions regarding final classification of these mining wastes but were made for costing purposes. In addition, the author asserts that these mining wastes which it judges would fail the proposed hazardous characteristics, or which were included in the proposed hazardous wastes in the December 18, 1978, proposed hazardous waste regulations, were excluded from consideration in this study addressing the cost impact of Section 4004. The disposal technologies used in this report were not assumed to be the only design standards which meet the performance criteria for disposal of non-hazardous wastes under Section 4004, but were one set of alternative technologies which would meet the criteria.

This study focuses on the following 10 mining industries: copper, iron ore, molybdenum, gold, lead, zinc, phosphate, clay, stone, and sand and gravel. These 10 industries contribute about 91 percent of all the mining solid wastes assumed to be non-hazardous (excluding coal mining wastes), as shown in Table C-8. This table exhibits the quantities of non-hazardous wastes from each industry. All mine wastes (overburden and waste rock) from these industries are considered non-hazardous, with the exception of about 30 percent of the phosphate overburden generated in Florida, which is considered hazardous. (The hazardous designation is based on the criteria that the overburden contains radium that emits levels of radioactivity that exceed a proposed standard of 5 picocuries per gram. The value of 30 percent was estimated by the author based on information and a report entitled "Radioactivity of Lands and Associated Structures" from the University of Florida for the Florida Phosphate Council.) Only four

TABLE C-8

ESTIMATED MINING INDUSTRY PRODUCTION AND NONHAZARDOUS WASTE QUANTITIES (1,000 metric tons/year)

Mining industry	No. of mines	Product§§	Nonhazardous wastes**		
			Tailings	Mine wastes	Total
Copper	61	4,237		627,900	627,900
Iron ore	68	80,160		234,800	234,800
Molybdenum	3	55		10,740	10,740
Gold	99	0.021	2,740*	8,408	11,148
Lead/zinc	33/36	16,840		4,778	4,778
Phosphate	47	44,600	62,500¶¶	150,200§	212,700
Clay	1,249	39,770	2,275	33,760	36,035
Stone	5,584	815,400	Negligible	66,160	66,160
Sand and gravel	7,007	718,000	35,900	Negligible	35,900
Coal	6,459	573,300		¶	¶
Other††		829,000	21,840†	97,730@	119,570
Total			125,255	1,234,476	1,359,731

*Represents tailings from gold placer mining. Other gold mining tailings are considered hazardous.

†Fifty percent of tailings from other mining industries are considered to be nonhazardous.

§Thirty percent of all phosphate mine waste in Florida is considered hazardous (i.e., thought to contain radium 226 that emits radioactivity in excess of a proposed 5 picocurie per gram standard) and thus is not included in this number.

¶Coal mine wastes are regulated by the Surface Mining Control and Reclamation Act and were not considered in this study. The March 13, 1979, Federal Register contains the Permanent Regulatory Program of Surface Coal Mining and Reclamation Operations. Estimated costs of control methods for nonhazardous wastes from coal mining are presented in a report entitled "Permanent Regulatory Program of the Surface Mining Control and Reclamation Act of 1977, Final Regulatory Analysis (OSM-RA-1), March 1979."

@All mine wastes from other mining industries are considered to be nonhazardous.

**The quantities shown were taken from "Study of Adverse Effects of Solid Wastes from All Mining Activities on the Environment." The quantities represent 1975 statistics based on Tables 2 and 11 of the preprint from the 1975 Bureau of Mines Minerals Yearbook.

††Includes more than 20 industries.

§§These quantities represent the final products from the mining industries (e.g., concentrate from beneficiation plants) with the exception of gold which represents the pure product.

¶¶Represents sand tailings.

of the industries -- clay, sand and gravel, gold (placer mines only), and phosphate (sand tailings) -- generate non-hazardous tailings (beneficiation wastes). Non-hazardous wastes from all other domestic mining industries, constituting the remaining 9 percent of non-hazardous mining wastes, are shown in various tables in this study as "other industries." No hazardous wastes are addressed in this report.

The costs are divided, for each criterion, into national baseline costs; national state- and other Federally induced costs; and national 4004 (criteria induced) costs (Table VII-9). The baseline costs represent estimated costs of control methods already in use by the industry -- tailings ponds, diversion ditches, closure practices -- that satisfy or partially satisfy any of the six 4004 criteria. State-induced costs represent estimated costs of complying with existing state standards for the control of non-hazardous wastes; other Federally induced costs represent those of complying with Federal regulations other than RCRA. For example, the Clean Water Act of 1977 covers surface waters and the issuing of National Pollutant Discharge Elimination System (NPDES) permits to disposal sites located in wetlands; therefore, the costs of relocating a facility outside of a wetland area or protecting surface water are attributable to this Federal regulation. It should be noted that the costs of control methods for non-hazardous wastes from coal mining are regulated by the Surface Mining Control and Reclamation Act of 1977 (SMCRA); therefore, these costs are not included. Estimates of these costs are presented in a report entitled "Permanent Regulatory Program of the Surface Mining Control and Reclamation Act of 1977, Final Regulatory Analysis (OSM-RA-1)"; this report was prepared to support the final SMCRA regulations (Federal Register, March 13, 1979). Criteria-induced costs are those costs of complying with Section 4004 that exceed the compliance costs for state and other Federal standards.

TABLE C-9

ESTIMATED NATIONAL BASELINE AND REGULATORY COSTS FOR NONHAZARDOUS MINING WASTE CONTROLS (1,000 dollars)

Costs*	Ground Water: NPDES permit granted	Ground Water: NPDES permit denied	Surface Water: NPDES permit granted	Surface Water: NPDES permit denied	Wetlands: NPDES permit denied	Floodplains	Closure	Total: NPDES permit granted	Total: NPDES permit denied
National Baseline									
Total Capital	2,166	2,166	440,800	440,800			30,660	473,626	473,626
Annual O&M	111	111	22,410	22,410			12,420	34,941	34,941
Total annualized	411	411	98,530	98,530			21,150	120,091	120,091
National state- and other Federal-induced									
Total capital	317,800	295,900	141,200	110,500	276,600	208,300		667,300	891,300
Annual O&M	34,600	32,400	6,500	5,500	451,500	10,400		51,500	499,800
Total annualized	101,800	96,000	40,600	34,800	500,700	66,400		208,800	697,900
National criteria-induced									
Total capital	66,100	61,500				206,400	828,600	1,101,100	1,096,500
Annual O&M	7,300	6,800				10,300	62,130	79,730	79,230
Total annualized	21,100	19,900				66,500	225,900	313,500	312,300

*These costs do not include nonhazardous waste control costs for the coal mining industry.

Note: Cost numbers in this table are slightly different than total costs shown in Table 4 due to rounding component costs to four significant digits.

The three cost categories presented in this report are total capital, annual operation and maintenance, and total annualized solid waste disposal costs. The last is the sum of annualized capital and annual operation and maintenance costs.

As shown in Table C-9, baseline costs for ground water are minimal when compared with the costs induced by state and Federal regulations. Baseline costs for surface water, however, are considerably greater because of the surface water protection afforded by existing tailings ponds at mine sites. There are no baseline costs for floodplains and air quality because practically no controls are specifically in use to satisfy these criteria. Some industries do employ measures that satisfy the Section 4004 closure requirements; however, it is estimated an additional capital cost of $829 million would be required to meet the Section 4004 closure criterion. (Closure in this study includes soil coverage of a depth of 0.15 meter. If 0.6 meter of soil material is used, total closure costs are estimated at $1.84 billion.)

National baseline capital costs of non-hazardous waste control for all mining industries are estimated at $474 million. The annualized baseline control costs are an estimated $120 million. National state- and other Federally induced capital costs are estimated at $667 million if NPDES permits are granted for facilities located in wetlands and $891 million if these permits are not granted. Respective annualized costs are $209 million and $698 million. The total Section 4004 or Criteria-induced costs are estimated at $1.101 billion (NPDES permits granted) and $1.097 billion (NPDES permits denied). Respective annualized costs are $314 million and $312 million.

The NPDES permit granted scenario exhibits a higher Criteria-induced cost than the NPDES permit denied scenario due to additional environmental controls required in a wetland. The state- and other Federally induced costs, however, reflect the true costs of relocating outside of a wetland.

2. Development of Model Plants

Costs attributable to Section 4004 criteria and other state and Federal legislation were determined by using the concept of a model plant, because a detailed, site-by-site study was beyond the scope of this report. For each of the 10 major mineral industries, a model plant was developed that represented a typical production level and the quantities of tailings and mine wastes generated. Production levels were obtained from the Minerals Yearbook, and solid waste tonnages were obtained from available sources and contacts within the mining industries.[1,2]

Figures C-1 through C-9 display the model plant sizes used in the study. These model plants include various steps within the process that generate significant quantities of solid wastes. The horizontal arrows show the flow from mine site to usable product (e.g., concentrate for a smelter);vertical arrows show mine waste and tailings waste streams. The figures also reflect any current control methods to the extent that they are practiced within the industry. Each state was allocated a number of model plants based on the production levels for that industry within the state. These estimates were later used to allocate state-induced costs.

The model plant size for the copper industry (Figure C-1) was determined on the basis of the total solid wastes generated within the industry and from the fact that 25 out of 61 mines produce 93 percent of the Nation's copper.[2,3] The model plant, therefore, is a typical mine within the group of 25 major producing mines.

The iron ore model plant size (Figure C-2) was determined by the same method, but with only 68 mines producing all of the Nation's iron ore.[3]

All of the primary molybdenum ore is produced at three mines, and a model plant size was thus developed from information on actual tonnages obtained from the respective mining companies. The tonnages in Figure C-3 represent a molybdenum mine that uses both surface and underground mining methods.

The gold ore model plant size (Figure C-4) was based on the production figures for only those sites that mine gold as the principal ore: i.e., actual gold mines.

The lead/zinc industry model plant size (Figure C-5) was based on combined production levels for the two industries. It is an average of the model plant sizes for lead and zinc, as determined separately. The ore to product ratios for the lead and zinc industries shown in this model plant diagram are not meant to depict these ratios at an actual mine site; an average of a range of ratios for the two industries was chosen. The lead model plant size was based on 25 mines producing 99 percent of the Nation's lead, and the zinc model plant size was based on 25 mines producing 89 percent of the Nation's zinc ore.[3]

The clay model plant size (Figure C-7) was determined by two methods. Mine waste tonnage was calculated as the average of the total mine wastes produced at all clay mines. Tailings tonnage was calculated as the average from the production of kaolin and fuller's earth only, because these are the only clay processes that generate significant quantities of tailings.[4]

The model plant sizes for the remaining industries -- phosphate rock (Figure C-6; crushed, broken, and dimension stone (Figure C-8; sand and gravel (Figure C-9 -- were calculated as an average production size based on the total number of mine sites within the respective industries.

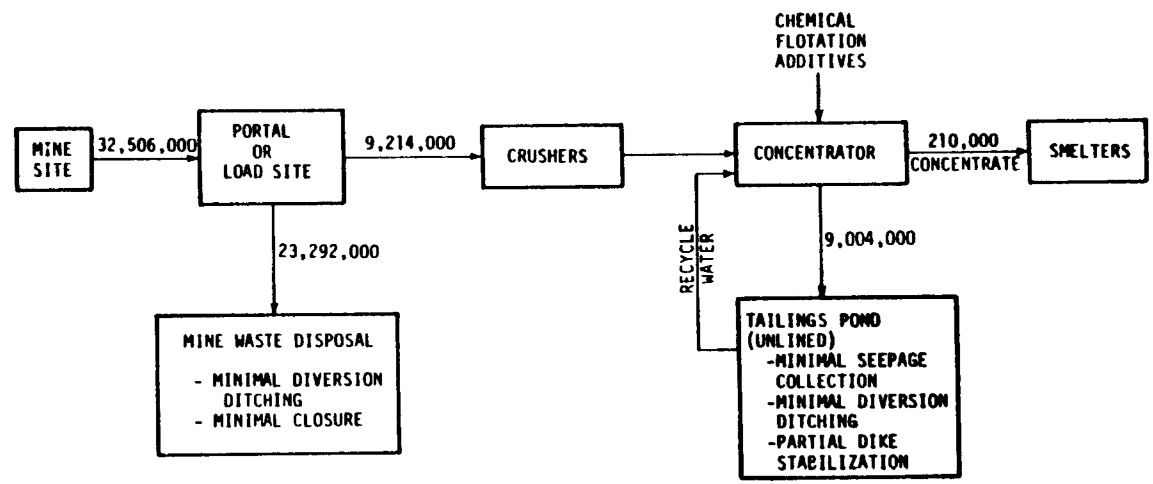
3. Baseline and Criteria-Induced Control Technologies for Tailings and Mine Wastes at Model Plants

Most mining industries are now using certain control technologies that satisfy at least some portion of the Federal Section 4004 criteria. These baseline controls are indicated on the model plant block diagrams for each industry (Figures C-1 through C-9). The copper, iron ore, gold, lead/zinc, clay, and stone industries have minimal diversion ditching to prevent surface waters from interacting with overburden piles. These industries also have minimal closure practices for overburden, usually involving grading and revegetation. "Minimal" diversion ditching and closure means that 20 percent (for ditching) and 10 percent (for closure) of the individual facilities within the industry are using these practices. Diversion ditching and closure of overburden primarily protect surface water from pollution by suspended solids.

The molybdenum industry makes extensive use of diversion ditches, which are present in about 80 percent of the industry. Both the molybdenum and phosphate industries commonly grade and revegetate their overburden. Phosphate mining companies in Florida reclaim all or nearly all of their overburden.

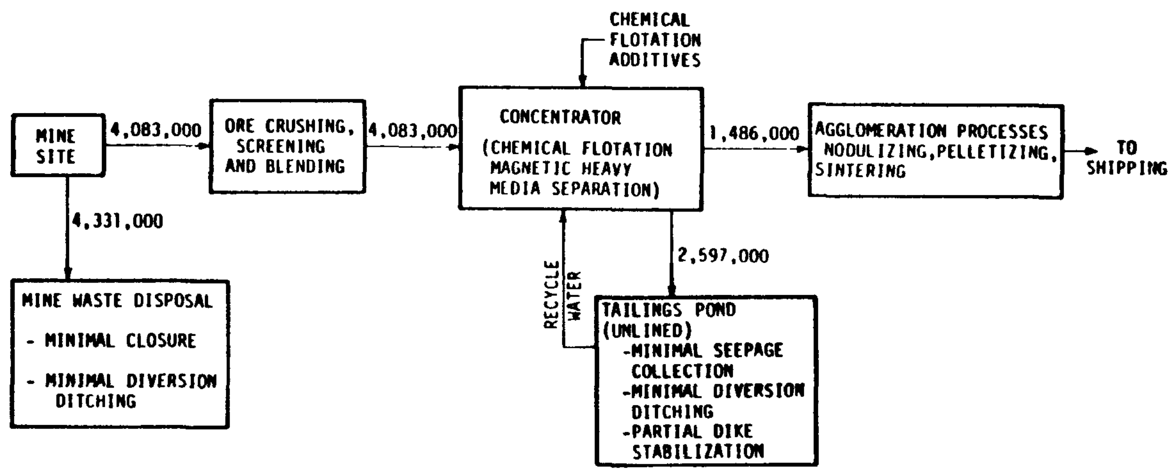
Unlined ponds are the baseline controls used in the (clay, phosphate, and sand and gravel industries. In addition to the ponds, the clay industry practices minimal closure for tailings. The stone industry produces negligible quantities of tailings and has not been considered in this study.

The additional control technologies necessary to meet the criteria of Section 4004 have been formulated and are shown in Figures C-10 through C-15. These various controls are discussed below in terms of the criterion to which they apply.



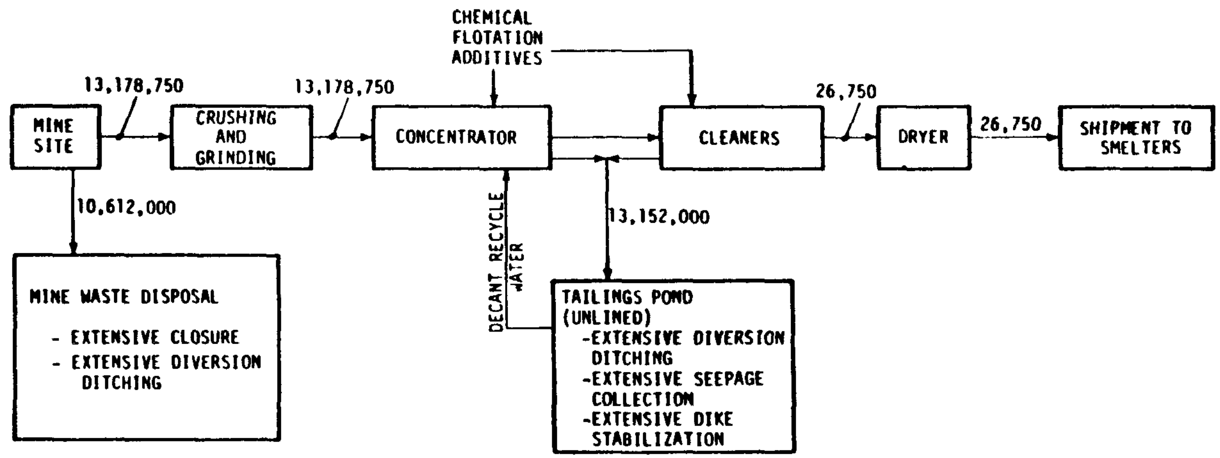
ALL VALUES IN DRY METRIC TONS PER YEAR.

Figure C-1 Copper mining and beneficiating model plant.



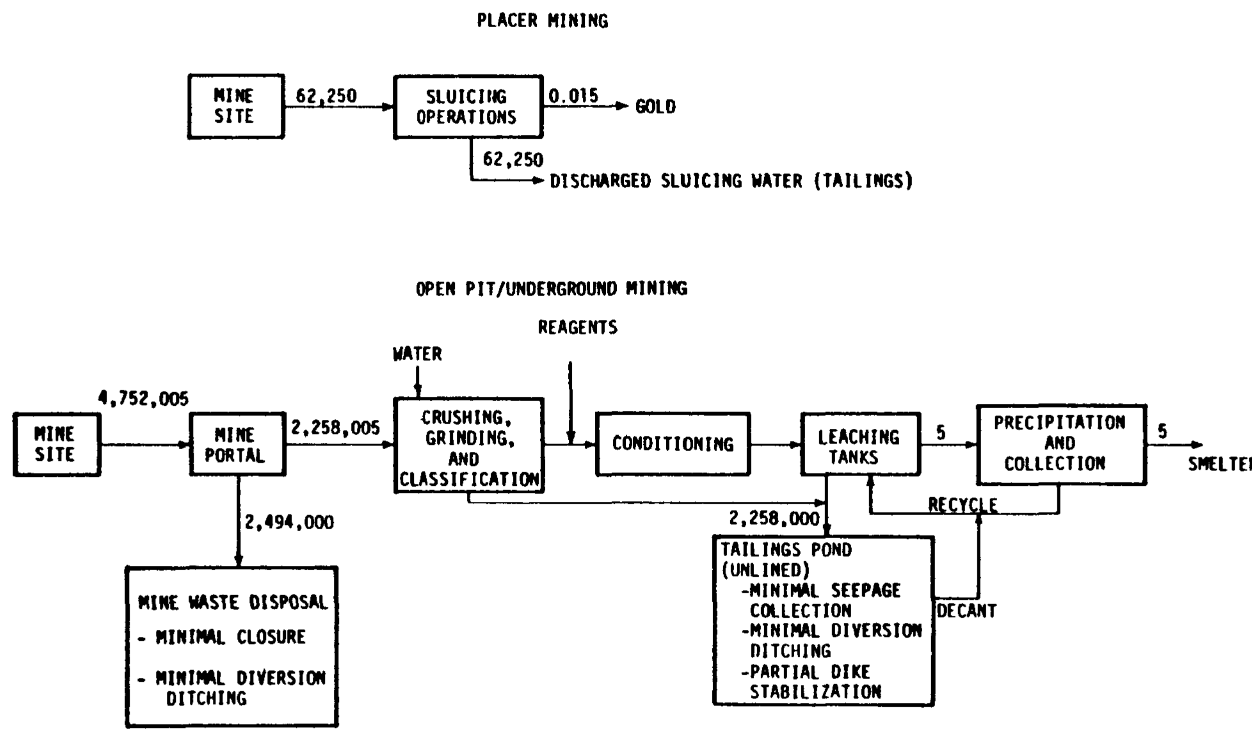
ALL VALUES IN DRY METRIC TONS PER YEAR.

Figure C-2 **Iron ore mining and beneficiating model plant.**



ALL VALUES IN DRY METRIC TONS PER YEAR.

Figure C-3 Molybdenum mining and beneficiating model plant.



ALL VALUES IN DRY METRIC TONS PER YEAR.

Figure C-4 Gold mining and beneficiating model plant.

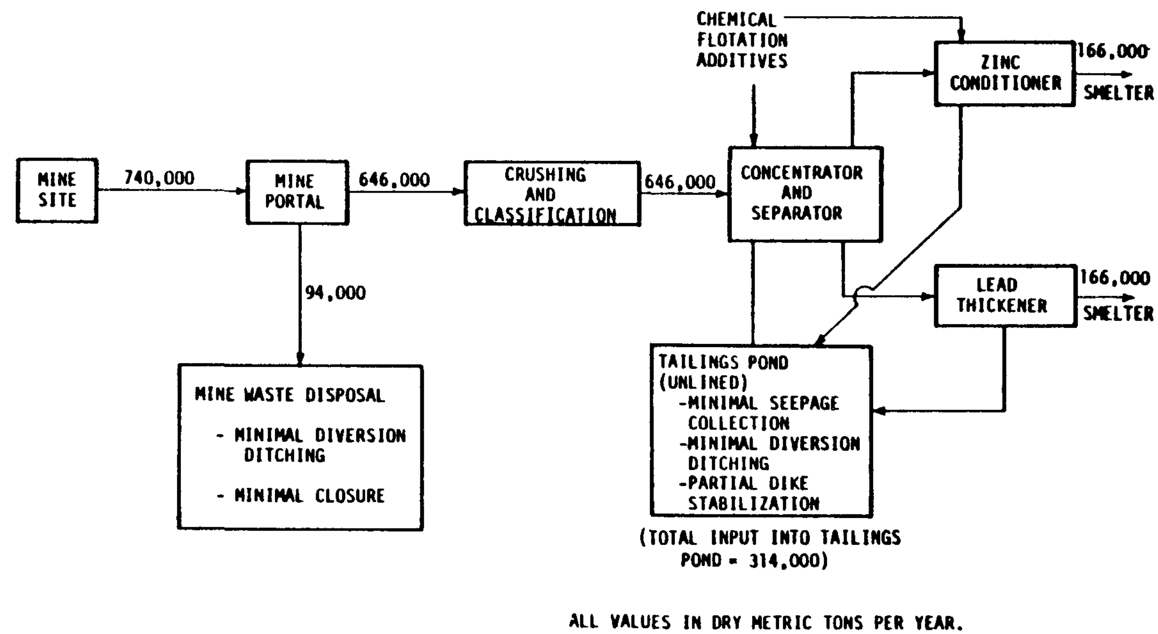


Figure C-5 Lead/zinc mining and beneficiating model plant.

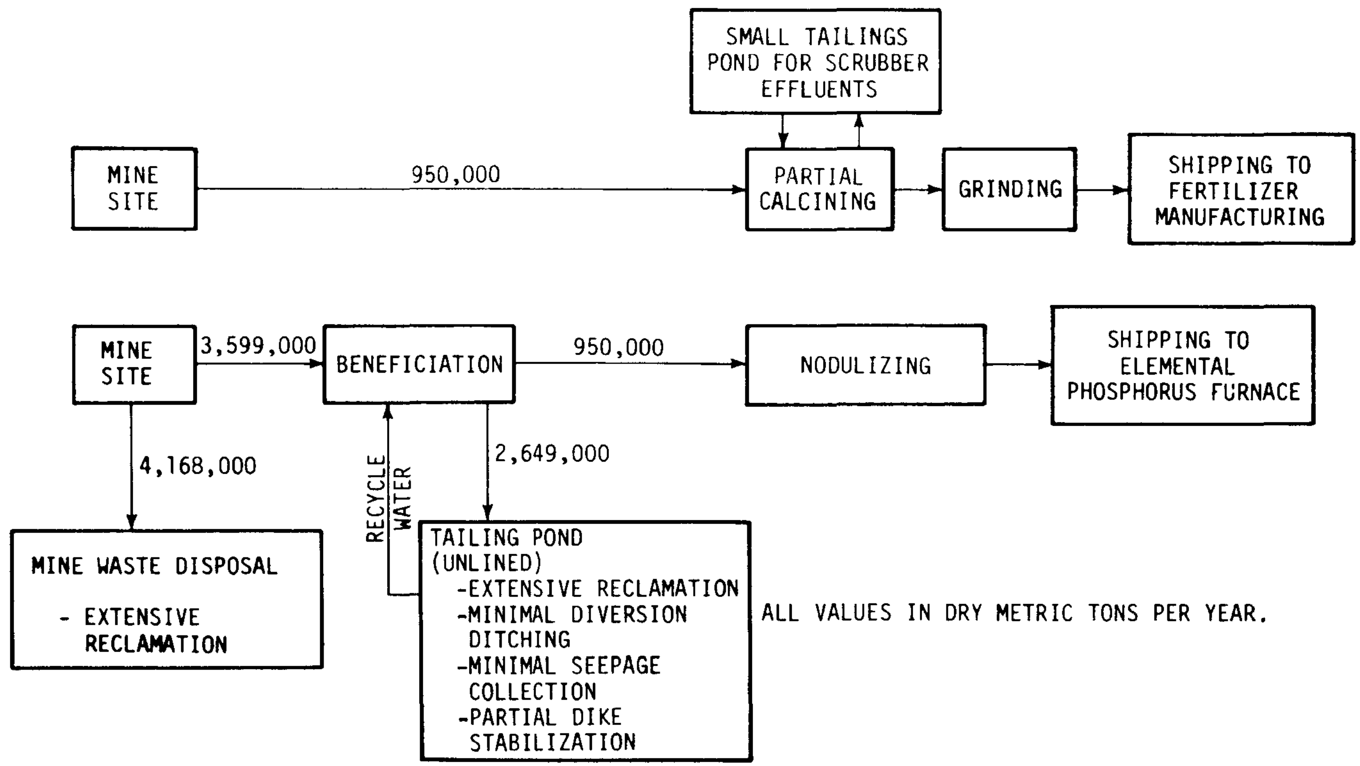


Figure C-6 **Phosphate mining and beneficiating model plant.**

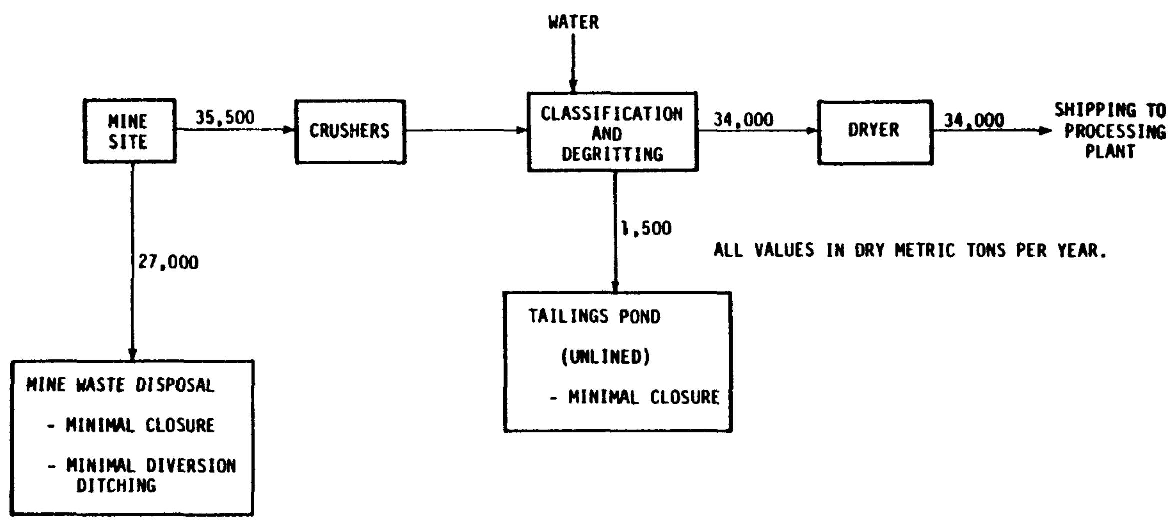


Figure C-7 **Clay mining and beneficiating model plant.**

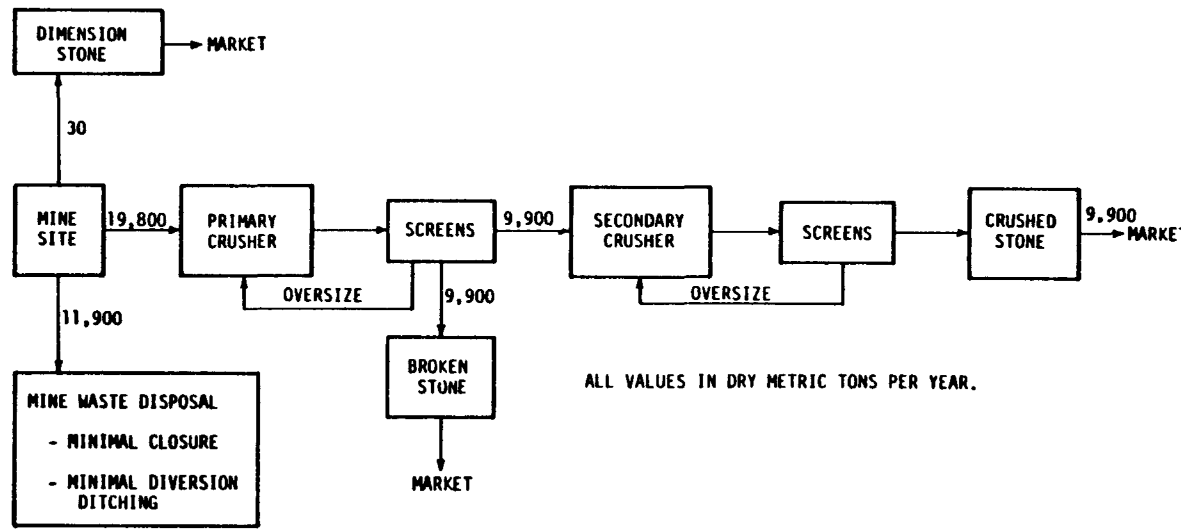


Figure C-8 **Crushed, broken, and dimension stone mining model plant.**

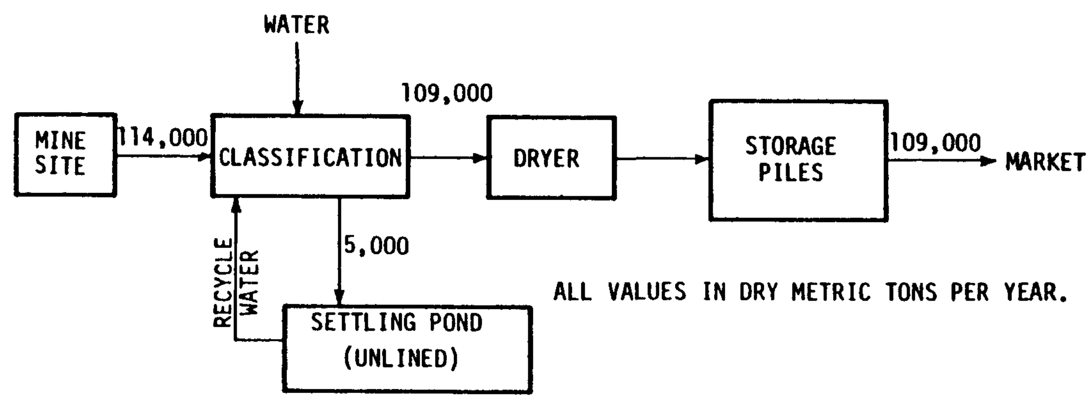


Figure C-9 Sand and gravel mining model plant.

a. Ground Water

A control technology that would meet the Section 4004 ground-water criterion for overburden and waste rock (Figure C-10) is the construction of diversion ditches to direct water away from the disposal areas. This control reduces the leaching of materials from these areas and subsequent pollution of the ground water by diverting rainwater from prolonged contact with the waste.

In order to determine the control technologies required for industries that generate non-hazardous tailings, an evaluation of the water table is necessary to determine whether leachate from existing unlined tailings ponds could adversely affect the quality of the ground water. A high/low water table has been delineated for this purpose. In a particular industry, the degree to which the tailings ponds will have an adverse impact on the ground water was determined by the region in which the industry is located. This study assumes, for example, that in the southeastern section of the country 25 percent of the land has a low water table and 75 percent a high water table; these percentages are assumed to be reversed in states in the Southwest. A national summary of these estimated high/low water-table percentages was prepared for the Northwest, Southeast, Southwest, Northeast, and Midwest (Table C-10).

TABLE C-10

ESTIMATED REGIONAL PERCENTAGE OF LOW OR HIGH WATER TABLE USED IN ANALYSIS OF GROUND-WATER CRITERION

Region	Low water table (%)	High water table (%)
Northeast	50	50
Southeast	25	75
Southwest	75	25
Northwest	75	25
Midwest	25	75

*These estimates are based on engineering judgment; they were not obtained from referenced material of actual measurements.

Non-hazardous tailings ponds located in areas with low water tables are assumed to need no additional controls to satisfy the ground-water criterion because of the natural filtration of suspended solids as the leachate perculates through the soil. Ponds in areas with high water tables could be subjected to a site evaluation (consisting of a hydrogeological survey, permeability tests, evaluation, and report) to determine the actual impact on the ground water. It is estimated that 80 percent of the site evaluations would show an insignificant impact, with the accompanying recommendation that monitoring wells should be installed and data collected quarterly at these sites. The remaining 20 percent of the evaluations would indicate significant ground-water impact, with the recommendation that these sites install further control technologies consisting of collection wells for the leachate to prevent ground-water contamination. In addition, monitoring wells would be installed in appropriate locations to perform quarterly checks of the leachate collection system.

b. Surface Water

Control technologies to meet the Section 4004 surface-water criterion are shown in Figure C-11. Diversion ditches around mine waste piles would prevent surface runoff from interacting with the waste and carrying it, primarily as suspended solids, into surface waters. The tailings pond is a baseline control technology for all mining industries producing beneficiation wastes. It contains the tailings and prevents surface-water contamination. One exception is gold placer mining operations, located primarily in Alaska and California. Sluiced wastes (tailings) from these operations are the only nonhazardous tailings within the gold mining and beneficiating industry. These wastes are currently pumped directly to streams and rivers. Control of the tailings from gold sluicing operations could be accomplished by construction of tailings ponds.

For industries having tailings ponds, further controls to meet the surface-water criterion include diversion ditches and upgrading of the pond dikes by compaction, soil coverage, and revegetation. The diversion ditches would direct waters away from tailings ponds to prevent the dikes from being weakened or washed out and to reduce the chances of pond overflow. Either situation could cause suspended solids to contaminate surface waters.

TABLE C-11

ESTIMATED TOTAL BASELINE AND GOVERNMENT-INDUCED COSTS BY INDUSTRY AND BY CRITERION (1,000 dollars)

		Costs attributable to government regulations (above baseline)*								
		Ground water		Surface water		Wetlands			Total	
Mining industry	Baseline† costs	NPDES permit granted	NPDES permit denied	NPDES permit granted	NPDES permit denied	NPDES permit denied	Floodplains	Closure	NPDES permit granted	NPDES permit denied
Copper										
Total capital	94	185	185	185	185			181,300	181,670	181,670
Annual O&M	8,239	10	10	10	10			21,150	21,170	21,170
Total annualized	2,250	37	37	37	37			47,770	47,844	47,844
Iron Ore										
Total capital	134	384	264	264	264	26,700	4,500	187,900	193,048	219,628
Annual O&M	1,028	33	14	14	14	15,800	224	18,580	18,851	34,632
Total annualized	1,044	85	50	50	50	19,200	823	43,740	44,698	63,863
Molybdenum										
Total capital	1,960	3	3	3	3			4,960	4,966	4,966
Annual O&M	129	1	1	1	1			630	632	632
Total annualized	369	1	1	1	1			1,230	1,232	1,232
Gold										
Total capital	6	1,947	1,947	5,286	5,286		1,044	5,297	13,574	13,574
Annual O&M	39	208	208	265	265		54	610	1,137	1,137
Total annualized	39	628	628	1,042	1,042		110	1,388	3,168	3,168
Lead/Zinc										
Total capital	26	65	52	52	52	30	419	3,628	4,164	4,181
Annual O&M	43	8	4	4	4	30	22	532	566	592
Total annualized	48	17	13	13	13	35	95	1,174	1,299	1,330
Phosphate										
Total capital	59	1,338	119	119	119	137,000	2,828	24,860	29,145	164,926
Annual O&M	7,435	181	7	7	7	383,400	141	3,730	4,059	387,285
Total annualized	7,445	418	28	28	28	407,300	650	8,130	9,226	416,136
Clay										
Total capital	46,800	17,515	9,109	18,317	4,003	16,320	7,891	18,240	61,963	55,563
Annual O&M	2,485	1,431	923	291	201	2,977	397	3,259	5,378	7,757
Total annualized	9,355	3,955	2,861	1,739	1,040	5,743	2,050	7,081	14,825	18,775
Stone										
Total capital	1,300	16,630	2,500	2,500	2,500	10,840	16,350	37,330	72,810	69,520
Annual O&M	600	1,988	125	125	125	5,000	822	6,671	9,606	12,743
Total annualized	734	5,559	650	650	650	7,200	4,250	14,500	24,959	27,250
Sand and gravel										
Total capital	380,200	310,800	310,800	101,830	87,970	60,590	345,100	289,800	1,047,530	1,094,260
Annual O&M	17,800	34,300	34,300	5,092	4,399	3,030	17,300		56,692	59,029
Total annualized	87,900	101,100	101,100	33,336	28,800	15,530	113,000	80,390	327,826	338,820
Other										
Total capital	43,060	35,103	32,500	12,643	10,040	25,150	37,810	75,330	160,886	180,830
Annual O&M	3,180	3,727	3,560	671	503	41,020	1,896	6,966	13,260	53,945
Total annualized	10,920	11,123	10,540	3,750	3,166	45,500	12,100	20,540	47,513	91,846
Total										
Total capital	473,639	383,970	357,479	141,199	110,422	276,630	415,942	828,645	1,769,756	1,989,118
Annual O&M	34,978	41,887	39,152	6,480	5,529	451,257	20,856	62,128	131,351	578,922
Total annualized	120,104	122,923	115,908	40,646	34,827	500,508	133,078	225,943	522,590	1,010,264

*In columns where numbers are left blank, the industries are not affected by these criteria
These costs do not include nonhazardous waste control costs for the coal mining industry
Note: Some total annualized cost numbers in this table and those shown in Table 5 are slightly different due to rounding component costs.

†These costs include estimated expenditures for stabilization of overburden returned to the mine site.

TABLE C-12

ESTIMATED BASELINE AND REGULATORY COSTS PER UNIT BASIS

Mining industry	Current product value* ($/metric ton)	Baseline costs: National annualized costs ($1000/yr)	Baseline costs: $/metric ton of waste	Baseline costs: $/metric ton of product
Copper	1,325	2,250	0.004	0.53
Iron ore	24.70[†] and 0.67[§]	1,044	0.004	0.013
Molybdenum	10,990[¶]	369	0.034	6.71
Gold	6,770,000[@]	39	0.003	1,857
Lead/Zinc	Lead, 747; Zinc, 681	48	0.010	0.003
Phosphate	17.40	7,445	0.035	0.167
Clay	2.20 to 220[**]	9,355	0.260	0.235
Stone	2.85[††]	734	0.011	0.001
Sand and gravel	2.46	87,900	2.45	0.122

*1978 dollars; 1979 Mineral Commodity Summaries, U.S. Bureau of Mines

†Natural ores, 51.5% Fe.

§Pellets, per metric ton unit of Fe.

¶Per ton of molybdenum in concentrate.

@Based on average selling price of $192.50/oz.

**Price varies with type and quality of clay.

††Dimension stone at $89.80/metric ton accounts for 0.15% of stone production.

(continued)

TABLE C-12 (con't)

Mining industry	State-and other Federal-induced costs (NPDES permit granted)			State-and other Federal-induced costs (NPDES permit denied)		
	National annualized costs ($1000/yr)	$/metric ton of waste	$/metric ton of product	National annualized costs ($1000/yr)	$/metric ton of waste	$/metric ton of product
Copper	69	0.0001	0.02	69	0 0001	0.02
Iron ore	829	0.004	0.01	19,980	0 085	0.25
Molybdenum	1	0.0001	0 02	1	0.0001	0 02
Gold	1,723	0.15	82,050	1,723	0.15	82,050
Lead/Zinc	99	0 02	0.006	134	0 03	0.008
Phosphate	704	0.003	0 016	408,300	1.92	9.15
Clay	5,640	0 16	0.14	10,500	0 29	0.26
Stone	4,565	0.07	0 006	11,100	0.17	0 01
Sand and gravel	169,300	4.72	0.24	183,300	5 1	0.26

(continued)

TABLE C-12 (con't)

Mining industry	Criteria-induced costs (NPDES permit granted)			Criteria-induced cost (NPDES permit denied)		
	National annualized costs ($1000/yr)	$/metric ton of waste	$/metric ton of product	National annualized costs ($1000/yr)	$/metric ton of waste	$/metric ton or product
Copper	47,970	0.08	11.3	47,970	0.08	11.3
Iron ore	43,840	0.19	0.55	43,840	0.19	0.55
Molybdenum	1,230	0.11	22.4	1,230	0.11	22.4
Gold	1,462	0.13	69,620	1,462	0.13	69,620
Lead/Zinc	1,191	0.25	0.07	1,191	0.25	0.07
Phosphate	8,540	0.04	0.19	8,130	0.04	0.18
Clay	9,291	0.26	0.23	8,341	0.23	0.21
Stone	20,210	0.31	0.02	16,460	0.25	0.02
Sand and gravel	158,890	4.43	0.22	155,840	4.34	0.22

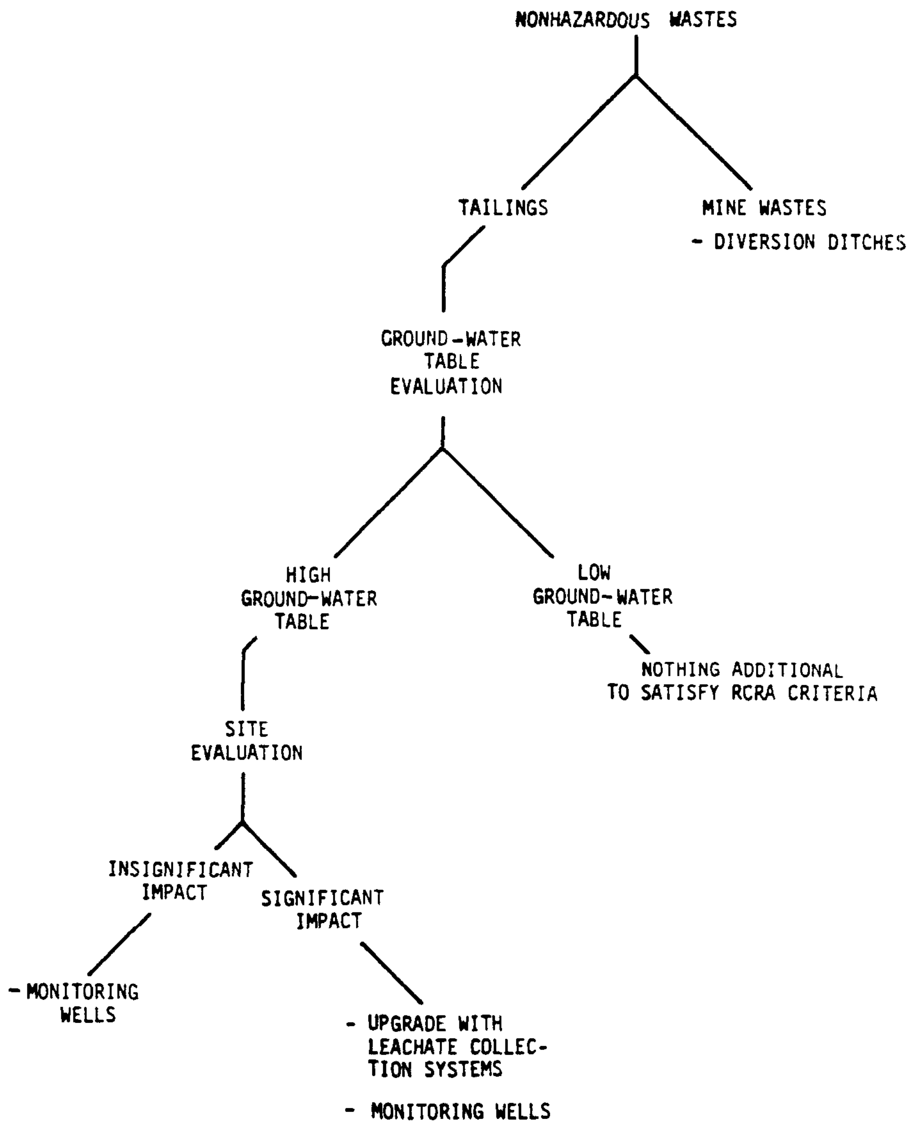


Figure C-11 Controls induced by RCRA ground-water criterion covering nonhazardous wastes from the mining industry.

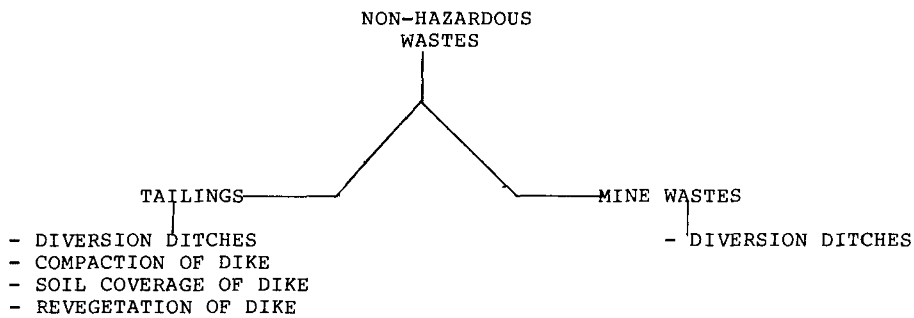


Figure C-10 Controls induced by RCRA surface-water criterion covering non-hazardous wastes from the mining industry.

c. Wetlands

Control technologies to meet the Section 4004 wetland criterion are shown in Figure C-12. Two scenarios are considered for tailings and other mine wastes. One scenario assumes that NPDES permits will be granted to all mining industries located in wetlands, allowing solid wastes to be disposed of within the area. The second scenario assumes that no NPDES permits will be granted and that all mining wastes generated in wetlands will have to be transported out of the area. Control technologies for the two scenarios are outlined in the following paragraphs.

NPDES permits granted. It is assumed that monitoring wells, checked on a quarterly basis, would be installed around mine waste piles as a precautionary measure to insure protection of the well and that the dikes around tailings ponds permitted to stay in the wetland would be upgraded into a 3:1 sloped structure (3 horizontal, 1 vertical). This control would also include dike compaction, soil coverage, and revegetation (similar to the controls for the surface-water criterion).

NPDES permits denied. This scenario would entail the purchase of land outside the wetlands to construct disposal facilities for tailings and mine wastes. The additional costs would include the transportation of these non-hazardous wastes to the new sites. It is assumed that the wastes from all mining industries located in wetlands would have to be trucked a distance of 16 kilometers one way, with the exception of wastes from the Florida phosphate industry, which is located in areas of extensive wetlands. The assumed trucking distance in this case is 32 kilometers one way.

Because of the distances involved, pumping the tailings to the new facility is not considered feasible. The control method described here includes thickening the tailings slurry to a 70 percent solids sludge before it is transported by truck. Overflow from the centrifuge would be pumped to storage tanks as recycle water.

In addition to trucking the newly generated tailings to new disposal facilities that meet Section 4004 criteria, the scenario includes closing the existing tailings ponds (pond free water pumped off, pond allowed to drain, 0.15 meters of soil uniformly graded over the pond, and revegetation). Closure measures for the relocated disposal facilities at the end of its life are described under the closure criterion.

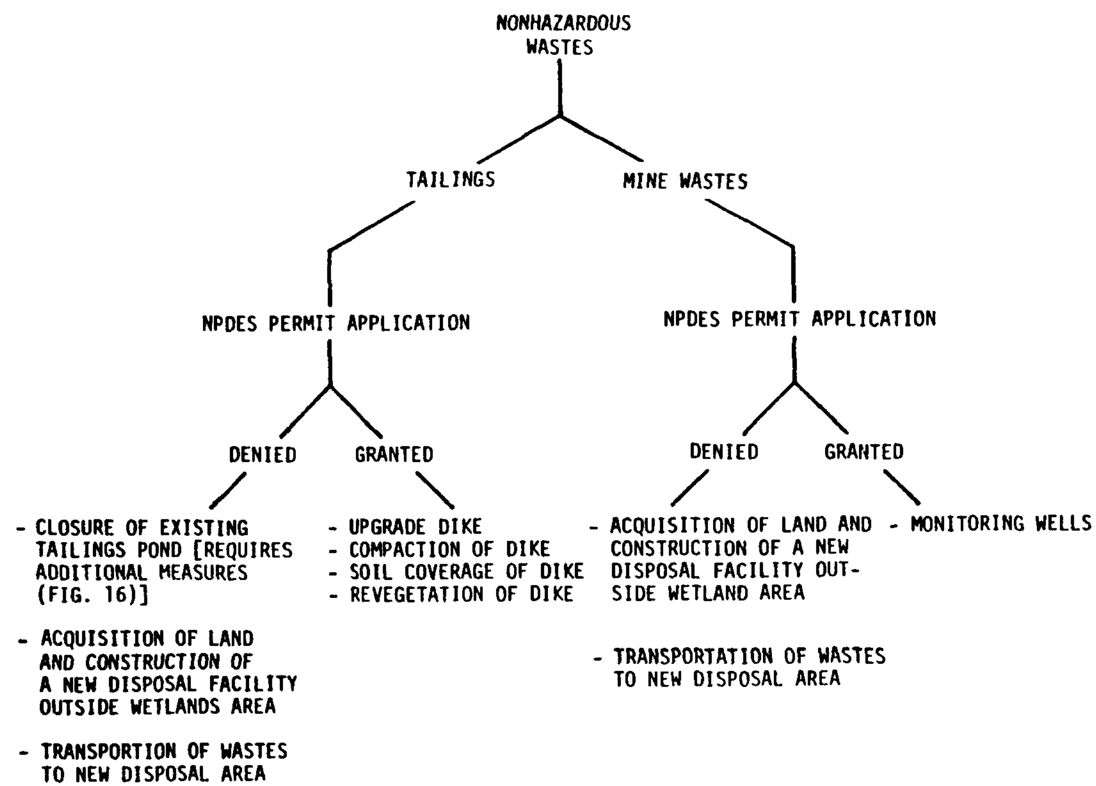


Figure C-12 Controls induced by RCRA wetland criterion covering nonhazardous wastes from the mining industry.

The percentages of the specific industries located in wetlands were calculated from the percentages presented in Table C-27. (Volume I) of the EIS; and adjustments to the percentage were based on knowledge of locations of these minerals industry facilities relative to wetlands when this information was available. For example, although 46 percent of Florida is wetlands, the majority of the Florida phosphate industry is located within these wetlands; therefore, it was assumed 90 percent would be affected by the wetlands criterion.

d. <u>Floodplains</u>

Control technologies to meet the Section 4004 floodplains criterion are shown in Figure C-13. Diking is the principal method selected, for both tailings and mine wastes,to satisfy this criterion. For mine wastes, this entails construction, compaction, soil coverage, and revegetation of dikes 3 meters high at a 3:1 slope. The dikes would be built around accumulated plus newly generated mine waste. Based on a national average, it was assumed three sides of the mine waste piles (assuming roughly rectangular shapes)would require diking. In actuality, some waste piles are located against a ridge or ridges bordering the floodplains; these piles may be protected from floods on one, two, or three sides. Other waste piles are located in the middle of floodplains, and dikes would have to be built around their entire periphery.

NON-HAZARDOUS WASTES
(TAILINGS AND MINE WASTES)

- DIKE CONSTRUCTION
- COMPACTION OF DIKE
- SOIL COVERAGE OF DIKE
- REVEGETATION OF DIKE

Figure C-13. Control technologies to meet the Section 4004 floodplains criterion.

For tailings ponds,the floodplain criterion would require upgrading the existing pond dikes to a 3:1 slope, compacting, covering these dikes with 0.6 meters of soil, and seeding and fertilizing to prevent erosion.

The percentage of industries located in floodplains were estimated on a state-by-state basis. Most of the states were assigned a value of 5 percent, which is the estimated average percentage of land in the United States that is within floodplains.[5] Deviations from this value were based on knowledge of specific mine locations with respect to floodplains.

It is noted that the strategy of upgrading tailings ponds in wetlands and floodplains is the same. Based on the general location of the applicable mine sites and small percentages of mines in wetlands and floodplains, it was assumed for cost purposes that the industries located in wetlands are mutually exclusive from those located in floodplains.

e. Air Quality

Control methods to prevent adverse impacts on air quality are shown in Figure C-14. No controls are needed on an annual basis during the active life of the mine waste disposal site. Long-term protection of the air quality after the site is retired would result from revegetating the piles. This method is discussed under the closure section.

Fugitive dust can also be generated by winds blowing across dried areas of tailings ponds, particularly in arid regions of the West and Southwest. Tailings from the clay and sand and gravel industries are contained in small ponds and are nearly all located in nonarid regions. As a result, the pond surfaces remain wet a majority of the time due to the addition of new tailings water and the fact that the precipitation rates exceeds the evapotranspiration rate for these areas. Because the ponds do not dry out and create dust problems, no additional controls to protect air quality standards are considered necessary.

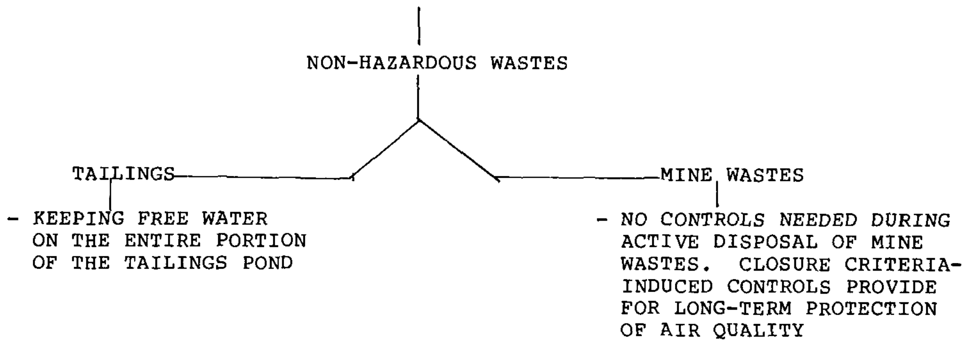


Figure C-14 Controls induced by RCRA air quality criterion covering non-hazardous wastes from the mining industry.

f. Closure

Control technologies necessary to meet the 4004 closure requirements are shown in Figure C-15. It is assumed that accumulated and newly generated non-hazardous mine wastes will be closed with 0.15 meters of soil cover and that the soil be revegetated to restore the land similar to its original condition. With a few exceptions, such as Florida phosphate, most of the mineral industries have allowed mine wastes to accumulate in piles since the startup of the mines. The quantity of these wastes is considerable, depending on the type of industry and length of time the mines have been in operation; the copper model plant, for example, has been operating for an estimated 15-year period. (These estimated periods of other industries are shown later in Table C-13). The control method for stabilizing these accumulated mine waste piles would involve regrading to provide adequately contoured slopes; compaction of this material; coverage with 0.15 meters of soil; soil amelioration; and seeding to revegetate.

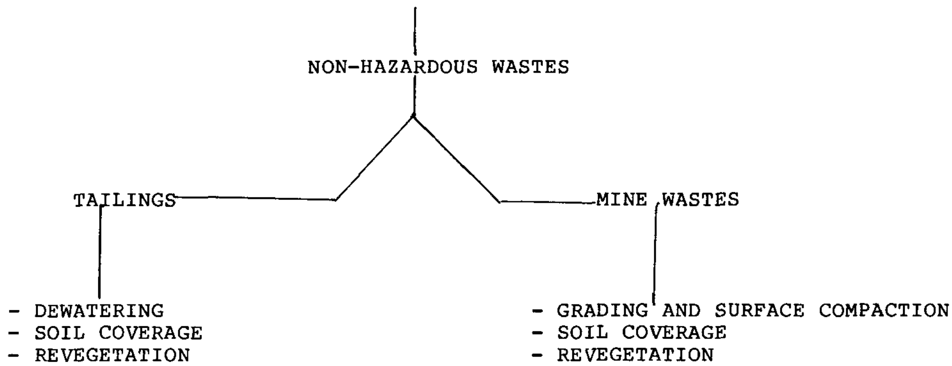


Figure C-15 Controls industed by RCRA closure criterion covering non-hazardous wastes from the mining industry.

The newly generated mine wastes would be spread out, compacted, covered with soil, and revegetated on a continual basis. These procedures are similar to the reclamation that is practiced in some industries. Closure would thus occur regularly, so that the wastes would be "closed" on a weekly, monthly, or even an annual basis rather than be allowed to accumulated through the remainder of the mine life.

Procedures for closure of a tailings pond when it is full are also shown in Figure C-15. Pond free water would be pumped to a pressurized filtering system to remove solids, and the clarified water would be discharged to a surface stream or river or used for operational purposes at the mine or mill. When the drained area was stable, 0.6 meter of soil would be used to cover the tailings, followed by compaction and revegetation.

4. Costs and Cost Methodology

This section presents and discusses baseline costs, State- and other Federal-induced costs, and Criteria-induced costs on a capital and an annualized basis. All the costs are given in 1978 dollars.

The methodology used to determine these costs is also discussed. The two principal sources of cost data were Richardson and Means;[6,7] other sources were used for additional unit costs.[8,9]

a. Baseline and Above-Baseline Costs

For each of the 10 mining industries, costs have been calculated for the baseline case and for the control methods attributable to government regulations (Table C-11). Baseline costs include all control technologies the industries are currently implementing in the absence of Federal solid waste regulations which meet the Section 4004 criteria. Costs above baseline are figured and shown separately for each criterion. In the copper industry, for example, the 61 mines have a total baseline capital cost (for all criteria) of $94,000; annual operating and maintenance costs are $2,239,000; and total annualized costs are $2,250,000. Capital costs above baseline to meet the ground-water criterion (NPDES permits granted or denied) are estimated at $185,000, and total annualized costs are estimated at $37,000. Additional costs are shown for surface-water criterion and closure. Within this industry, the sum of the costs above baseline to meet these criteria is estimated at capital costs of $182 million, annual operation and maintenance costs of 21 million, and total annualized costs of $48 million. It is noted that the capital costs of satisfying the floodplains and closure criteria for the sand and gravel industry are considerable for several reasons. Fifty percent of the disposal facilities in this industry are assumed to be in floodplain areas; thus costs of upgrading tailings pond dikes are great. As shown in Table C-8), the sand and gravel industry has by far the greatest amount of non-hazardous tailings produced by over 7000 mines. The cost of closing this number of ponds at the end of their lives also is great compared with other industries. (Closure of ponds is a capital expense because the money for this purpose is set up in a trust fund.)

For costs above baseline, each column total represents the estimated cost of all mining industries to meet a criterion. The grand total shown in the bottom right hand corner of Table C-11 represents the estimated total cost that all mining industries would have to incur to satisfy the Section 4004 criteria. Two grand totals are shown to represent two situations. It will cost an estimated $1.77 billion in capital costs to meet Section 4004 criteria if NPDES permits are granted to disposal facilities located in wetlands or an estimated $1.99 billion if NPDES permits are denied to those facilities in wetlands.

b. Costs per Unit of Waste and Product

The control method costs have also been calculated per metric ton of waste and of product, based on the total annualized costs for each industry (Table C-12). For example, for the baseline case, the annualized cost in the copper industry is estimated at $2.25 million; this figure equals additional disposal costs of $0.004 per metric ton of waste and if prices were passed directly on to consumers an additional $0.53 per metric ton of product. (Tons of waste and product were shown in Table C-8). For State- and other Federal-induced annualized costs (NPDES permit granted), the estimate is $69,000; this figure equals $0.0001 per metric ton of waste and $0.02 per metric ton of product. For Criteria-induced annualized costs (NPDES permit granted), the estimate is $48 million; this figure equals $0.08 per metric ton of waste and $11.30 per metric ton of product.

c. Cost Methodology

(1) Capital Costs

National baseline and above-baseline capital costs for each mining industry were based on the size of the model plant and the control methods chosen to meet the Section 4004 criteria. Unit costs were determined for components of control methods that are current or baseline and those that are above baseline to provide compliance with Section 4004. The baseline and above-baseline control method component costs were subsequently calculated for the model plants. The sum of the control costs to meet a criterion for a model plant was then calculated, as applicable, for tailings and mine wastes. These costs were determined for each of the six criteria for each model plant. When one control strategy satisfied two criteria, such as surface water and ground water, the costs for the strategy were divided equally between them.

In each industry, the baseline costs to meet all criteria were determined from the multiplication of the number of model plants by the sum of the model plant control costs for all criteria. The total baseline costs per criterion were determined from the multiplication of the number of model plants in the industry by the model plant cost of meeting that criterion. The individual industry criterion costs were summed to get the total mining industry criterion costs.

The criterion costs were used to develop the baseline and above-baseline costs by State. The number of model plants in each State by industry and by type of waste (tailings and mine wastes) were determined by proportioning total tailings and mine waste quantities among that States, based on industry production figures.[1,2] For each State, the cost increment was determined from the multiplication of number of model plants per industry by model plant control costs for a criterion. The sum of these incremental costs for all industries within a particular State is that State's total industry cost to meet one Section 4004 criterion. The sum of these costs for all States in the United States is the national mining industry's cost to meet a criterion; and the sum of these costs for all criteria is the national cost impact on the mining industry of meeting Section 4004-level controls for non-hazardous wastes.

A contingency factor of 20 percent is included with the capital costs shown in the tables.

Costs of Section 4004-level controls were calculated by State to determine that total State-induced costs. Control costs in each State having regulations equivalent to the Section 4004 criteria were added together, then deducted from the national total costs of Section 4004-level controls. The matrix shown in another appendix (Economic Impact Analysis) to this document lists the States that have regulations with provisions equivalent to Section 4004 criteria. Other Federal-induced costs (in Table C-9, and included in above-baseline costs in Tables C-11 and C-12) are those attributable to the Clean Water Act. They represent the controls installed to meet the surface water and wetlands criteria (NPDES permit denied). State and other Federal-induced costs are combined and deducted from the costs of meeting Section 4004-level controls to yield the actual Criteria-induced cost.

(2) Annualized Capital Costs and Trust Funds

Annualized capital costs were determined for each industry by amortizing the capital at 12 percent interest over the remaining life of the model plant. The equation for determining the annuity or capital recovery factor is:

$$\frac{[i(1 + i)^n]}{[(1 + i)^n - 1]},$$

where i is the interest rate and n is the number of years. Annuity factors for the main industries considered in this study are shown in Table C-13.

TABLE C-13

ANNUITY FACTORS FOR MAJOR MINING INDUSTRIES

WITH NON-HAZARDOUS WASTES

Industry	Assumed remaining life of model plant (years)	Annuity factor
Copper, gold	15*	0.1468
Iron ore	20*	0.1339
Molybdenum	30	0.1241
Lead/zinc, phosphate	10*	0.1770
Clay, stone	7.5*	0.2096
Sand and gravel	5*	0.2774

* These remaining lives are assumed to be half of the full lives.

Another annualized capital cost is the establishment of trust funds to pay for the closure of tailings ponds at the end of a mining operation and the operation and maintenance of monitoring wells after closure. A closure period of 1 year was assumed for non-hazardous tailings ponds for costing purposes. During the closure period, the pond free water would be pumped from the pond to quicken the time that natural evaporation and drainage would take, adequate drainage then allowed to occur, soil material added on top of the drained tailings, and the soil material seeded and fertilized.

The trust fund for the monitoring wells is based on the assumption that they will be operated and maintained for 5 years after closure. (This 5-year period is not a requirement stated in Section 4004, but is a period of time in which collected monitoring data should be indicative of whether leachate from a closed pond is impacting ground water and to what degree.) Equations were derived to determine the trust funds for closure and for the monitoring wells (Table C-14). The equations take into account variations in remaining life among the model plants, and they include a 2 percent return (above inflation) on capital. In the equations, T is the capital cost of the trust fund; and S is the cost of closure and of well operation and maintenance for 1 year.

TABLE C-14

EQUATION FOR TRUST FUNDS

Industry	Tailings pond closure	Monitoring well upkeep
Iron ore		T = 3.202 S
Lead/zinc, phosphate		T = 3.903 S
Clay, stone	T = 0.853 S	T = 4.101 S
Sand and gravel	T = 0.897 S	T = 4.309 S

(3) Other Annual Costs

In addition to annualized capital costs, the other annual costs include maintenance of the various control systems (assumed to be 5 percent of the applicable total capital costs); electricity to operate pumps, as during pond dewatering (assumed to cost 30 mills/kWh); labor to operate equipment, such as the front-end loader (costed at $26.60 per man-hour, including supervision and overhead); trucking of trailings and mine wastes from wetlands when NPDES permits are denied (assumed to be done by a contractor); and annual costs of continuous overburden grading, soil spreading, and revegetating (also assumed to be done by a contractor). These latter costs and trucking costs are discussed further in the following subsection.

d. Configuration and Costs of Control Methods

The flow diagrams (Figures C-1 through C-9) and "tree" diagrams (Figures C-10 through C-15) presented the different baseline controls and those that would meet Section 4004 criteria, respectively. This section discusses design parameters and components of the control methods. Unit costs are listed, where appropriate, in parentheses.

(1) Tailings Pond

The tailings pond is the principal method used to control mining beneficiation wastes. Most mines have tailings ponds; some, such as gold placer mines, discharge their waste sluicing water to streams and rivers. To determine the cost of constructing a tailings pond for non-hazardous beneficiation wastes, this study assumed the following design parameters: rectangular-shaped pond; depth of about 11 meters from the top of the dike to the bottom of the pond; dike around three sides of the pond (assuming a natural barrier on one side); and a slope of 2:1 (horizontal:vertical) except in floodplains or wetlands, where dikes are sloped 3:1. The dikes are constructed to have a 6-meter-wide horizontal section along the top so that machinery can be driven and maneuvered there. Ponds are designed with a 1.5-meter freeboard above the water and an allowance of 1.2 meters of free water above the settled solids. Incoming slurry is assumed to be 30 percent solids, by weight; and settled tailings are assumed to be 65 percent solids, with an average specific gravity of 1.8. The excavated depth of a pond is based on the amount of material needed to construct the dike. The length-to-width ratio of the pond is 2:1.

With the exception of the sand and gravel industry and the phosphate industry, it is assumed that one pond will accommodate the beneficiation (tailings) wastes from the other subject mineral industries over the entire life of each model plant. Sand and gravel and phosphate operations typically construct a small settling pond at the startup of a mine to receive beneficiation wastes during the initial two or three years of operation, with subsequent employment of one or more excavated areas from the mining operation for this purpose; conse quently, baseline control costs for tailings from the sand and gravel and phosphate industry are based on this configuration, i.e., construction of a 3-year settling pond and operation and maintenance of this pond and the ponds created by the mining operation over the life of the mine. Nearly all of the cost of building a disposal pond for the phosphate industry is for the slimes since the pond is sized to handle a five percent slime slurry. The only cost for sand tailings disposal assumed in this report is for the transportation of these wastes outside a wetlands area if an NPDES permit is denied. All other costs are assumed attributable to slime disposal, which is not covered in this report.

In a case where a new pond must be built (e.g., gold placer mining) the cost is calculated for a capacity adequate to handle tailings for half the duration of a mine life; it is assumed that the mines on the average are halfway through their useful lives. (The life of a mine cannot accurately be estimated because it depends on many factors; two, for example, are market conditions and technological breakthroughs that can reduce ore recovery and treatment costs.) For both baseline case ponds and new ponds, assumptions about the annual quanities of tailings received were shown in Table C-8.

The capital cost of constructing a tailings pond includes the following components: land (rural undeveloped, $2,400 per hectare); land clearing ($1,300 per hectare); survey ($925 per hectare); excavation of pond area ($0.47 per cubic meter); hauling and dumping overburden at the dike area ($0.47 per cubic meter); dike formation and compaction ($1.88 per cubic meter); and fine grading ($0.69 per square meter).

(2) Ground-Water Evaluation

This evaluation is the determination of the water table level. The main costs are for drilling temporary test wells, which in this study are assumed to be 6.35 centimeters in diameter. The cost of a 15-meter-deep well is $475, and each linear meter exceeding that depth is $25.

(3) Site Evaluation

The detailed site evaluation considered in this report includes a hydrogeological survey to determine ground-water movement and flow nets ($5,000 per site) and tests of borings to determine leachability and permeability ($3,000 per site). The capital cost of such an evaluation, including engineering appraisal and a report, is estimated at $15,000.

(4) Leachate Collection System

The system considered here is a group of collection wells spaced at a density of one per hectare. Each well is equipped with piping and a pump located above ground level. The wells collect the leachate and pump it back to the tailings pond. Cost of a well, with pump and piping, is estimated at $4,500.

(5) Monitoring Wells

The monitoring wells are costed according to depth. The wells include casing 10 centimeters in diameter, piping 3.8 centimeters in diameter, and pumps rated at 5,700 liters per hour. The installed cost of a 15-meter-deep monitoring well is estimated at $3,000; and a 30-meter-deep well, at $4,000. The shallower wells would be used to measure ground water in wetlands; and deeper wells, in all other areas.

(6) Diversion Ditches

Cost of construction of diversion ditches (1.8 meters deep by 0.6 meters wide at the top) with a trencher is approximately $2.10 per linear meter.

(7) Dike Formation, Soil Coverage, Revegetation

Dikes are the principal control method used in this study for protecting overburden in floodplains. They are also part of the construction of a tailings pond, when no natural barriers are available. In this study, tailings pond costs normally include dikes with 2:1 slopes (which are assumed to exist at all baseline case ponds). Costs of dikes for new ponds to replace ponds closed because of wetlands criterion are attributable to Section 4004, as are the costs of new dikes (3:1 slopes) around overburden in floodplains and the costs for modifying existing pond dikes in wetlands and floodplains to 3:1 slopes.

Unit construction costs used for dike construction and compaction were: $1.25 per cubic meter of dike material to build a floodplain dike around mine wastes (3:1 slopes, 3 meters high, constructed of overburden) and $1.88 per cubic meter to build a tailings pond dike (2:1 slopes).

Costs of $0.51 per cubic meter (above the $1.26 value) are needed to modify pond dikes in floodplains from a 2:1 to a 3:1 slopes; these costs are for loading trucks and hauling overburden from the piles to the dike areas.

The revegetation costs for dikes or for closing tailings ponds and mine waste piles include the cost of fill soil, top soil, seeding, and fertilizing. It was assumed that all of the soil would have to be purchased. When mine wastes are revegetated as an ongoing procedure (e.g., in the Florida phosphate industry), it is assumed that usable soil material could be segregated during mining operations so that only 50 percent of the soil would need to be purchased.

Unit costs of soils and revegetation used in this study are as follows: purchased fill soil is $3.40 per cubic meter delivered to dike areas and $23,500 per hectare delivered to overburden piles and tailings ponds for closure; purchased top soil is $4.12 per cubic meter delivered to dike areas and $8,800 per hectare delivered to the site for closure purposes. The surface areas used to determine costs, by industry, are shown in Table C-15.

Where only the outer slope and horizontal portion of the dike are covered with fill soil and top soil (i.e., for tailings pond dikes), costs of spreading and compacting the two soils are $1.26 and $1.53 per cubic meter. The costs increase by 50 percent if both slopes (as on floodplain dikes) are covered with soil. Fine grading of the soil on dikes is costed at $0.69 per square meter. Revegetating, including seed and fertilizer, is costed at $2,500 per hectare. This revegetation cost applies to dikes and the closure of tailings and mine wastes.

(8) Waste Transportation

If NPDES permits are not granted to mines in wetlands, costs must be included for transporting newly generated mining wastes out of those areas. Capital costs include purchasing a front-end loader to load the newly generated mine waste from the piles onto 30-ton trucks. If the front-end loader is used full time for 8 hours a day, 5 days a week, 50 weeks a year, the cost of the equipment per hour is estimated at $52. Trucking of the waste from the mine site to the disposal facility is assumed to be done by a contractor, which makes it an operating cost. The unit cost of trucking is $1.05 per metric ton of waste, including fuel and labor and based on a round trip of 32 kilometers. This distance was assumed for all mines in wetlands except the Florida phosphate industry, which is located in extensive wetlands areas. A round trip distance of 64 kilometers was assumed there, bringing the unit cost of trucking to an estimated $1.96 per metric ton of waste.

Other operating costs include labor and fuel to operate the front-end loader. Direct labor plus overhead is estimated at $26.60 per man-hour, and fuel is estimated at $6.00 per hour per loader (38 liters of fuel per hour at $0.16 per liter).

TABLE C-15

SURFACE AREAS OF NONHAZARDOUS

MINING WASTES BY INDUSTRY MODEL PLANT

Industry	Full life* Mine wastes (hectares)	Full life* Tailings pond (hectares)
Copper	716	NA+
Iron	355	NA
Molybdenum	5.28	NA
Gold	153	0.5**
Lead/zinc	7.73	NA
Phosphate	171	NA
Clay	1.67	2.3
Stone	1.42	Negligible
Sand and Gravel	Negligible	0.8

* For model plant half life, values are half the number shown.

\+ Not applicable, wastes are considered hazardous.

** Only tailings wastes from mining of placer deposits.

The capital costs of transporting tailings wastes include such major items as purchase of a centrifuge (to concentrate the slurry from 30 percent solids to 70 percent solids), a slurry feed pump plus spare, a sludge conveying system/hopper, and recycle water tanks. The sum of these items for the clay industry model plant, for example, is about $205,000.

(9) Dewatering Tailings Pond for Closure

In this study, dewatering consists of pumping the free water off the tailings pond and allowing the retained surface water to drain until the ground is stable enough for machinery to work on it. The costs include pumping the water from the pond surface and purchasing a fine-mesh, backwash filter to remove suspended solids. The capital cost of the filtering unit, with pumps and piping, is $25,000. The main operating cost is for electricity (30 mills per kilowatthour) to run the centrifugal feed and backwash pumps.

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C. THE COST IMPACT OF SECTION 4004 OF THE RESOURCE CONSERVATION AND RECOVERY ACT ON THE COAL-FIRED UTILITY INDUSTRY

1. Summary

The purpose of this section is to define the cost impact of the proposed 4004 criteria on the coal-fired utility industry.

The coal-fired utility industry is currently the largest volume producer of non-hazardous industrial waste, producing two major streams of waste: ash (flyash, bottom ash and boiler slag) and flue gas desulfurization (FGD) sludge. In 1977, approximately 62 million metric tons of ash[1] and approximately 2.5 million metric tons of FGD sludge were produced.[2] (A variety of other wastes are generated by the utility industry. Although it was not in the scope of this report to cover these wastes, it is recognized costs for controlling these wastes will increase the impact of Section 4004.)

Ultimate disposal of any of these wastes is in a pond or landfill, either lined or unlined.

Flyash collected in a flue gas cleaning device can be pumped to disposal as a slurry to a settling pond or transported dry via pneumatic handling to a storage silo and subsequent trucking to a landfill. The choice of disposal is highly site specific and highly dependent upon the method of collection. Most dry material leaving coal-fired utility plants ends up in landfills. These landfills are rarely lined. Where ponds are used for disposal liners, which include clay and synthetic liners, are sometimes used.

Disposal options for sludge involve direct ponding or dewatering. In either case the sludge can be mixed with (1) flyash or flyash and lime or (2) a number of other materials used for commercial fixation processes, depending on the chemical nature of the sludge.

If dewatering is not used the sludges are commonly pumped as 10-15 percent solids. Sludge can undergo partial dewatering and be pumped to ponds as 20-35 percent solids. The sludge can be vacuum filtered to 50-60 percent solids and trucked or otherwise hauled to the landfill.

In every case where ponding is used, either for dewatered sludges or the slurry pumped directly to ponds, the solids can be removed and landfilled after settling.[3]

The three criteria which will have the greatest impact on utility disposal sites are: 1) surface water (concerning disposal in wetlands) 2) floodplains and 3) ground-water criteria. In order to determine the national cost impact of these three criteria on the coal-fired utility industry, new and existing disposal facilities are examined separately.

The total national solid waste disposal costs for new plants expected to come on line through 1985 are broken down to show costs of disposal assuming current practices, costs for compliance with existing State solid waste and Federal regulations, and the additional costs for compliance with Section 4004 criteria.

Existing sites are examined based on available data regarding current disposal practices. Estimates are made for the number of sites failing the three (wetlands, floodplains and ground-water) criteria. Average costs for closing and upgrading are developed.

Based on this study, the costs for solid waste disposal for the coal-fired utility industry are shown below.

The range of cost reflects difference scenarios for granting and denying of NPDES permits for disposal in wetlands. These scenarios in turn affect ground-water and flood protection costs, depending on the number of sites required to move outside the wetlands area.

As the distance from the plant to the disposal site increases, it is assumed the probability of locating impermeable soils increases. It is also assumed sites five to ten miles from the site will not require protection against washout. A further explanation of these scenarios and the range of costs follows in the text.

a. Cost for New Facilities

Total national solid waste costs for the approximately 250 new plants (135,000 MW) expected to come on line by 1985 are estimated to fall within the following ranges:

Capital Investment Costs	Average Operating Costs
$1.4-$1.5 billion	$100-140 million

This amounts to $340-370 million in annualized costs. Annualized costs are calculated by amortizing capital investments over the thirty year life of the site assuming a pre-tax cost of capital of 16%. The amortized capital is added to annual operating and maintenance charges to obtain the annualized solid waste disposal cost. The annualized cost must be recovered from consumers and for the case of electric utilities, increases in the price of electricity are shown in mills per kilowatt hour (kwh).[4]

The portion of these cost assignable to existing State solid waste and Federal regulations range from:

Capital Investment Costs	Annual Operating Costs
$240-275 million	$24.5-40.5 million

These account for between $54 and $84 million of the national annualized solid waste and .09 and .14 mills per kwh for the consumer charge.

The portion attributable to Section 4004 range from:

Capital Investment Cost	Annual Operating Cost
$165-195 million	$.8 million

The annualized cost of Section 4004 ranges between $27 and $32 and the charge to consumers will be between .04 and .05 mills per kwh.

b. Cost for Existing Facilities

The current cost for the utility industry to dispose of their 65 million metric tons of solid waste is estimated to be $195 million annually. This is based on an average disposal cost of $3.00 per metric ton.

Total national solid waste costs associated with bringing the disposal sites at the current 400 plants (200,000 MW) into compliance with the criteria are:

Capital Investment Costs	Annual Operating Costs
$198-$268 million	$2.5-50 million

This would increase total annualized costs between $85 and 110 million.

The total costs required to comply with existing Federal regulations and state solid waste regulations for the coal-fired utility industry are:

Capital Investment Costs	Annual Operating Costs
$162-211 million	$2.2-50 million

This amounts to 67 to 112 million in annualized costs. These expenses will increase electricity costs by .11-.19 mills per kwh.

The 4004-induced costs amount to:

Capital Investment	Annual O & M
$36-57 million	$.16-.30 million

These costs amount to between $12 and 18 million in annualized solid waste costs. Based on the estimated 134,000 MW of capacity assumed to be affected, electricity costs will increase between 0.02 and 0.03 mills per kwh.

Explanations of the criteria, assumptions, methodology and procedures for cost development are shown in detail in the following sections.

2. Development of Model Plant

In order to develop the base number from which average national costs for future utilities can be extrapolated, a model plant approach is utilized. The typical plant characterized for the purpose of developing national average costs is based on a 1000 MW "nameplate" capacity. Average dollar per kw capital investment costs and dollar per ton annual operating costs are generated using published data. Cost data for model plant disposal options are taken from EPRI FP-671 "State-of-the-Art of FGD Sludge Fixation." Additional sources are utilized and will be referenced.

The annual quantities of ash and sludge a utility plant produces is a function of several variables including the ash and sulfur content of the coal. Because several Eastern and Western coals with varying range of ash and sulfur are utilized, one Eastern and one Western coal is assumed with the specific ash and sulfur content shown below:

Eastern Coal:	14% ash, 3.5% sulfur, 12,000 BTU/lb.
Western Coal:	8% ash, 0.8% sulfur, 9,000 BTU/lb.

Based on Federal Energy Administration projections for Eastern and Western coal use in 1985, it is assumed the model plant burns 77% Eastern coal and 23% Western coal.[5] The average capacity of the power plant over its thirty year life is assumed to be 4380 hours (50% capacity) per year. This is based on an average of 7000 hours for the first ten years, 5000 hours for the next five, 3500 for the next five, and 1500 for the last ten.[6] This average is used to estimate average quantities of flyash and sludge generated over the lifetime of the plant. Density figures were used to estimate the volume of solid waste to determine the required size of the disposal facility (see appendix).

Current emission standards for coal-fired utilities limit SO_2 emissions to 1.2 lb $SO_2/10^6$ Btu and require 99% flyash removal. Announced new source performance standards (ANSPS) would require 85% removal of SO_2 from all coals. Promulgation of these regulations will affect all coal-fired utilities coming on line beginning 1983. The dominant impact of the proposed regulations is for scrubber sludge at plants burning low sulfur coal. The impact of these regulations on solid waste production will be significant in the 1990's. The EPA Office of Air Quality Planning and Standards projects that the megawatt capacity of coal-fired utilities scrubbing in 1985 will increase by approximately 4,800 MW due to the ANSPS and sludge generation will increase by approximately 2 million metric tons per year.[7]

This report examines planned facilities expected to come on line through 1985. The majority of these facilities operating scrubbers by 1985 will be complying with current emission standards. Therefore, for the purpose of developing solid waste costs, annual quantities of solid waste produced by the typical plant are based on current emission standards.

The quantities of waste are:[3,8]

ASH	187,000 MT
SLUDGE*	162,000 MT

The ANSPS is taken into account by increasing the megawatt capacity disposing of both flyash and sludge by 4,800 MW.

Bottom ash, or boiler slag, generated in smaller quantities can be disposed in separated ponds or together with flyash and scrubber sludge. Alternatives for bottom ash disposal are more limited and less complicated in terms of disposal alternatives. Although bottom ash is not separately treated in this report, ash quantities do reflect

*Limestone is assumed to be the scrubber reagent, based on current industry practice.

Table C-16

COSTS FOR SOLID WASTE DISPOSAL
MODEL 1000 MW PLANT
FLYASH DISPOSAL

FLYASH POND	CAPITAL INVESTMENT ($ x 10^3)	($/MT)	ANNUAL OPERATING COSTS * ($ x 10^3)	($/MT)	ANNUAL SOLID WASTE COST ($ x 10^3)	($/MT)
Lined, 3 km from site	13,246	2.36	139	.74	2,284	12.21
Unlined, 3 km from site	8,709	1.55	139	.74	1,548	8.28
Lined, 8 km from site	20,664	3.68	515	2.75	3,860	20.64
Unlined 8 km from site	13,586	2.42	515	2.75	2,616	13.99
Lined, 16 km from site	28,744	5.12	577	3.09	5,230	27.97
Unlined, 16 km from site	18,899	3.36	577	3.09	3,545	18.96
FLYASH LANDFILL **						
Lined, 3 km from site	4,360	.77	662	3.54	1,367	7.31
Unlined, 3 km from site	1,564	.29	662	3.54	915	4.89
Lined, 8 km from site	4,622	.82	933	4.99	1,681	8.99
Unlined, 8 km from site	1,657	.30	933	4.99	1,125	6.02
Lined, 16 km from site	4,840	.86	1,143	6.11	1,927	10.30
Unlined, 16 km from site	1,736	.31	1,143	6.11	1,290	6.90

Based on 187,000 MT/yr. - 5,610,000 MT/life of the site

* It is assumed annual operating and maintenance costs will be the same for lined and unlined ponds.

** It should be noted for disposal of flyash, landfilling is significantly less expensive than ponding.

Table C-16 (con't)

COSTS FOR SOLID WASTE DISPOSAL
MODEL 1000 MW PLANT
FLYASH/SLUDGE DISPOSAL

FLYASH/SLUDGE POND	CAPITAL INVESTMENT ($ x 10^3)	($/MT)	ANNUAL OPERATING COSTS ($ x 10^3)	($/MT)	ANNUAL SOLID WASTE COST ($ x 10^3)	($/MT)
Lined, 3 km from site	21,512	2.05	146	.42	3,626	10.38
Unlined, 3 km from site	12,628	1.21	146	.42	2,189	6.27
Lined, 8 km from site	33,559	3.21	695	1.99	6,128	17.56
Unlined, 8 km from site	19,700	1.88	695	1.99	2,492	7.14
Lined, 16 km from site	46,681	4.46	747	2.14	8,304	23.79
Unlined, 16 km from site	27,403	2.62	747	2.14	5,012	14.36
FLYASH/SLUDGE LANDFILL						
Lined, 3 km from site	14,857	1.42	2,085	5.97	4,489	12.86
Unlined, 3 km from site	9,566	.91	2,085	5.97	3,632	10.41
Lined, 8 km from site	15,748	1.50	2,972	8.52	5,521	15.82
Unlined, 8 km from site	10,140	.97	2.972	8.52	4,467	12.80
Lined, 16 km from site	16,491	1.58	3,660	10.49	6,330	18.14
Unlined, 16 km from site	10,618	1.01	3,660	10.49	5,121	14.67

Based on 349,000 MT of Sludge and Ash Per Year 10,470,000 MT/life of the site both flyash and bottom ash. Co-disposal of bottom ash with flyash and scrubber sludge is assumed; therefore, costs accurately reflect total disposal costs for all coal-fired utility wastes, although bottom ash is not specifically mentioned throughout the remainder of this report.[9]

There are four basic disposal practices used for the calculations in this study. They are ponding of ash, landfilling of ash, ponding of FGD sludge and ash, and landfilling of FGD sludge and ash. These four practices are assumed to be representative of current industry solid waste disposal.

Disposal costs for these four scenarios are shown in Table VII-16. These costs include all expenses considered necessary to meet the 4004 criteria. Costs for varying distances to the disposal sites are also shown. By comparing capital investment requirements for a pond and landfill, ponding is more expensive due to pumping and piping expenses. Landfilling, on the other hand, tends to incur greater annual operating costs resulting from operation and maintenance of moving equipment and labor. Where ash and sludge are disposed, operating costs for landfills show a sharp increase due to additional maintenance of the processing facility utilized for dewatering.

Construction designs for the four disposal sites along with component costs are shown in the appendix.

All national cost estimates in this report are derived utilizing the average kilowatt capital investment costs and annual operating costs. Projections are made regarding the future megawatt capacity employing the various disposal scenarios and the existing megawatt capacity failing the three criteria. These projections are explained in the following sections. Solid waste disposal costs and costs for upgrading and closure are derived by multiplying these megawatt capacities by average dollar per kilowatt costs. In order to derive annual operating costs, these megawatt capacities are converted into equivalent 1000 MW plants and multiplied by the annual operating costs shown. The cost figures represent average cost figures to the extent that the 1000 MW plant is representative of a typical plant. It is recognized the average existing utility is approximately 500 MW; therefore, a power-rating-size cost adjustment factor was used for existing plants.

Ponds are assumed to be approximately 9 meters deep, rectangular in shape and contained by dikes with a two to one slope. In actual practice, the depth and shape of the pond will be determined by local conditions. The ponds provide a thirty-year lifetime. Ash and sludge are assumed to settled to 65% solids.

Landfills are assumed to be approximately 12 meters at the mean depth and provide a thirty-year lifetime. Flyash is collected dry and mixed with water to be landfilled at 20% moisture content and ash and sludge are dewatered to approximately 50% moisture content. Land requirements for the four scenarios are as follows:

ASH POND	92 hectares (230 acres)
ASH LANDFILL	62 hectares (155 acres)
ASH/SLUDGE POND	168 hectares (420 acres)
ASH/SLUDGE LANDFILL	107 hectares (268 acres)

Land requirements needed for ultimate disposal depends on water content.

Distance from the plant to the disposal site is assumed to be approximately 3 km (2 miles).[3]

3. Solid Waste Costs for New Facilities

New plants coming on line by 1986 are projected to add 135,000 MW of generating capacity. Of these 135,000 MW, 70,000 MW will be operating scrubber units, based on current and proposed NSPS. Coal-fired sites will be located in forty out of the fifty States, with major capacity generated in EPA Regions 4, 5, and 6. The current mix of disposal practices at coal-fired utilities is based on data collected from the most current Federal Power Commission (FPC) tape for their Form 67 data for the year ending 31 December 1974, and a survey of 64 coal-fired utility plants, most of which began operation in the period 1970-1978.[3] The latter data are more up-to-date and more accurate than the FPC data. Based on this survey determining disposal practices by quantities of ash, it is assumed, of the 65,000 MW of capacity coming on line and producing ash only, 51% (33,000 MW) will landfill their wastes, 35% (23,000) will pond them, and the remaining 14% (9,000 MW) are assumed to incur no costs due to resource recovery practices for their ash.[10] This 14% reflects 1977 flyash utilization figures produced by the National Ash Association.*

The data obtained from the 1974 Form 67 or additional contact with 64 plants were not sufficient to cover solid wastes from flue gas desulfurization processes. Additional data was gathered on 38 plants contracted for SO_2 removal systems or under letter of intent to do so by April 1, 1978.[3] These plants should begin operation by 1986. Of 36 plants (25,000 MW) which have decided on disposal options, 19 units (11,500 MW) 46% will utilize landfill and 17 units (13,700 MW) 54% will use ponding. Based on this survey, for the 70,000 MW producing both ash and sludge, 54% are assumed to pond their waste and 46% are assumed to landfill it. (Although some of this scrubbing capacity refers to retrofitting existing facilities, disposal costs for new scrubbing capacity will be handled under new facilities.)

Solid waste capital investment costs for new facilities are estimated to range from $1.4 billion to $1.5 billion. Annual operating costs are estimated to range from $100 to $140 million. This amounts to between $340 and $370 in annualized solid waste costs, of which consumers will pay between .5 and .6 mills per kwh for solid waste disposal.

*NOTE: In this case 14% approximately reflects the national utilization rate for flyash. Bottom ash, due to its higher carbon content, has a higher economic value and was utilized at a higher rate of 33%.

The majority of these national solid waste disposal costs include base solid waste costs incurred for disposal of waste according to current practices. The remainder of the costs are assignable to existing Federal regulations, (specifically, section 404 of the Federal Water Pollution Control Act) and State solid waste regulations, and Section 4004 (which have comparable provisions for wetlands and floodplains protection). In order to develop the cost impact of Section 4004, projections are made regarding future disposal practices based on compliance with the ground-water, wetlands and floodplain provisions. Costs to comply with these three criteria are isolated. State solid waste regulations and existing Federal regulations are assessed for corresponding criteria and the assignment of State-standards costs is performed. The grid prepared for the Economic Impact Analysis for the Criteria was utilized for this operation. The final cost for Section 4004 is the difference between the costs to comply with the criteria and federal and state-standard induced costs.

a. Ground Water

The first criteria requiring safeguards by the coal-fired utility industry is the ground-water criterion.

Clay lining, monitoring wells and leachate collection and treatment facilities are considered to be the best available control technology for prevention of ground-water contamination. The extent to which these measures are employed at each site is entirely site specific. Certain natural conditions at the disposal site may provide adequate protection without a liner. These conditions include soil characteristics, hydrogeologic and geologic conditions and climate.

Very little information is currently available to determine what percentage of sites will require liners. The majority of utility plants employ on-site disposal. Since they are located relatively close to their water source, there is a high probability these sites will be located on sandy, alluvial soil which is highly permeable.

For the purpose of estimating the cost to protect ground water, it is assumed that two-thirds of all new sites will require liners and the remaining one-third will locate on land providing an indigenous liner. These percentages are based on three data points available from monitoring at utility disposal sites.[11, 12, 13]

It is assumed a .6m natural clay liner will prevent endangerment of the ground water. The national cost for clay liners is estimated to be between $280 and $314 million in capital investment costs. This is based on material and installation costs of approximately $5.80/m^3.[14] These capital investment costs can be annualized to $45-50 million a year.

Monitoring costs vary from site to site, depending on the data collected. Monitoring is costed into each site at a price of $40,000 for capital investment and $16,800 per year for analysis. This $40,000 capital investment cost reflects 4 3-cluster piezometer wells to determine direction of ground water, 7 sampling wells, and cost of drilling, engineering, mobilization, equipment and materials.[15] The annual operating costs include quarterly sampling and a comprehensive annual sampling.

Monitoring costs are assumed at all disposal sites. Monitoring costs are estimated at $5.4 million for capital investment and $2.3 million per year for analysis. This equals an annualized cost of $3 million per year.

Leachate collection and treatment systems are not included in these total national costs. A clay-lined pond is assumed to prevent contamination and the supernatant pump is assumed to maintain the water balance and eliminate the need for collection and treatment. It is also assumed the landfill will be constructed to prevent the problem of leachate. Due to the unknown nature of leachate, the amount occurring and the degree of treatment, no exact costs are available for leachate treatment and collection. If leachate collection and treatment becomes necessary at lined landfills costs will increase. If annual treatment costs per gallon of leachate average 2¢ a gallon,[14] annual solid waste 'costs for the industry would increase by approximately $23 million.

Thirty-one of the forty states in which coal-fired utilities are projected are assumed to have a ground-water criterion comparable to the Section 4004 criteria. Approximately one-third of projected capacity is located in the remaining nine states; therefore one-third of the ground-water projection costs are attributable to Section 4004.[16] These costs are estimated to be $95-105 million in capital investment, $.8 million in annual operating costs or an annualized cost of $16-18 million per year.

b. Wetlands

The degree to which new facilities would be likely to locate disposal facilities in wetland and violate surface water criterion is unknown. There are currently very few detailed maps available designating wetland areas. The U.S. Office of Fisheries and Wildlife has begun extensive mapping of wetland areas; however, this project is only scheduled for completion in 1983.

For the purpose of determining to what degree coal-fired utilities in states with varying concentration of wetland will be affected, Land Use Development maps available at the U.S. Geological Survey were consulted. The longitude and latitude of utilities in two states, South Carolina and Pennsylvania, were used to determine the location of plants in relation to wetlands. South Carolina was chosen as a state with high concentration of wetlands and Pennsylvania as a state where wetlands are sparser. The majority of existing coal-fired utilities in South Carolina are located near enough to wetlands to assume all existing sites are affected and future sites will be affected. The coal-fired utilities which were plotted in Pennsylvania were not affected by the wetlands. Therefore it is assumed existing sites and future sites, in this state, will not be affected.

To apply these conclusions to the nation the Natural Wetlands map by the U.S. Water Resources Council, 1968 (see appendix) was consulted. The twelve states which contain large concentrations of wetland are: Arkansas, Florida, Georgia, Louisiana, Michigan, Minnesota, North Carolina, North Dakota, South Carolina, South Dakota, Texas and Wisconsin. It is assumed sites in these states will be affected by the wetlands provision and sites in the remaining states will not be affected. Approximately 60 plants or twenty percent of the projected coal-fired generating capacity will be built in these twelve states.

The distances from the plant to which these disposal sites must move are unknown and will vary. Costs were developed for distances of 8 km (5 miles) and 16 km (10 miles) from the site. Where wetlands are highly dense, it is assumed the disposal site will be located 16 km from the plant; other sites in less dense areas are assumed to be able to locate disposal sites 8 km away.

Three scenarios are examined for the national costs of wetlands criterion. The first case assumes that all 60 new facilities are denied NPDES permits and will be forced to locate their disposal facilities outside the wetlands. For this case 50% MW of the sites are assumed to move 8 km from their plant and 50% are assumed to move 16 km.

The second national cost which is developed assumes that sites located in Louisiana, Texas, Florida, North Carolina and South Carolina will be granted NPDES permits. Due to the ubiquitous nature of wetlands in these states, it is assumed that no technically or economically feasible alternative exists for disposal. Twenty-five of the sixty sites are located in wetlands in states other than these five states. The 25 sites represent 8 percent of the projected coal-fired generating (10,600 MW) capacity. Because these states are those with sparser wetlands it is assumed all these sites will only be required to move a maximum of 8 km.

The third scenario assumes all sites applying for an NPDES permit will be granted one. In this case, no additional costs are incurred.

The costs of increasing the distance from a coal-fired utility and its disposal pond include additional capital expenses for larger pumping facilities and piping installations to the disposal site and additional operating costs resulting from greater transportation distances. For the purposes of this study, it is assumed that moving a pond 8 km from the plant increased capital costs 56% and annual operating costs 69% from the base case. Moving a pond 16 km from the site is assumed to increase capital investment 117% and annual operating costs 129%.

Landfill costs increase due to costs of additional equipment for transporting the wastes and increased operation and maintenance costs due to increased distances. For the purpose of this study, it is assumed moving a landfill 8 km will increase capital investment costs 6% and annual operating costs 23%. Moving a landfill 16 km will increase capital costs 11% and annual operating costs 41%. These percentage figures are taken from EPA Report 600/7-78-023A "Economics of Disposal of Lime/Limestone Scrubbing Wastes; Untreated and Chemically Treated Wastes." Corresponding annual operating costs are extrapolated and shown in Table VII-16.

In order to develop the cost incurred due to increased transportation, two assumptions come into play. It is assumed a plant will use the cheapest disposal method at the new site. It is also assumed for plants requiring to site their disposal sites 8 or 16 km from the plant, a higher probability exists for locating impermeable sites. For those sites forced to move 8 km from the site, 50% will be required to line. For those sites 16 km away, only one out of three will be required to line. What would normally account for an increase of capital cost due to increased distance to the disposal site is off-set by these two assumptions. The first is sites which would have previously ponded will convert to landfilling. This assumption results in a substantial decrease in capital costs. Secondly, because it is assumed the probability of finding sites with indigenous clay liners increases, the increase in capital costs caused by the additional distance to the site is off-set by the decrease in liner expense.

The majority of the cost impact of the wetlands criteria is seen in increasing operating costs.

The additional solid waste disposal costs incurred if all new facilities are denied NPDES permits and 10% of new facilities are required to move 8 km and 10% of new facilities are required to move 16 km amounts to $39 million in annual operating costs.

Under the second scenario, additional annual operating and maintenance charges amount to $14 million.

The wetlands criterion is a direct attempt to coordinate solid waste regulation with the Clean Water Act. The issuance or denial of these permits and the resulting requirement to move are costs assignable to the Clean Water Act of 1972 and are not charged to Section 4004.

c. Floodplains

The total cost impact of this criterion consists of costs to protect sites against washout by the 100-year flood.

Based on the assumption that 100 percent of these facilities will be located in the floodplain, costs to protect against washout are the costs of flood protection dikes for all new facilities. Since the levels and velocity of each flood are site specific, the height and material requirements for each dike will vary. A 3 meter dike is assumed to be a sufficient average height to protect against the floodwaters. A cost of $\$2.60/m^3$ for fill material is assumed to cover the cost of building a dike on dry land. This price includes availability and compactability of the material as well as leveling and digging expenses.[17]

The capital costs of the pond discussed earlier already include embankments approximately 9 meters high. It is assumed these embankments can and will be built to protect against the floodwaters. Because these embankments are constructed in the absence of flood protection requirements, only the portion of the costs incurred for protection against erosion are charged to the criterion. It is assumed $1.40/$m^3$ is the base price for building the embankment for the pond.[18] Therefore, the remaining $1.20/$m^3$ required for protection against washout is attributed to the criterion.

The cost of flood protection for landfills includes the entire cost of the 3 meter dike.

[<u>NOTE</u>: *In the previous chapters of this EIA, costs for flood proofing* were assumed to be based on a 3:1 sloped dike and material and placement costs of $2.00/$m^3$. Separate calculations were performed to determine the dollar value by which these estimated costs would change based on these two varying assumptions.

Because the dike surrounding the landfill is only 3 meters high, a 2:1 slope is technically feasible.

The higher cost for material of a dike used for this coal-fired utility report with a 2:1 slope off-sets the lower estimate for volume of material required for a dike with a 2:1 slope surrounding the landfills in this report. Costs to protect against washout would be reduced by approximately $17,000 for flyash landfill sites and $26,000 for flyash/sludge landfills, which accounts for less than .2% and .4% of total capital investment costs respectively. Due to the insignificant amount of these costs, this difference is not accounted for in the total flood protection figure.

For the 9 meter dike which is currently built to surround a surface impoundment, a 3:1 slope may be the most technically and economically feasible option to protect against washout and insure that the dike will not erode with the 100-year flood. The difference in costs between the assumptions made in this report and those previously mentioned is an additional capital investment cost of $221,000 in capital costs for the flyash pond and $272,000 for the flyash/sludge pond. These costs represent an increase of 1.7% and 1% of capital costs respectively. This difference has been included in the following estimates for the cost of flood protection and has been added to total national solid waste costs for new facilities to insure consistency and accuracy.]

Total costs for flood protection are calculated to be $120-$150 million for capital investment,which translate to an annualized cost of $19-24 million.

Only fifteen states are assumed to have comparable floodplain criteria in their solid waste regulations. These states are estimated to include approximately 40% (57,000 MW) of the projected 135,000 MW generating capacity.[19] Assigning the corresponding cost of $48-60 million to states for floodplain protection decreases the Section 4004 criterion costs to $72-$90 million in capital investments.

The total costs for new facilities to meet the ground-water, wetlands and floodplain criteria is estimated to range between $405 and $470 for capital investments and $15.7 and $40.9 for annual operating costs. The annualized costs range from $81 to $116 million which will increase the price of electricity between .14 and .20 mills per kilowatt hour. The total costs assignable to Section 4004 are between $165 and $195 million for capital investment and $.8 million for annual operating cost. Annualized Section 4004 criteria induced costs amount to $27 to 32 million or an increased consumer charge of .04-.05 mills per kilowatt hour.

4. Costs of 4004 on Existing Facilities

In order to assess the cost impact of Section 4004 on existing facilities, the basic methodology employed for new facilities is utilized with adaptations to account for additional knowledge.

Any site which fails the criteria and is listed as an open dump will be closed or upgraded according to a state compliance schedule. Although the average life of a utility plant is thirty years, many existing sites are built for five or ten year portions of this life. Information is not available concerning the age and remaining capacity of existing sites. For the purposes of determining the costs of upgrading and closure, all existing sites are assumed to have a ten year life and to have been in operation for five years. Capital costs incurred for upgrading or closure are annualized for the five years of the remaining life of the site. Therefore a different annuity factor is used.

A power-rating-size cost adjustment factor was used to offset any economies of scale which may exist for new 1000 MW plants coming on line but not for existing plants with an average capacity of 500 MW. It was assumed a capital cost of $1.00/MW for a 1000 MW plant would equal $1.32 and an annual operating cost of $1.00/ton of waste would equal $1.39 for a 500 MW plant. An average of $1.35 was applied to annualized costs to more accurately reflect costs.[8]

Current utility waste disposal practices are considered to be as follows:[20]

DISPOSAL PRACTICE	# OF PLANTS
ASH:	
Lined Pond	25
Unlined Pond	225
Unlined Landfill	175
ASH/SLUDGE:	
Untreated/Unlined Pond	14
Untreated Lined Pond	2
Treated Unlined Pond	1
Treated Unlined Landfill	4
Untreated Unlined Landfill	4
SLUDGE ONLY:	
Untreated Lined Pond	3

Of the approximate 200,000 MW of current coal-fired capacity, 12,000 MW are producing flyash and sludge. The distribution of the megawatt capacity utilizing each disposal practice is based on the previous chart. It is assumed 72 percent pond their sludge and 28 percent landfill.

Of the 188,000 MW producing flyash, 51% (96,000 MW) are landfilling, 35% (66,000 MW) are ponding and 14% (26,000 MW) are utilizing their ash. Sludge/flyash disposal is distributed as follows: 72% (8,700 MW) are ponding and 28% (3,400 MW) landfilling.

In the preceding disposal practice table, treatment refers to chemical/commercial fixation of flyash and sludge. Clarifier, vacuum filtration and centrifuge treatment are not included in this category because they are not considered to change the chemical properties of the water to eliminate leaching or decrease permeability of waste material.

2. Ground Water

Current flyash disposal sites which are lined (6,600 MT) and flyash/sludge sites using liners or chemical fixation (5,500 MW)[20] are assumed to meet sanitary landfill criteria. Of the remaining four hundred sites (155,400 MW) disposing of ash at unlined sites, approximately two-thirds (103,800 MW) are assumed to leach and one-third (51,600 MW) are assumed to be located in soils which provide indigenous liners. These percentages are based on the three data points previously mentioned.[11, 12, 13]

The same assumption is applied to the eighteen sludge disposal sites which neither line nor chemically fix the waste. Two-thirds (4,400 MW) are assumed to leach and one-third (2,100 MW) are assumed to meet the ground-water criteria.

Costs for upgrading sites are shown in Table C-17. It is assumed existing sites are one-third the size of the new facility with a thirty year lifetime. Liner costs of $\$5.80/m^3$ are assumed for material and installation. The cost of liner required for existing facilities is one-third of the cost for new facilities. The cost of removal of the waste is estimated to be approximately $\$.75/m^3$. Once again, very little cost information for removing wastes and upgrading the site is available. One case in Buffalo, New York cites the removal of 1.4 million cubic meters of waste and the construction of a sump to collect leachate for ten million dollars. A cost of $\$.75/m^3$ was assumed to be reasonable for removal of waste. Temporary storage is not included in these costs.[21]

It is assumed monitoring will be established at all existing sites failing the criteria and new replacement facilities. Monitoring expenses include capital costs of $40,000 for sinking wells and $16,800 per year for analysis.

It is assumed that all sites failing the ground-water criteria will be upgraded unless they are located in a wetland area, in which case closure is a possibility.

Due to the additional expense to build a facility to replace the open dump, upgrading costs shown for the model plant are less expensive than closure costs for all cases except flyash landfills. The ultimate decision to close or upgrade will be made by the operator of the site based on the remaining life of the site, land availability and comparative costs of options for compliance.

The cost for utilities to upgrade existing sites (including power-rating-size cost adjustment factor) ranges from $114 million to $216 million for capital investment and $1.3 to $2.5 million for operating costs depending on the number of sites required to close due to location in wetlands. This equals an annualized cost of approximately $37 to 52 million for ground-water protection.

Thirty-seven of the fifty states are assumed to have comparable ground-water regulations. The Section 4004 criteria-induced cost for those thirteen states are 12% of total costs to correspond with the approximate percentage of existing generating capacity located in the thirteen states where state solid waste regulations do not account for ground water (see appendix). Costs assignable to upgrading these sites are between $13 and $26 million for capital investment cost, .16 and .30 in annual operating costs or annualized costs of $4.5 to $8.5 million.

b. Wetlands

It is estimated that approximately 25% of existing sites, or 115 utilities (50,000 MW) of capacity are located in twelve "wetlands" states previously determined. (The background for this assumption is discussed in the wetland portion of the new facility section.) Since wetlands are generally located in shallow ground-water areas, it is assumed that these 50,000 MW are a total subset of the sites affected by the ground-water criterion. Costs are developed for three scenarios. The first scenario assumes that NPDES permits would be denied to all existing sites currently located in wetlands. The second scenario assumes that NPDES permits will be granted to the 30 sites (20,000 MW) in Texas, Louisiana, North Carolina, South Carolina, and Florida because of the lack of technical and economical disposal alternatives. These 30 sites will upgrade to meet the ground-water criterion.

TABLE C-17

COST OF UPGRADING AND CLOSURE +

	COST OF CLOSURE		COST OF UPGRADING	
	Capital ($X10^3$)	O&M	Capital	O&M
Flyash Pond:	2,361	16,800*	1,691	16,800
Flyash Landfill:	823	16,800	1,247	16,800
Flyash/Sludge Pond:	3,872	16,800	3,216	16,800
Flyash/Sludge Landfill:	2,662	16,800	2,373	16,800

Closure costs include capital to close open dumps and cost of replacement facility.

*Annual Operating and Maintenance costs due to the criteria include sampling/analysis shown at $16,800 and any costs incurred due to increased transportation to the disposal site (not shown here).

+These costs do not include power-rating-size cost adjustment factor, which has been applied to national total shown in the text.

The last scenario assumes that all sites will apply for NPDES permits and receive them, depending upon compliance with the technical requirements of Section 4004. These costs are shown as the highest ground-water costs previously discussed.

The cost components of this criterion include costs of closing open dumps, capital costs of establishing a new site and additional annual operating costs due to increased distances.

Closure of an open dump is assumed to require application of .6 m of final permeable cover at $.65/m^3$ and revegetation at $2,500/hectare. The $2,500/hectare includes $500 for seeding and $2,000 for fertilizer.[22]

The criteria-related capital cost of the replacement facility is assumed to be equal to one-sixth of the cost of the thirty year facility, based on a five year life, since only five years of the existing disposal facility capacity is retired. Additional operating costs are those incurred based on increased distances to the site and monitoring analysis.

The costs for these three options are:

	Capital Investment	Annual Operating Costs	Annualized Costs
SCENARIO I	46,600,000	49,100,000	62,200,000
SCENARIO II	28,200,000	22,400,000	30,500,000
SCENARIO III	-0-	-0-	-0-

No information is available regarding the enforcement action which will occur for these existing sites. In any case, these will be costs assignable to the Clean Water Act.

c. Floodplains

As with new sites, it is assumed that 100% of existing disposal sites are located in floodplains. Although utility plants, in recent years, have protected their generating facilities against the 100-year flood, it is assumed very little protection has been provided for their disposal facilities. Compliance costs for the floodplain criterion are the costs are flood protection dikes. Costs for the flood protection dikes for landfills are based on the same cost components used for new facilities. The perimeter of these sites is calculated by reducing the area of fill for the thirty year site to one-third and calculating a new perimeter. An operator may elect to build an embankment around land set aside for future disposal; however, for the purpose of this report, it is assumed only the remaining disposal area will be diked.

The costs for upgrading existing surface impoundment dikes to protect against washout includes application of 3 meters of rip-rap. This assumption is based on current practices for upgrading existing dikes for protection against floods. A rip-rap cost of $\$43/m^2$ is utilized to reflect material and placement costs.[23]

The capital cost for all existing sites to building flood protection dikes is approximately $37-51 million. The $51 million assumes that no existing site is moved. If sites are closed based on the wetland criterion and moved outside the wetlands area, it is assumed no floodplain protection costs will be incurred for sites 8 and 16 km from the plant and this criterion induced cost will decrease by $9-14 million. The annualized cost is between $11 and 16 million.

The twenty-three states shown to have comparable floodplain criteria constitute approximately 78,000 MW or 40% of existing capacity. The cost of upgrading the remaining 60% is assumed to be attributable to Section 4004. The corresponding portion of the diking cost is $22-32 million in capital investments or an annualized cost of $7.0 to 9.9 million.

The entire costs of upgrading existing facilities to meet the ground-water, wetlands, and floodplain criteria will vary depending on the amount of closure required in wetlands. Up to sixty-seven percent of existing capacity (134,000 MW) may be affected by these criteria. Approximately $200 million in capital investment will be necessary to close, upgrade and establish new sites if no existing facilities are permitted to continue in wetlands and $50 million in additional operating expenses would be required. For the least stringent wetland scenario -- no closure -- the cost of these criteria will be $270 million for capital investment and $2.5 million annual operating costs.

The annualized solid waste cost for existing facilities to upgrade to meet the criteria are estimated to range between $78 and $130 million. The consumer charge associated with these increased costs is between .13 and .22 mills per kwh.

The Section 4004 costs are between $36 and $57 million in capital investments, $.16 and $.30 million in annual operating costs. The increased annualized solid waste cost is $12-18 million and the associated consumer charge is .02 to 0.03 mills per kwh.

5. References

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6. Appendix

This appendix contains the charts and calculations which form the basis for extrapolating national solid waste costs and associated costs of compliance with the discussed criteria.

It is not possible to take the reader through each step of each calculation. What is shown are the unit costs and the flow charts of the models used to determine national costs.

Costs are initially calculated for new facilities having a thirty year life. Design and cost data for model plant disposal options are taken from EPRI FP-671 "State-of-the-Art of FGD Sludge Fixation." Changes are made where necessary to reflect costs of the criteria.

These charts take the reader step by step through the calculations for determining the size and costs of the disposal site. The flyash pond and flyash landfill show formulas as well as calculations. The 20% contingency fee added to the disposal site is a safety factor built into the costs which allows for increases in costs or forgotten items. The 50% added on as the owner's expense includes engineering, accounting, interest during construction, allowance for start up and modification, and miscellaneous expenses such as road installation, preparation of the area, installation of drainage facilities, findings, posting, guard duty and covering.

Separate costs are developed for unlined disposal sites and sites 8 km and 16 km from the plant.

All national cost estimates are derived utilizing the average kilowatt capital investment costs and annual operating costs. The projected megawatt capacity employing the various disposal options are multiplied by dollar per kilowatt costs to estimate capital investment required for disposal. Annual operating and maintenance expenses are estimated by coverting these megawatt capacities into equivalent 1000 MW plants and multiplying by annual operating costs shown.

The criteria induced costs are derived utilizing the same methodology. Unit costs ($/KW) for capital investment requirements or annual operating costs are applied to the megawatt capacities shown in the flow charts for the three scenarios. This applies to both new and existing sites.

*Other information in this appendix is self-explanatory. The power-*rating-size cost adjustment factor was applied to the totals shown in this appendix for inclusion in the text. No multiplication for this adjustment is shown.

Table C-18

ESTIMATED COST OF FLYASH POND

ASSUMPTIONS:

Useful Life	30 years
Power Station Load Factor	50 percent
Pond Depth	10.7 meters
Freeboard	1.5 meters
Buffer Zone	32.0 meters
Side Slopes	2 horizontal/1 vertical
Liner	0.6 meters natural clay
Erosion Protection	Rip-rap with filter
Perimeter Fencing	1.8 meters

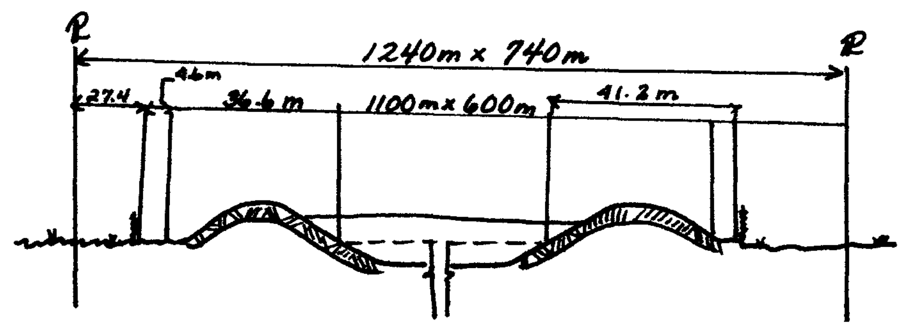


Table C-18 (con't)

Quantity Computations

186,000 MT/year
286,000 MT/year @ 65% solids

1 MT = .6 m^3

172,000 m^3/ year   Allow for water storage   200,000 m^3 / year.

Surface Area at Effective Depth:

$$\frac{m^3/yr \times \#\ yrs.}{\text{effective depth (meters)}} \qquad \frac{200{,}000\ m^3 \times 30}{9.1} = 660{,}000\ m^2$$

Use rectangular dimensions of 1100 m x 600 m

Land Area Required:

$$\frac{\text{length} \times \text{width}}{10{,}000\ m^2/\text{hectare}} \qquad \frac{740\ m \times 1240\ m}{10{,}000\ m^2} = \frac{917{,}600}{10{,}000} = 92\ \text{hectares}$$

Fencing Required

(682 x 2) + (1182 x 2) = 3728 meters

Embankment:

Dike Area:

$$\frac{b_1 + b_2}{2} \times \text{height} \qquad \left(\frac{50}{2}\right)(9.5) = 238\ m^2$$

Dike length at center line:

(1137 x 2) + (637 x 2) = 3550 m

Volume:

Dike area x dike length   238 m^2 x 3550 m = 845,000 m^3

Table C-18 (con't)

Cut:

Depth of cut x Surface area at effective depth   1.3 m (1100 m) (600 m)

Clearing:

$\frac{\text{Surface area of pond including embankment}}{10{,}000\ m^2/\text{hectare}}$ $\frac{(1182\ m)(682\ m)}{10{,}000\ m^2}$ = 81 hectares

Natural Clay Liner:

Area requiring liner x thickness of liner   (1137 m)(637 m) (.6 m) = 434,600 m^3

Rip- Rap:

Perimeter requiring rip rap x depth of rip rap (1123m x 2) + (623 x 2)(3) = 10,500 m^2

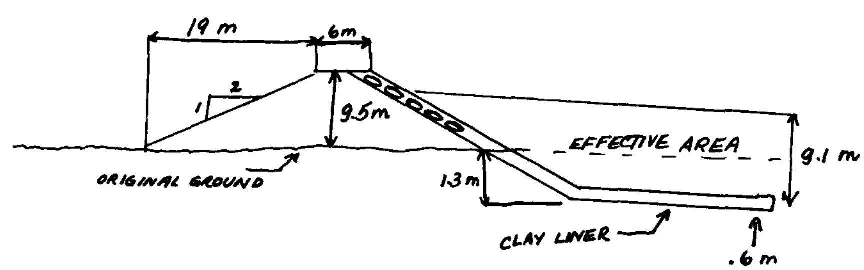


Table C-19
FLYASH POND ANNUAL O & M COSTS

Maintenance	@ 4% of capital		$10 000
Pumping Costs:	@ 75% = $20,000		
	@ 50% = 13,400		13,400
Labor:	9000 hours		99,000
Monitoring:	$400/sample/well with 4 samples		
	7 wells sampled quarterly ($2800 x 4)	$11,200	
	annual sample $800/sample/ well	5,600	16,800
			$139,200

Annual Revenue Requirement

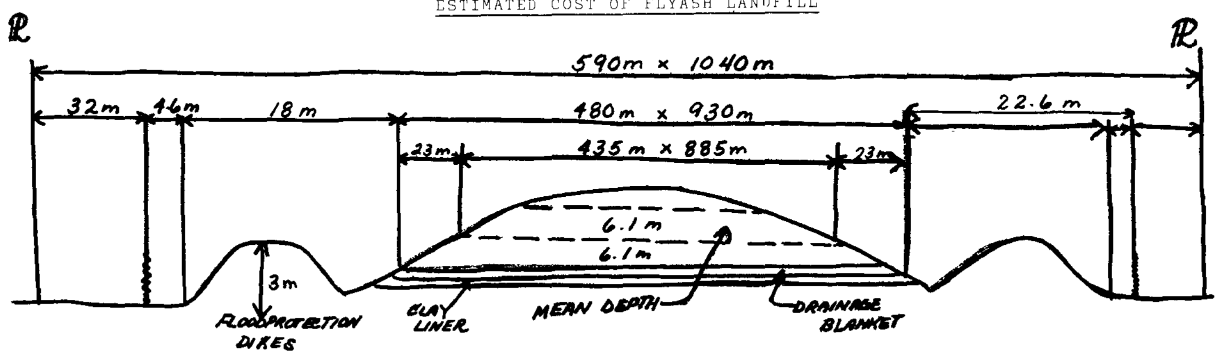
Capital Amortized @ 16% cost of capital over 30 year life .1618 annuity factor	
	2,144,406
Annual O & M	139,200
Annual revenue Requirement	2,283,606

Table C-19 (con't)
Flyash Pond

Capital Cost Estimate:

Clearing	\$2125/hectare	81 hectares	\$172,125
Cut	\$0.65/m^3	865,000 m^3	562,250
Embankment	\$2. 0/m^3	845,000 m^3	2,197,000
Fence	\$33/lineal meter	3728 l.m.	123,000
Clay Liner	\$5.80/m^3	434,600 m^3	2,520,680
Rip-rap	\$36/m^2	10,500 m^2	378,000
Land	\$6250/hectare	92 hectares	575,000
Outlet Structure			80,000
Supernatant Pump			30,000
Instrumentation			60,000
Monitoring			40,000
Sub-total			6,738,055
Contingency @ 20 %			1,347,611
Capital Requirement for Pond			8,085,666
Additional capital expense:			
Processing Facility			250,000
Pipeline System			495,000
Sub-total capital requirement			8,830,666
Owner's Expense at 50%			4,415,333
Total capital requirement			13,245,999

Table C-20
ESTIMATED COST OF FLYASH LANDFILL



Quantity Computations:

Weight of Water at 20% moisture content: Ww = Density of flyash (.96 MT/m^3) x .2 = .192 MT/.96 MT dry ash

.2 MT/MT dry ash

Quantity of waste over life of site

(annual waste)(weight of water) (life of site)

(186,000 MT)(1.2)(30) = 6,696,000 MT

Volume·

1 MT = .7 m^3

6,696,000 x .7 = 4,687,000 m^3

Area at Mean Depth:

$\frac{\text{Volume of Waste}}{\text{mean depth}} = \frac{4,687,000 \text{ m}^3}{12.2 \text{ m}} = 384,000 \text{ m}^2$

Rectangular Dimensions at mean depth:

435 m x 885 m

Land Required:

$\frac{590 \text{ m} \times 1040 \text{ m}}{10,000 \text{ m}^2/\text{hectare}} = \frac{613600 \text{ m}^2}{10,000} = 62 \text{ hectares}$

Table C-20 (con't)

<u>Area of Fill:</u>

480 m x 930 m = 446,400 m^2 = 45 hectares

<u>Fence:</u>

(525x2) + (965x2) = 2980 lineal meters

<u>Embankment:</u>

Dike Area:

$\frac{b_1 + b_2}{2} \times h$ $\frac{24.4}{2} \times 3.0 = 37\ m^2$

Dike length at center line:

(500 m x 2) +(920m x 2) = 2840 m

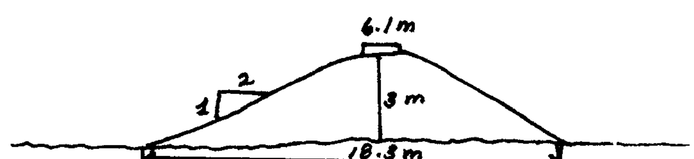
Volume:

Dike area x Dike length

2840 m x 37 m^2 = 105,000 m^3

<u>Clay Liner:</u>

Area of Fill x Depth of liner 446,400 x .6 m = 267,840 m^3



FLOOD PROTECTION DIKE

Table C-20 (con't)

Capital Cost Estimate:		Flyash Landfill
Land: \$6250/hectare	62 hectares	\$ 387,500
Storm and Diversion Drains: \$20,000		20,000
Pugmill to mix flyash and water: \$50,000		50,000
Fence: \$33/lineal meter	2980 lineal meters	98,340
Embankment: \$2.60/m^3	105,000 m^3	273,000
Monitoring: \$40,000/site		40,000
Liner: \$5.80/m^3	267,840 m^3	1,553,472
Subtotal		2,422,312
Contingency at 20%		484,462
Capital Investment for Landfill		2,906,774
Owner's Expense at 50%		1,453,387
Total Capital Requirement		\$ 4,360,161

Error: An additional 4.6 meters of buffer zone is added to the cost of the landfill. This increases land requirements by 1.5 hectares, which amounts to .02 percent of the capital requirement.

Table C-21

FLYASH LANDFILL - ANNUAL O & M

Flyash Transport:		
223,000 MT x .52/MT/km x 3.2 km		371,000
Flyash Disposal:		
Clear: 1.5 hectares @ $2125/hectare		3,200
Strip and Spread Top Soil		2,000
Construct Bottom Ash Underdrain		11,000
Place and Compact Fill: 156,100 m^3 2 $1.65/$m^3$		257,565
Monitoring:		
$400/sample/well with 4 samples		
7 wells sampled quarterly ($2800 x 4)	$11,200	
annual sample $800/sample/well	5,600	16,800
Average annual O & M		$ 661,565

Annual Revenue Requirement

Capital amortized at 16% cost of capital over 30 year life .1618 annuity factor	
	$ 705,475
Annual O & M	661,565
Annual revenue requirement	$1,367,040

Table C-22

ESTIMATED COST FOR CO-DISPOSAL OF FLYASH AND SLUDGE POND

ASSUMPTIONS:

Useful Life	30 years
Power Station Load Factor	50 percent
Pond Depth	10.7 meters
Freeboard	1.5 meters
Buffer Zone	32.0 meters
Side Slopes	2 horizontal/1 vertical
Liner	0.6 meters natural clay
Erosion Protection	Rip-rap with filter
Perimeter Fencing	1.8 meters

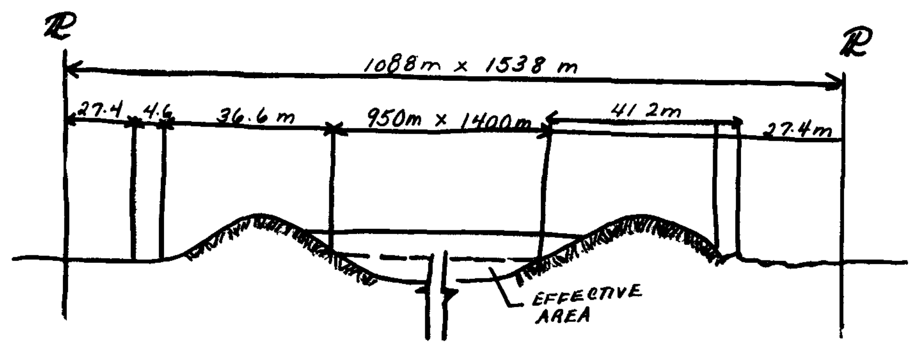


Table C-22 (con't)

Quantity Computations:

186,000 MT ash
161,000 MT sludge
347,000 MT/year

Assume ponding at 65% solids
534,000 MT/year
wet bulk density 1 MT = .6 m^3

Volume:

321,000 m^3 Assume 400,000 m^3 for water storage

Surface Area at Effective Depth:

$\frac{400,000\ m^3 \times 30\ years}{9.1\ m} = 1,320,000\ m^2$

Use rectangular dimensions of 950 m x 1400 m

Land Area Required:

$\frac{1088\ m \times 1538\ m}{10,000\ m^2} = 168$ hectares

Fence Required:
(1033 m x 2) + (1483 m x 2) = 5032 lineal meters

Embankment:

Dike area: $\frac{50}{2} \times 9.5 = 238\ m^2$

Dike length at center line: (987 m x 2) + (1437 m x 2) = 4850 m

Volume: 4850 m x 238 m^2 = 1,154,300 m^3

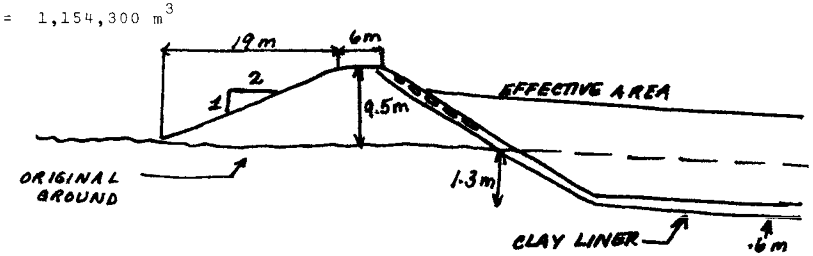


Table C-22 (con't)

Cut:

$1.3 \text{ m} \times 950 \text{ m} \times 1400 \text{ m} = 1,729,000 \text{ m}^3$

Clearing:

$\frac{1032 \text{ m} \times 1482 \text{ m}}{10,000 \text{ m}^2/\text{hectare}} = 153 \text{ hectare}$

Clay Liner:

$987 \text{ m} \times 1437 \text{ m} = 1,418,300 \text{ m}^2 \times .6 \text{ m} = 851,000 \text{ m}^3$

Rip-rap:

$[(973 \text{ m} \times 2) + (1423 \text{ m} \times 2)]3 = 14,400 \text{ m}^2$

Table C-22 (con't)

Capital Cost Estimate:		Flyash/Sludge Pond	
Clearing	\$2125/hectare	153 hectares	\$ 325,125
Cut	\$0.65/m^3	1,729,000 m^3	1,123,850
Embankment	\$2.60/m^3	1,154,300 m^3	3,001,180
Fence	\$33/lineal meter	5032 lineal meters	166,056
Clay Liner	\$5.80/m^3	851,000 m^3	4,935,800
Rip-rap	\$36/m^2	14,400 m^2	518,400
Land	\$6250/hectare	168 hectares	1,050,000
Outlet Structure			80,000
Supernatant Pump			60,000
Instrumentation			30,000
Monitoring			40,000
Sub-total			11,330,411
Contingency @ 20 %			2,266,082
			13,596,493
Additional capital expense:			
Processing Facility			250,000
Pipeline System			495,000
Sub-total capital requirement			14,341,493
Owner's Expense at 50%			7,170,747
Total capital requirement			\$ 21,512,240

Table C-23

FLYASH/SLUDGE POND - ANNUAL O & M

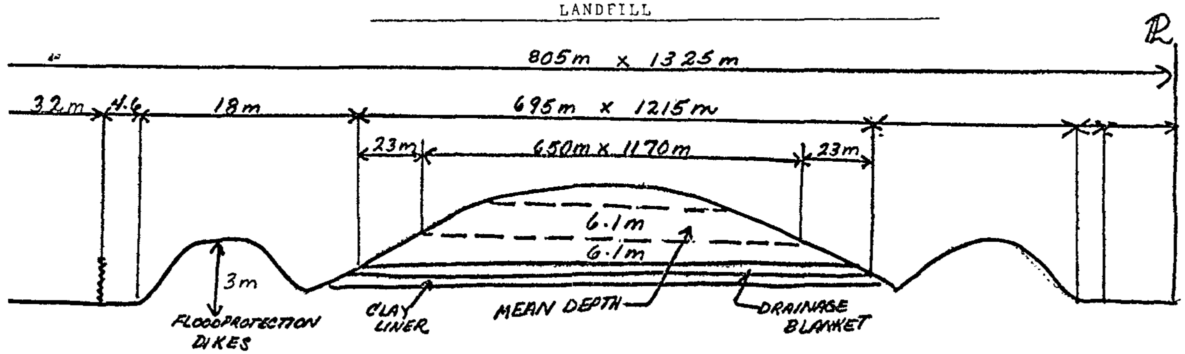
Maintenance	@ 4% of capital		$10,000
Pumping Costs			20,000
Labor:	9000 hours		99,000
Monitoring:	$400/sample/well with 4 samples		
	7 wells sampled quarterly ($2,800 x 4)	$11,200	
	annual sample $800/sample/well	5,600	16,800
			$145,800

Annual Revenue Requirement

Capital amortized @ 16% cost of capital over 30 year life .1618 annuity factor	$3,480,680
Annual O & M	145,800
Annual Revenue Requirement	$3,626,480

Table C-24

ESTIMATED FOR CO-DISPOSAL OF FLYASH AND SLUDGE LANDFILL



Quantity Computations:

186,000 MT Dry Ash
161,000 MT Dry Sludge
347,000 MT total
Assume landfilled at 48% moisture content

.48 x 347,000 = 167,000 MT of H_2O

Total weight = 514,000 MT/year

Total Volume:

1 MT = $.6 m^3$
308,400 m^3/year

9,252,000 m^3 for 30 year life

Surface Area at Effective Depth:

$\frac{9,252,000\ m^3}{12.2\ m} = 758,000\ m^2$

Use rectangular dimensions 650 m x 1170 m

Fence:

(740 x 2) + (1260 x 2) = 4000 lineal meters

Area of Fill:

$\frac{695\ m \times 1215 m}{10,000\ m^2} = 85$ hectares

Clay Liner:

695 m x 1215 m x .6 m = 506,655 m^3

Land Required:

$\frac{305\ m \times 1325\ m}{10,000\ m^2} = 107$ hectares

Embankment:

Area of Dike: $\frac{24.4}{2} \times 3.0 = 37\ m^2$

Dike length at center line:

(732x2) + (1252x2) = 3969 m

Volume: 146,816 m^3

Table C-24 (con't)

Capital Cost Estimate:	Flyash/Sludge Landfill	
Land: $6250/hectare	107 hectares	$668,750
Storm and Diversion Drains: $20,000		20,000
Fence: $33/lineal meter	4000 lineal meters	132,000
Embankment: $2.60/m^3	146,816 m^3	381,722
Monitoring: $40,000/site		40,000
Liner: $5.80/m^3	506,655 m^3	2,939,600
Subtotal		4,182,072
Contingency at 20%		1,672,829
Capital Investment for Landfill		5,854,901
Additional Capital Expense:		
Processing Facility		4,050,000
Subtotal		9,904,901
Owner's Expense at 50%		4,952,450
		$14,857,351

Error: Again, an additional 4.6 meters of buffer zone is added to the cost of the landfill. This increases land requirement by only 2.0 hectares, which amounts to less than .1% of the capital requirement.

Table C-25

FLYASH/SLUDGE LANDFILL - ANNUAL O & M

Waste Transport:		
514,000 MT x$.52/MT/km x 3.2 km		$855,296
Processing Facility Operation:		665,000
Disposal Operation:		
Clear 3 hectares @ $2125/hectare		6,375
Strip and Spread Topsoil 4,600 m^3 @ $.65/$m^3$		2,990
Construct Bottom Ash Underdrain		30,000
Place and Compact Fill 308,400 m^3 @ $1.65/$m^3$		508,860
Monitoring:		
$400/sample/well with 4 samples		
7 wells sampled quarterly ($2800 x 4)	$11,200	
annual sample $800/sample/well	5,600	16,800
Annual O & M		$ 2,085,321

Annual Revenue Requirement

Capital amortized at 16% cost of capital over 30 year life .1618 annuity factor	$2,403,919
Annual O & M	2,085,321
Annual revenue requirement	4,489,240

Figure C-16

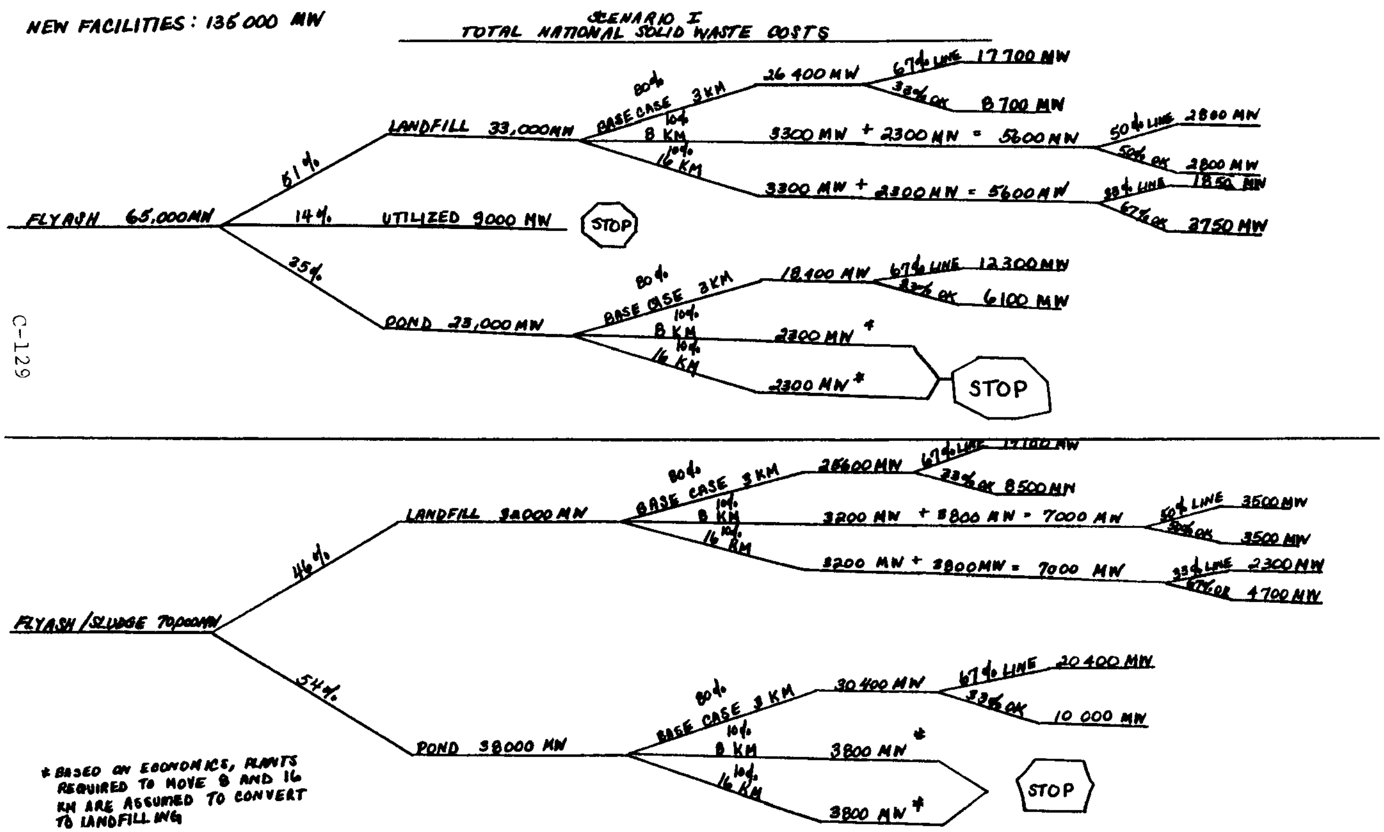

NEW FACILITIES: 136 000 MW
SCENARIO I
TOTAL NATIONAL SOLID WASTE COSTS
FLYASH 65,000 MW
61%
14%
25%
LANDFILL 33,000 MW
UTILIZED 9000 MW
STOP
POND 23,000 MW
80% BASE CASE 3 KM
10% 8 KM
10% 16 KM
26 400 MW
67% LIME 17 700 MW
33% OX 8700 MW
3300 MW + 2300 MW = 5600 MW
50% LIME 2800 MW
50% OX 2800 MW
3300 MW + 2300 MW = 5600 MW
33% LIME 1850 MW
67% OX 3750 MW
18,400 MW
67% LIME 12300 MW
33% OX 6100 MW
2300 MW *
2300 MW *
STOP
FLYASH/SLUDGE 70,000 MW
46%
54%
LANDFILL 32000 MW
80% BASE CASE 3 KM
10% 8 KM
10% 16 KM
25600 MW
33% OX 8500 MW
3200 MW + 3800 MW = 7000 MW
50% LIME 3500 MW
50% OX 3500 MW
3200 MW + 3800 MW = 7000 MW
33% LIME 2300 MW
67% OX 4700 MW
POND 38000 MW
80% BASE CASE 3 KM
10% 8 KM
10% 16 KM
30 400 MW
67% LIME 20 400 MW
33% OX 10 000 MW
3800 MW *
3800 MW *
STOP
* BASED ON ECONOMICS, PLANTS REQUIRED TO MOVE 8 AND 16 KM ARE ASSUMED TO CONVERT TO LANDFILLING

Figure C-17

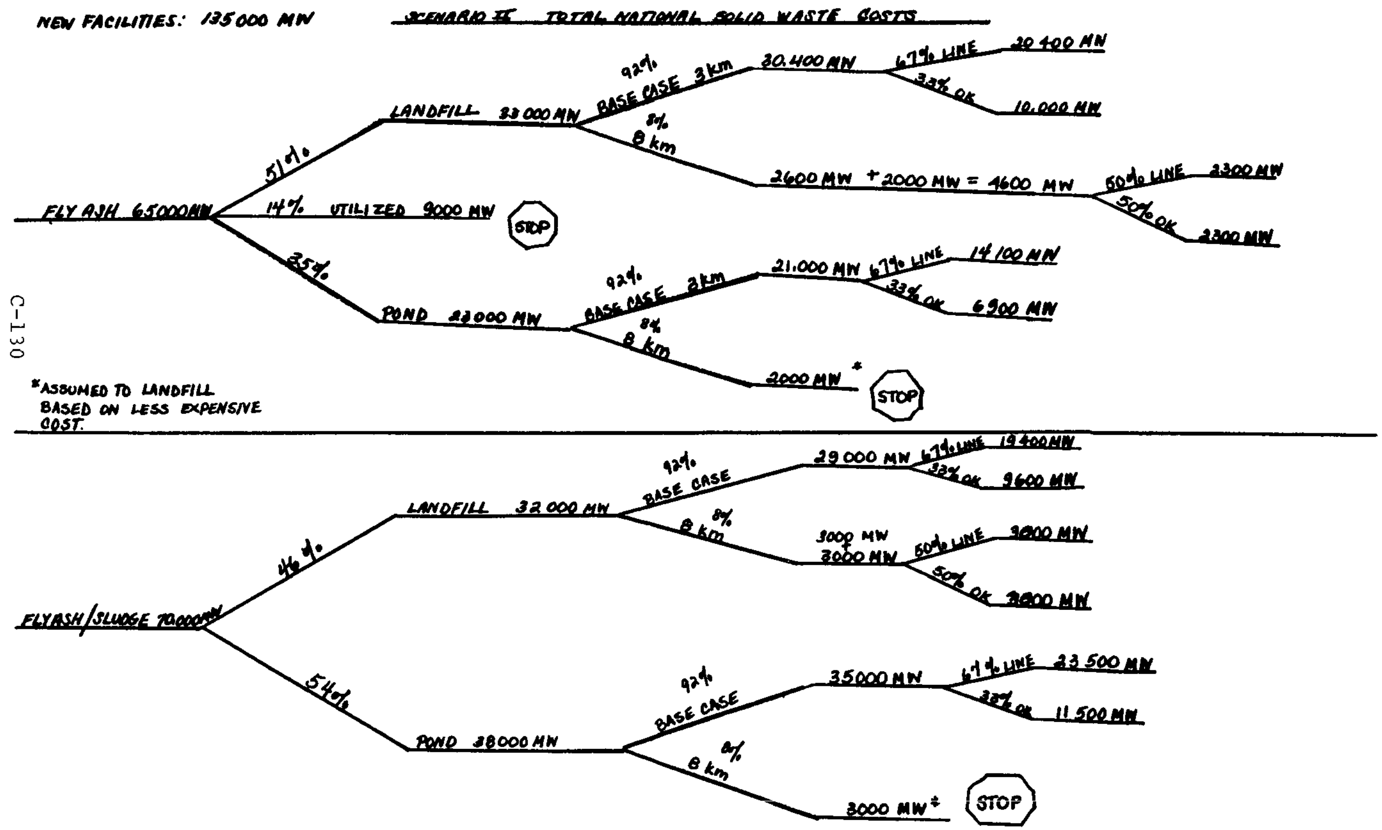
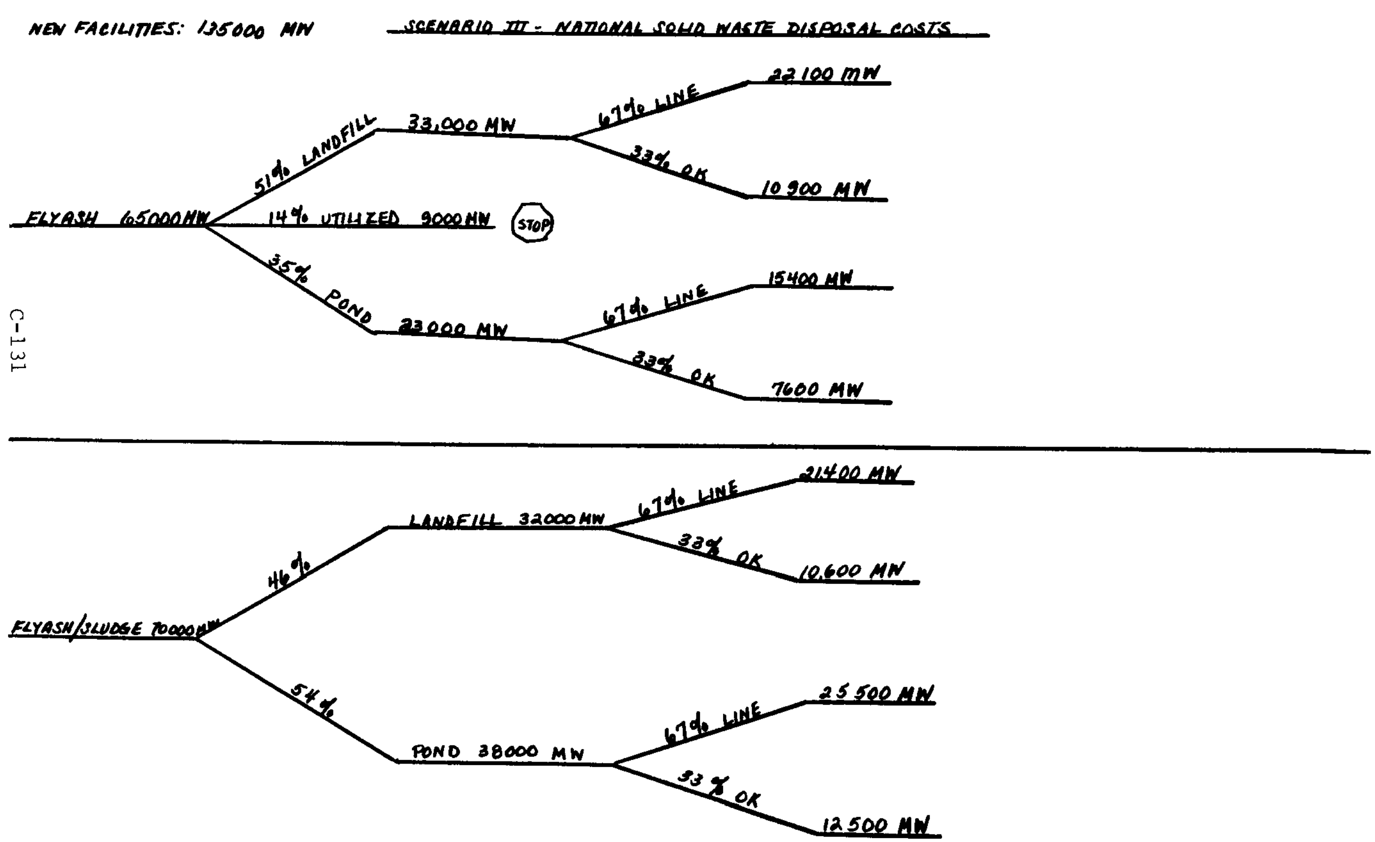

NEW FACILITIES: 135 000 MW
SCENARIO II TOTAL NATIONAL SOLID WASTE COSTS
FLY ASH 65000 MW
51%
LANDFILL 33 000 MW
92%
BASE CASE 3 km
30.400 MW
67% LINE
20 400 MW
33% OK
10.000 MW
8%
8 km
2600 MW + 2000 MW = 4600 MW
50% LINE
2300 MW
50% OK
2300 MW
14%
UTILIZED 9000 MW
STOP
35%
POND 23 000 MW
92%
BASE CASE 2 km
21.000 MW
67% LINE
14 100 MW
33% OK
6900 MW
8%
8 km
2000 MW *
STOP
*ASSUMED TO LANDFILL BASED ON LESS EXPENSIVE COST.
FLYASH/SLUDGE 70.000 MW
46%
LANDFILL 32 000 MW
92%
BASE CASE
29 000 MW
67% LINE
19 400 MW
33% OK
9600 MW
8%
8 km
3000 MW
50% LINE
50% OK
54%
POND 38000 MW
92%
BASE CASE
35000 MW
67% LINE
23 500 MW
33% OK
11 500 MW
8%
8 km
3000 MW *
STOP

Figure C-18



NEW FACILITIES: 135000 MW
SCENARIO III - NATIONAL SOLID WASTE DISPOSAL COSTS
FLYASH 65000 MW
51% LANDFILL
33,000 MW
67% LINE
22100 MW
33% OK
10900 MW
14% UTILIZED 9000 MW
STOP
35% POND
23000 MW
67% LINE
15400 MW
33% OK
7600 MW
FLYASH/SLUDGE 70000 MW
46%
LANDFILL 32000 MW
67% LINE
21400 MW
33% OK
10,600 MW
54%
POND 38000 MW
67% LINE
25500 MW
33% OK
12500 MW

Table C-26

NATIONAL SOLID WASTE COSTS--NEW FACILITIES

	CAPITAL INVESTMENTS	ANNUAL O & M	ANNUALIZED SOLID WASTE COST
SCENARIO I	$1.427 billion	$135.9 million	$367.0 million
SCENARIO II	$1.485 billion	$101.8 million	$342.4 million
SCENARIO III	$1.526 billion	$ 99.3 million	$344.0 million

Table C-27

CRITERIA-INDUCED COSTS
NEW FACILITIES

CAPITAL INVESTMENT

SCENARIO	I	II	III
Wetlands	-0-	-0-	-0-
Floodplains	121,690,000	139,570,000	152,110,000
Groundwater:			
Liners	279,880,000	302,480,000	313,540,000
Monitoring	5,400,000	5,400,000	5,400,000
TOTAL	406,970,000	447,450,000	471,050,000
TOTAL			

Annualized for 30 year life of site at approximately 16% cost of capital

ANNUAL O & M

	I	II	III
Wetlands	38,587,400	13,431,600	-0-
Floodplains	-0-	-0-	-0-
Groundwater:			
Liners	-0-	-0-	-0-
Monitoring	2,270,000	2,270,000	2,270,000
Total	40,857,400	15,701,600	2,270,000

Table C-28

CAPITAL COST--CLAY LINER

FLYASH POND:		$2,520,680	
	20% contingency	504,136	
		$3,024,816	approx. $3/kw
FLYASH LANDFILL:		$1,553,472	
	20% contingency	310,694	
		$1,864,166	approx. $1.90/kw
FLYASH/SLUDGE POND:		$4,935,800	
	20% contingency	987,160	
		$5,922,960	approx. $5.90/kw
FLYASH/SLUDGE LANDFILL:		$2,939,600	
	20% contingency	587,920	
		3,527,520	approx. $3.50/kw

The above cost estimates are used to estimate the capital investment required for .6 m of natural clay liner. In order to derive an estimate for an unlined pond the above costs plus an additional 50% for owner's expense is subtracted from the base cases. The entire costs of the clay liners including the 50% owner's expense are:

FLYASH POND = $4,537,224
FLYASH LANDFILL = $2,796,249
FLYASH/SLUDGE POND = $8,884,440
FLYASH/SLUDGE LANDFILL = $5,291,280

Table C-29

MONITORING COSTS

CAPITAL INVESTMENT = $40,000 or $.04/kw

ANNUAL O & M = $16,800

Table C-30

LEACHATE TREATMENT AND COLLECTION

FOR LINED LANDFILLS ONLY

FLYASH LANDFILL $446{,}400\ m^2 \times \frac{.15\ m}{yr.} \times \frac{7.5\ gal}{.028\ m^3} = 17{,}935{,}714$ gal.

FLYASH/SLUDGE LANDFILL $844{,}425\ m^2 \times \frac{.15\ m}{yr.} \times \frac{7.5\ gal}{.028\ m^3} = 33{,}927{,}790$ gal.

Assume treatment cost @ 2¢ per gallon

FLYASH LANDFILL = $359,000

FLYASH/SLUDGE LANDFILL = $679,000

FORMULA FOR DERIVING GALLONS OF LEACHATE ASSUMING A .15 m INFILTRATION RATE

$$\frac{\#\ m^2}{site} \times \frac{.15}{yr.} \times \frac{ft^3}{0.028\ m^3} \times \frac{7.5}{ft^3}$$

Table C-31

COST OF DIKING

		AMOUNT SPENT IN ABSENCE OF FLOODPLAIN CRITERIA*	CRITERIA-INDUCED PORTION
FLYASH POND: @$2.60/$m^3$			
	$2,197,000	$1,183,000	$1,453,400
w/20% cont.	439,400		
	$2,636,400	(845,000 m X $1.40)	
FLYASH LANDFILL:			
	$273,000	-0-	$327,600
w/20% cont.	54,600		
	$327,600		
FLYASH/SLUDGE POND:			
	$3,001,180	$1,616,160	$1,985,256
w/20% cont.	600,236		
	$3,601,416	(1,154,300 m^3 X $1.40)	
FLYASH/SLUDGE LANDFILL:			
	$381,722	-0-	$458,066
w/20% cont.	76,344		
	$458,066		

* Amount spent in the absence of floodplain criteria refers to building the dike to contain the waste but not to protect against washout from the 100-year flood. These dollar amounts reflect a unit cost of $1.40/$m^3$ which is normally spent to construct the embankments.

Table C-32

CORRECTIONS FOR DIFFERENT DIKING ASSUMPTIONS

TYPE OF DISPOSAL	ASSUMPTIONS IN THIS REPORT	ASSUMPTIONS IN EIA
FLYASH POND	Side slopes = 2:1	Side slopes = 3:1
	Area of dike = 238 m^2	Area of dike = 328 m^2
	Dike length at center line = 3550 m	Dike length at center line = 3630m
	Volume of material required = 844,900 m^3	Volume of material required = 1,190,640 m^3
	Unit price = \$2.60/m^3	Unit price = \$2.00/m^3
	Total price including 20% contingency \$2,636,400	Total price including 20% contingency \$2,857,200
DIFFERENCE = \$220,800		
FLYASH LANDFILL	Side slopes = 2:1	Side slopes = 3:1
	Area of dike = 37 m^2	Area of dike = 45 m^2
	Dike length at center line = 2880 m	Dike length at center line = 2920 m
	Volume of material required = 106,560 m^3	Volume of material required = 131,400 m^3
	Unit price = \$2.60/m^3	Unit price = \$2.00/m^3
	Total price including 20% contingency \$332,467	Total price including 20% contingency \$315,360
DIFFERENCE (\$17,107)		

Table C-32 (con't)

CORRECTIONS FOR DIFFERENT DIKING ASSUMPTIONS

TYPE OF DISPOSAL	ASSUMPTIONS IN THIS REPORT	ASSUMPTIONS IN EIA
FLYASH/SLUDGE POND	side slopes = 2:1	Side slopes = 3:1
	Area of dike = 238 m^2	Area of dike = 328 m^2
	Dike length at center line = 4850 m	Dike length at center line = 4928 m
	Volume of material required = 1,154,300 m^3	Volume of material required = 1,613,920 m^3
	Unit price = \$2.60/ m^3	Unit price = \$2.00/m^3
	Total price including 20% contingency \$3,601,416	Total price including 20% contingency \$3,873,408
DIFFERENCE =\$271,992		
FLYASH/SLUDGE LANDFILL	Side slopes = 2:1	Side slopes = 3:1
	Area of dike = 37 m^2	Area of dike = 45 m^2
	Dike length at center line = 3982 m	Dike length at center line = 3916 m
	Volume of material required = 144,004 m^3	Volume of material required = 176,220 m^3
	Unit price = \$2.60/m^3	Unit price = \$2.00/m^3
	Total price including 20% contingency \$449,292	Total price including 20% contingency \$422,928
DIFFERENCE (\$26,364)		

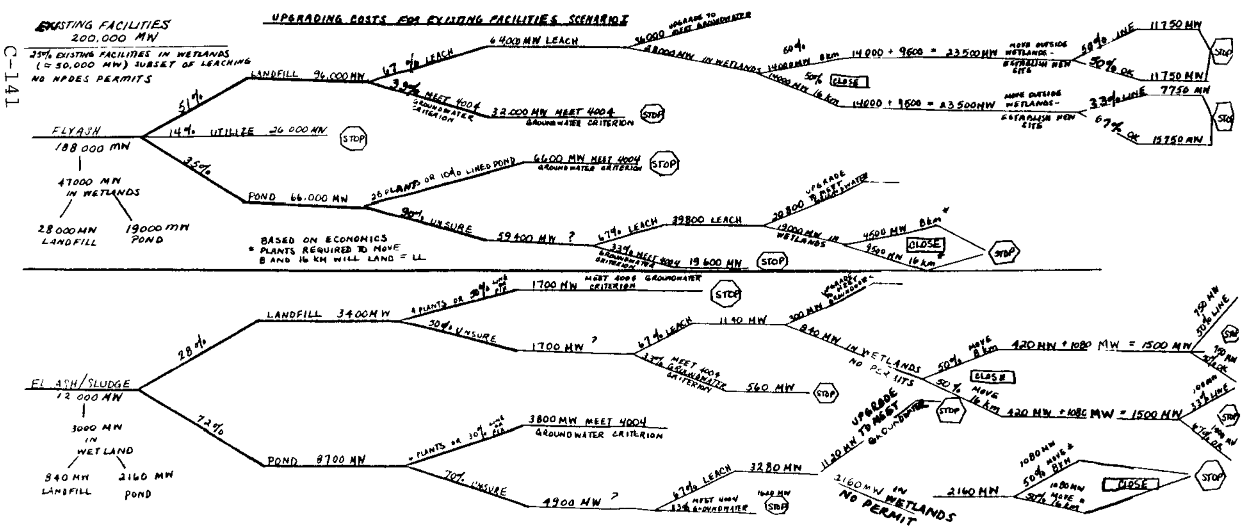
Table C-33

CAPITAL COST --DIKING

FLYASH POND:	Criteria-induced portion	$1,453,400	
	Correction	220,800	
		$1,674,000	Unit cost approx. $1.7/kw
FLYASH LANDFILL		$327,600*	Unit cost approx. $.33/kw
FLYASH/SLUDGE POND:	Criteria-induced cost	$1,985,256	
	Correction	271,992	
		$2,257,248	Unit cost approx. $2.3/kw
FLYASH/SLUDGE LANDFILL:		$458,066*	Unit cost approx. $.46/kw

* Because of small degree of difference due to varying assumptions, no correction is included here.

Figure C-19



* BASED ON ECONOMICS,
PLANTS REQUIRED TO MOVE 8KM WILL
LANDFILL

Figure C-20

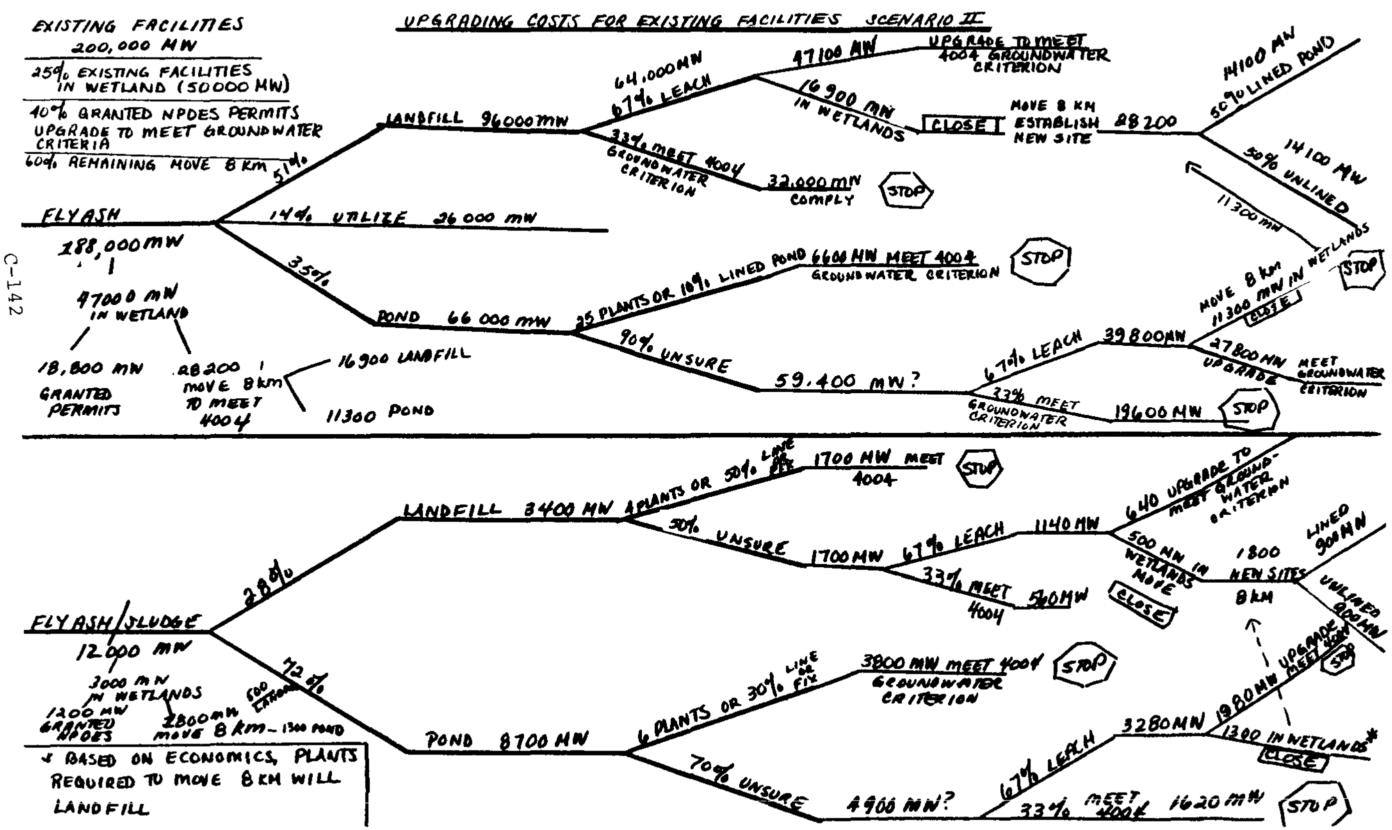

UPGRADING COSTS FOR EXISTING FACILITIES SCENARIO II
EXISTING FACILITIES
200,000 MW
25% EXISTING FACILITIES IN WETLAND (50000 MW)
40% GRANTED NPDES PERMITS UPGRADE TO MEET GROUNDWATER CRITERIA
60% REMAINING MOVE 8 KM
FLY ASH
188,000 MW
47000 MW IN WETLAND
18,800 MW GRANTED PERMITS
28200 MOVE 8 km TO MEET 4004
16900 LANDFILL
11300 POND
51%
LANDFILL 96000 MW
64,000 MW 67% LEACH
47100 MW
UPGRADE TO MEET 4004 GROUNDWATER CRITERION
16900 MW IN WETLANDS
CLOSE
MOVE 8 KM ESTABLISH NEW SITE
28200
14100 MW 50% LINED POND
14100 MW 50% UNLINED
11300 MW
33% MEET 4004 GROUNDWATER CRITERION
32,000 MW COMPLY
STOP
14% UTILIZE 26 000 MW
35%
POND 66 000 MW
25 PLANTS OR 10% LINED POND 6600 MW MEET 4004 GROUNDWATER CRITERION
90% UNSURE
59,400 MW?
67% LEACH
39800 MW
MOVE 8 km 11300 MW IN WETLANDS
27800 MW UPGRADE
MEET GROUNDWATER CRITERION
33% MEET GROUNDWATER CRITERION
19600 MW
FLY ASH/SLUDGE
12000 MW
3000 MW IN WETLANDS
1200 MW GRANTED NPDES
2800 MW MOVE 8 km
1300 POND
28%
LANDFILL 3400 MW
4 PLANTS OR 50% LINE OR FIX
1700 MW MEET 4004
50% UNSURE
1700 MW
67% LEACH
1140 MW
640 UPGRADE TO MEET GROUNDWATER CRITERION
500 MW IN WETLANDS MOVE
1800 NEW SITES 8 KM
LINED 900 MW
UNLINED 900 MW
33% MEET 4004
560 MW
72%
POND 8700 MW
6 PLANTS OR 30% LINE OR FIX
3800 MW MEET 4004 GROUNDWATER CRITERION
70% UNSURE
4900 MW?
67% LEACH
3280 MW
1980 MW UPGRADE MEET 4004
1300 IN WETLANDS*
33% MEET 4004
1620 MW
* BASED ON ECONOMICS, PLANTS REQUIRED TO MOVE 8 KM WILL LANDFILL

Figure C-21

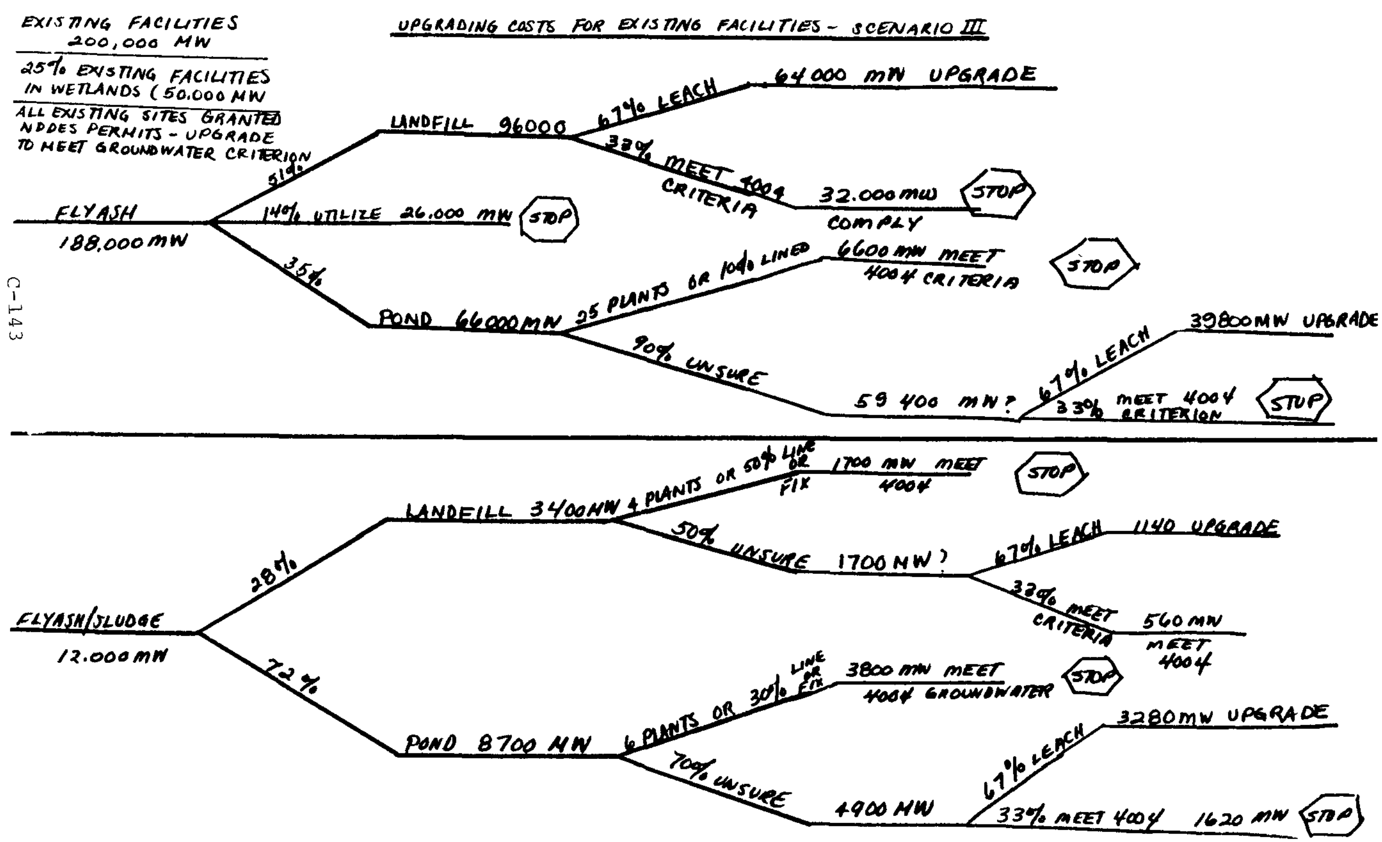

EXISTING FACILITIES
200,000 MW
25% EXISTING FACILITIES IN WETLANDS (50,000 MW
ALL EXISTING SITES GRANTED NPDES PERMITS - UPGRADE TO MEET GROUNDWATER CRITERION
UPGRADING COSTS FOR EXISTING FACILITIES - SCENARIO III
FLYASH
188,000 MW
51%
LANDFILL 96000
67% LEACH
64000 MW UPGRADE
33% MEET 4004 CRITERIA
32,000 MW COMPLY
STOP
14% UTILIZE 26,000 MW
STOP
35%
POND 66000 MW
25 PLANTS OR 10% LINED
6600 MW MEET 4004 CRITERIA
STOP
90% UNSURE
59 400 MW?
67% LEACH
39800 MW UPGRADE
33% MEET 4004 CRITERION
STOP
FLYASH/SLUDGE
12,000 MW
28%
LANDFILL 3400 MW
4 PLANTS OR 50% LINE OR FIX
1700 MW MEET 4004
STOP
50% UNSURE
1700 MW?
67% LEACH
1140 UPGRADE
33% MEET CRITERIA
560 MW MEET 4004
72%
POND 8700 MW
6 PLANTS OR 30% LINE OR FIX
3800 MW MEET 4004 GROUNDWATER
STOP
70% UNSURE
4900 MW
67% LEACH
3280 MW UPGRADE
33% MEET 4004
1620 MW
STOP

TABLE C-34

CRITERIA INDUCED COST
EXISTING FACILITIES

CAPITAL INVESTMENT

SCENARIO	I	II	III
Wetlands:			
Closure	6,211,600	3,857,000	-0-
New Facilities	29,100,000	17,496,000	-0-
	35,311,600	21,353,000	
Floodplains	28,224,600	32,738,000	39,475,000
Ground Water	86,464,000	116,360,000	164,092,000
TOTAL	150,000,000	170,451,000	203,567,000

Annualized for five years at approximately 16% cost of capital.
Annuity factor = .305

ANNUAL O & M

	I	II	III
Wetlands:			
Closure	-0-	-0-	-0-
New Facilities	35,291,920	16,105,450	-0-
Floodplains	-0-	-0-	-0-
Ground Water	978,096	1,302,336	1,818,096
TOTAL	36,270,016	17,407,786	1,818,096

ANNUALIZED COSTS

	I	II	III
	82,020,016	69,395,341	63,906,031

TABLE C-35

ASSUMPTIONS FOR EXISTING SITES

EXISTING SITES ARE ASSUMED TO BE ONE-THIRD THE SIZE OF NEW FACILITIES.

FLYASH POND

Surface area at Effective Depth for New Pond 1100 m x 600 m = 66 hectares
Assume existing site 400 m x 600 m Surface Area = 24 hectares

FLYASH LANDFILL

Area of fill new site: 45 hectares
Assume area of fill at existing site: 15 hectares

FLYASH/SLUDGE POND

Surface Area at Effective Depth for New Pond 950 m x 1400 m = 133 hectares
Assume existing site 470 m x 950 m = 45 hectares

FLYASH/SLUDGE LANDFILL

Area of fill new site: 85 hectares
Assume area of fill at existing site: 29 hectares

TABLE C-36

COST OF CLOSURE

COST OF CLOSURE IS BASED ON .6 METERS OF PERMEABLE COVERING (ON-SITE SOURCE) AT $\$.65/m^3$ AND REVEGETATION COSTS OF $2500/HECTARE.

	PERMEABLE COVER	REVEGETATION	TOTAL COST
FLYASH POND Area = 240,000 m^2	144,000 m^3 $93,600	$60,000	$153,600 $.15/kw
FLYASH LANDFILL Area = 150,000 m^2	90,000 m^3 $58,500	$37,500	$ 96,000 $.10/kw
FLYASH/SLUDGE POND Area = 446,500 m^2	267,900 m^3 $174,135	$112,500	$286,635 $.29/kw
FLYASH/SLUDGE LANDFILL Area = 290,000 m^2	174,000 m^3 $113,100	$72,500	$185,600 $.19/kw

TABLE C-37

COST OF REPLACEMENT FACILITY

REPLACEMENT FACILITY IS ASSUMED TO BE BUILT WITH FIVE-YEAR LIFE.
APPROXIMATE COST IS ESTIMATED TO BE ONE-SIXTH OF NEW FACILITY.

FLYASH POND	CAPITAL INVESTMENT	($/kw)
Lined, 3 km from site	$2,208,000	$2.2
Unlined, 3 km from site	$1,452,000	$1.5
Lined, 8 km from site	$3,444,000	$3.4
Unlined, 8 km from site	$2,264,000	$2.3
Lined, 16 km from site	$4,791,000	$4.8
Unlined, 16 km from site	$3,150,000	$3.2
FLYASH LANDFILL		
Lined, 3 km from site	$ 727,000	$ .73
Unlined, 3 km from site	$ 260,000	$ .26
Lined, 8 km from site	$ 770,000	$ .77
Unlined, 8 km from site	$ 276,000	$ .28
Lined, 16 km from site	$ 807,000	$ .81
Unlined, 16 km from site	$ 289,000	$ .29
FLYASH/SLUDGE POND		
Lined, 3 km from site	$3,585,000	$3.6
Unlined, 3 km from site	$2,105,000	$2.1
Lined, 8 km from site	$5,593,000	$5.6
Unlined, 8 km from site	$3,283,000	$3.3
Lined, 16 km from site	$7,780,000	$7.8
Unlined, 16 km from site	$4,567,000	$4.6
FLYASH/SLUDGE LANDFILL		
Lined, 3 km from site	$2,476,000	$2.5
Unlined, 3 km from site	$1,594,000	$1.6
Lined, 8 km from site	$2,625,000	$2.6
Unlined, 8 km from site	$1,690,000	$1.7
Lined, 16 km from site	$2,749,000	$2.7
Unlined, 16 km from site	$1,770,000	$1.8

TABLE C-38

COST OF UPGRADING

COST OF UPGRADING BASED ON REMOVAL OF WASTE @ $.75/m^3$, RELINING THE SITE ASSUMED TO BE ONE-THIRD COST OF LINER FOR NEW SITE, AND ESTABLISHING MONITORING @ $40,000/SITE.

	REMOVAL OF WASTE	RELINING SITE	MONITORING	TOTAL COST
FLYASH POND: 1,430,000 MT 858,000 m^3 waste	$ 643,500	$1,008,000	$40,000	$1,691,500 $1.7/kw
FLYASH LANDFILL: 1,116,000 MT 781,200 m^3 waste	$ 585,900	$ 621,000	$40,000	$1,246,900 $1.3/kw
FLYASH/SLUDGE POND: 2,670,000 MT 1,602,700 m^3 waste	$1,201,500	$1,974,000	$40,000	$3,215,500 $3.2/kw
FLYASH/SLUDGE LANDFILL: 2,570,000 MT 1,542,000 m^3 waste	$1,156,500	$1,176,000	$40,000	$2,372,500 $2.4/kw

TABLE C-39

COST OF FLOOD PROTECTION

PONDS: ASSUME UPGRADING EXISTING DIKES WITH 3 METERS OF RIP-RAP

LANDFILLS: ASSUME CONSTRUCTION OF DIKE

<u>FLYASH POND</u>: 400 m x 600 m base of dike 42 m [(484m x 2) + (684 + 2)] 3m = 7,008 m^2

$301,000
$.30/kw

<u>FLYASH LANDFILL</u>: Area of dike = 37 m^2

Dike length at center line = 1672 m

Volume = 61,864 m^3 @ $2.60/$m^3$

$160,800
$.16/kw

<u>FLYASH/SLUDGE POND</u>: 470 m x 950 m base of dike 42 m [(554 m x 2) + (1034 m x 2)] 3m = 9,528 m^2

$409,700
$.41/kw

<u>FLYASH/SLUDGE LANDFILL</u>: Area of dike - 37 m^2

Dike length at center line = 2,322 m

Volume - 85,914 m^3 @ $2.60/$m^3$

$223,400
$.22/kw

Table C-40

EXISTING SITES: STATES AND CORRESPONDING CAPACITIES

FLOODPLAIN CRITERIA

State	EPA Region	No. Plants With Coal-Fired Units	Total Plant Capacity (MW)	Total Coal-Fired Capacity (MW)	Average Coal-Fired Capacity per Plant (MW)
Alabama	IV	10	7991.02	7975.74	797.57
Arizona	IX	3	2534	2441	813.67
Arkansas	VI	0	0	0	0
California	IX	0	0	0	0
Colorado	VIII	8	2519.75	2514.25	314.28
Connecticut	I	0	0	0	0
Delaware	III	2	459.5	459.5	229.75
District of Columbia	III	0	0	0	0
Florida	IV	6	4705.7	3992.8	665.47
Georgia	IV	10	8138.9	7775.2	777.52
Idaho	X	0	0	0	0
Illinois	V	26	17,131.46	16,033.56	616.67
Indiana	V	27	11,790.21	11,558.85	428.11
Iowa	VII	22	3200.58	3077.32	139.88
Kansas	VII	8	2631.4	2157.4	269.68
Kentucky	IV	16	6555.1	6431.1	401.94
Louisiana	VI	0	0	0	0
Maine	I	0	0	0	0
Maryland	III	5	4345.3	3353	670.6
Massachusetts	I	4	2692.12	2642.39	660.6
Michigan	V	27	12,299.03	11,038.45	408.83
Minnesota	V	16	2773.95	2747.95	171.75
Mississippi	IV	0	0	0	0
Missouri	VII	16	8735.19	8092.04	505.75
Montana	VIII	3	939.54	939.54	313.18
Nebraska	VII	3	938	938	312.67
Nevada	IX	2	1910	1910	955
New Hampshire	I	1	506	459	459
New Jersey	II	6	4470.94	3373.71	562.29
New Mexico	VI	3	2872.2	2872.2	957.4
New York	II	10	2967.15	2960.25	296.03
North Carolina	IV	13	11,711	10,905	838.85
North Dakota	VIII	6	1205.5	1205.5	200.92
Ohio	V	35	23,692.61	22,203.34	634.38
Oklahoma	VI	0	0	0	0
Oregon	X	0	0	0	0
Pennsylvania	III	32	20,133.82	18,027.62	563.36
Rhode Island	I	2	242.88	194.5	97.25
South Carolina	IV	9	3870.94	2983.46	
South Dakota	VIII	6	542.9	542.9	90.5
Tennessee	IV	8	10,090.4	10,090.4	1261.3
Texas	VI	2	2300	2300	1150
Utah	VIII	5	923.65	923.65	184.73
Vermont	I	0	0	0	0
Virginia	III	9	6618.12	5629.82	625.54
Washington	X	1	1329.8	1329.8	1329.8
West Virginia	III	12	12,023.45	12,004.86	1000.41
Wisconsin	V	20	5510.55	5250.45	262.52
Wyoming	VIII	5	3046.36	3045.36	609.07
U. S. TOTAL Inventoried for 1976		399	216,349 02	202,379.89	507.22

Total MW Capacity in States with comparable floodplain regulations	78,400 MW approx. 40%

Table C-41

EXISTING SITES: STATES AND CORRESPONDING CAPACITIES

GROUNDWATER CRITERIA

State	EPA Region	No. Plants With Coal-Fired Units	Total Plant Capacity (MW)	Total Coal-Fired Capacity (MW)	Average Coal-Fired Capacity per Plant (MW)
Alabama	IV	10	7991.02	7975.74	797.57
Arizona	IX	3	2534	2441	813.67
Arkansas	VI	0	0	0	0
California	IX	0	0	0	0
Colorado	VIII	8	2519.75	2514.25	314.28
Connecticut	I	0	0	0	0
Delaware	III	2	459.5	459.5	229.7.
District of Columbia	III	0	0	0	0
Florida	IV	6	4705.7	3992.8	665.47
Georgia	IV	10	8138.9	7775.2	777.52
Idaho	X	0	0	0	0
Illinois	V	26	17,131.46	16,033.56	616.67
Indiana	V	27	11,790.21	11,558.85	428.11
Iowa	VII	22	3200.58	3077.32	139.88
Kansas	VII	8	2631.4	2157.4	269.68
Kentucky	IV	16	6555.1	6431.1	401.94
Louisiana	VI	0	0	0	0
Maine	I	0	0	0	0
Maryland	III	5	4345.3	3353	670.6
Massachusetts	I	4	2692.12	2642.39	660.6
Michigan	V	27	12,299.03	11,038.45	408.33
Minnesota	V	16	2773.95	2747.95	171.75
Mississippi	IV	0	0	0	0
Missouri	VII	16	8735.19	8092.04	505.75
Montana	VIII	3	939.54	939.54	313.18
Nebraska	VII	3	938	938	312.67
Nevada	IX	2	1910	1910	955
New Hampshire	I	1	506	459	459
New Jersey	II	6	4470.94	3373.71	562.29
New Mexico	VI	3	2872.2	2872.2	957.4
New York	II	10	2967.15	2960.25	296.03
North Carolina	IV	13	11,711	10,905	838.85
North Dakota	VIII	6	1205.5	1205.5	200.92
Ohio	V	35	23,692.61	22,203.34	634.38
Oklahoma	VI	0	0	0	0
Oregon	X	0	0	0	0
Pennsylvania	III	32	20,133.82	18,027.62	563.36
Rhode Island	I	2	242.88	194.5	97.25
South Carolina	IV	9	3870.94	2983.46	
South Dakota	VIII	6	542.9	542.9	90.5
Tennessee	IV	8	10,090.4	10,090.4	1261.3
Texas	VI	2	2300	2300	1150
Utah	VIII	5	923.65	923.65	184.73
Vermont	I	0	0	0	0
Virginia	III	9	6618.12	5629.82	625.54
Washington	X	1	1329.8	1329.8	1329.8
West Virginia	III	12	12,023.45	12,004.86	1000.41
Wisconsin	V	20	5510.55	5250.45	262.52
Wyoming	VIII	5	3046.36	3045.36	609.07
U. S. TOTAL Inventoried for 1976		399	216,349 02	202,379 89	507.22

Total MW Capacity in States with comparable groundwater regulations — 178,300 MW approx. 88%

Table C-42

MEGAWATT CAPACITIES IN STATES WITH WETLANDS

State	EPA Region	No. Plants With Coal-Fired Units	Total Plant Capacity (MW)	Total Coal-Fired Capacity (MW)	Average Coal-Fired Capacity per Plant (MW)
Alabama	IV	10	7991.02	7975.74	797.57
Arizona	IX	3	2534	2441	813.67
Arkansas	VI	0	0	0	0
California	IX	0	0	0	0
Colorado	VIII	8	2519.75	2514.25	314.28
Connecticut	I	0	0	0	0
Delaware	III	2	459.5	459.5	229.75
District of Columbia	III	0	0	0	0
* Florida	IV	6	4705.7	3992.8	665.47
Georgia	IV	10	8138.9	7775.2	777.52
Idaho	X	0	0	0	0
Illinois	V	26	17,131.46	16,033.56	616.67
Indiana	V	27	11,790.21	11,558.85	428.11
Iowa	VII	22	3200.58	3077.32	139.88
Kansas	VII	8	2631.4	2157.4	269.68
Kentucky	IV	16	6555.1	6431.1	401.94
* Louisiana	VI	0	0	0	0
Maine	I	0	0	0	0
Maryland	III	5	4345.3	3353	670.6
Massachusetts	I	4	2692.12	2642.39	660.6
Michigan	V	27	12,299.03	11,038.45	408.83
Minnesota	V	16	2773.95	2747.95	171.75
Mississippi	IV	0	0	0	0
Missouri	VII	16	8735.19	8092.04	505.75
Montana	VIII	3	939.54	939.54	313.18
Nebraska	VII	3	938	938	312.67
Nevada	IX	2	1910	1910	955
New Hampshire	I	1	506	459	459
New Jersey	II	6	4470.94	3373.71	562.29
New Mexico	VI	3	2872.2	2872.2	957.4
New York	II	10	2967.15	2960.25	296.03
* North Carolina	IV	13	11,711	10,905	838.85
North Dakota	VIII	6	1205.5	1205.5	200.92
Ohio	V	35	23,692.61	22,203.34	634.38
Oklahoma	VI	0	0	0	0
Oregon	X	0	0	0	0
Pennsylvania	III	32	20,133.82	18,027.62	563.36
Rhode Island	I	2	242.88	194.5	97.25
* South Carolina	IV	9	3870.94	2983.46	
South Dakota	VIII	6	542.9	542.9	90.5
Tennessee	IV	8	10,090.4	10,090.4	1261.3
* Texas	VI	2	2300	2300	1150
Utah	VIII	5	923.65	923.65	184.73
Vermont	I	0	0	0	0
Virginia	III	9	6618.12	5629.82	625.54
Washington	X	1	1329.8	1329.8	1329.8
West Virginia	III	12	12,023.45	12,004.86	1000.41
Wisconsin	V	20	5510 55	5250.45	262.52
Wyoming	VIII	5	3046.36	3045.36	609.07
U. S. TOTAL Inventoried for 1976		399	216,349 02	202,379.89	507.22

Total	115	48,741 MW
Total of 5 states with asterisk	30	approx. 20,000 MW

Figure C-22

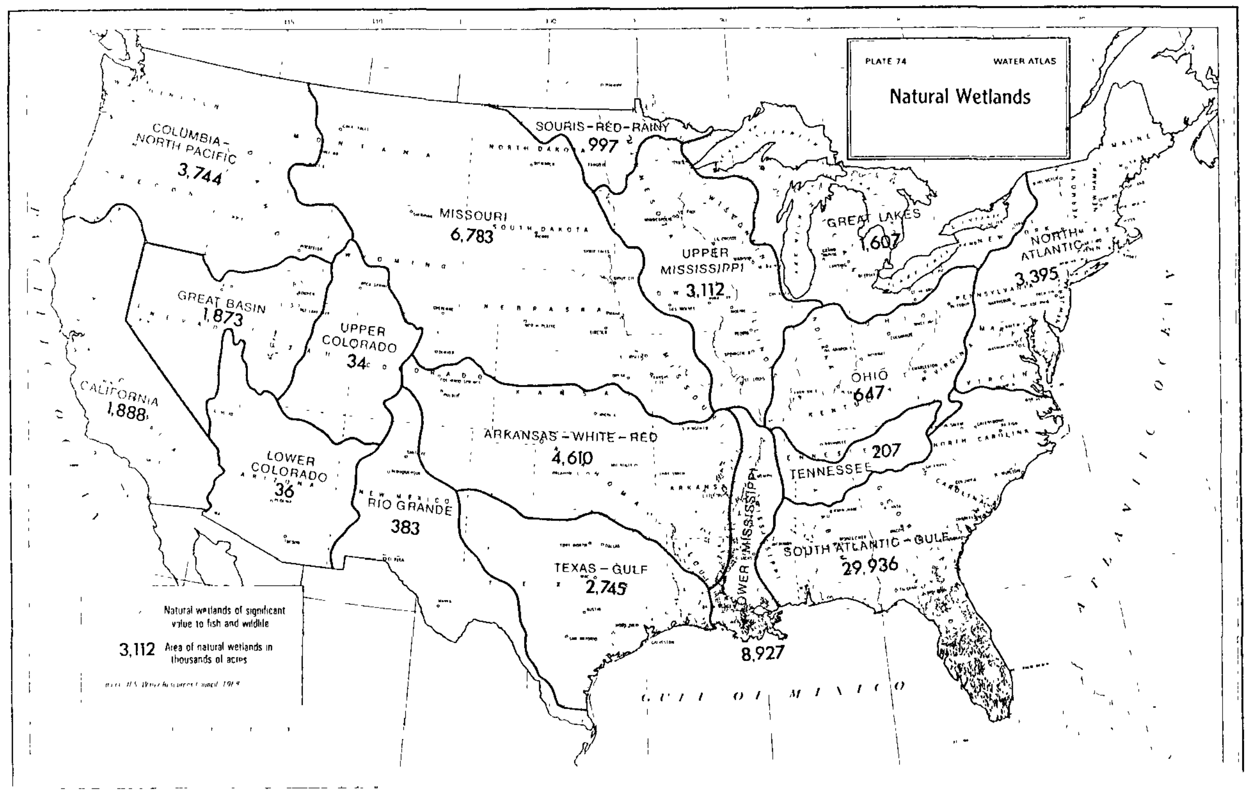


PLATE 74
WATER ATLAS
Natural Wetlands
COLUMBIA-NORTH PACIFIC
3,744
MISSOURI
6,783
SOURIS-RED-RAINY
997
UPPER MISSISSIPPI
3,112
GREAT LAKES
1,607
NORTH ATLANTIC
3,395
GREAT BASIN
1,873
UPPER COLORADO
34
CALIFORNIA
1,888
LOWER COLORADO
36
RIO GRANDE
383
ARKANSAS-WHITE-RED
4,610
OHIO
647
TENNESSEE
207
LOWER MISSISSIPPI
8,927
SOUTH ATLANTIC-GULF
29,936
TEXAS-GULF
2,745
GULF OF MEXICO
Natural wetlands of significant value to fish and wildlife
3,112 Area of natural wetlands in thousands of acres

TABLE C-43

DRY AND WET BULK DENSITIES OF FGD WASTE PRODUCTS[3]

	Specific Gravity	Dry Bulk Density @ Optimum	Dry Bulk Density @ 70% Solids	Dry Bulk Density @ 65% Solids	Dry Bulk Density @ 50% Solids	Wet Bulk Density @ Optimum	Wet Bulk Density @ 70% Solids	Wet Bulk Density @ 65% Solids	Wet Bulk Density @ 50% Solids
		Kgs. Dry Solids/m³				Kgs. Total/m³			
Fly Ash	2.55	1520	1220	1070	720	1790.	1730	1650	1430
Bottom Ash	2.55	1440	1220	1070	720	1760	1730	1650	1430
Scrubber Sludge	2.55	1280	1220	1070	720	1670	1730	1650	1430
Fly Ash and Scrubber Sludge	2.55	1520	1220	1070	720	1790	1730	1650	1430

$$\frac{kg}{m^3} \times \frac{MT}{1000\ kg} = \frac{MT}{m^3}$$

D. COST OF IRON AND STEELMAKING NON-HAZARDOUS SOLID WASTE DISPOSAL TO MEET THE 4004 CRITERIA

1. Summary

The iron and steelmaking industry generates about 50 million metric tons of non-hazardous solid waste per year. However, due to commercial sale and/or in-plant recovery of over 60% of these solid wastes, about 16.5 million metric tons (excluding rubble) of solid wastes remain to be disposed. Table C-44 shows the estimated quantities of non-hazardous solid wastes generated and disposed of by the iron and steelmaking industry. The most common disposal practice in current use is to dump/landfill the various wastes. All assumptions in this report regarding the percentage of current sites not meeting the Section 4004 criteria, the control technologies available for upgrading and the estimated costs of current and future disposal costs were made based on the author's best judgment.

Present disposal costs are estimated to be:

1) on-site - $1.20 to $2.00/MT waste (avg of $1.60/MT)
2) off-site- $2.00 to $3.00/MT waste (avg of $2.50/MT)

These disposal costs take into account the costs of land, labor, and transportation. In addition to these costs, it is estimated that current site operation and maintenance costs are approximately an additional 50%.

Assuming that the current practice is to landfill 50% (8.25 MMT) or iron and steelmaking non-hazardous solid waste on-site and 50% 8.25 MMT) off-site, the total current estimated disposal cost is $50.7 million. Of this $50.7 million, land, labor and transportation costs account for $33.8 million while an additional $16.9 million is incurred for site operation and maintenance. The costs assume that no costs for hydrogeologic surveys, land clearing, and other similar land preparation costs are currently being incurred.

The purpose of this assessment is to determine the cost impact of the final 4004 criteria on the iron and steelmaking industry. Estimated unit costs were derived from several sources (Fred C. Hart Assoc. Inc., Calspan, Draft 4004 EIS). The landfilling design and methods used in making the assessment were assumed merely to provide a basis for estimating various landfilling costs. They were not intended to be considered as guidelines for leachate control. The primary cost involved is the cost of providing protection of ground water from contamination due to leachate.

2. Major Assumptions

The cost of landfilling of these wastes is developed by considering the costs involved for a typical iron and steelmaking plant to provide a solid waste disposal facility which meets the 4004 criteria. A typical plant is considered as having an annual raw steel production of 2.5 million metric tons. The production data for such a typical plant is listed in Table C-45. The concept of a typical plant was utilized in order to develop a base cost from which the national disposal costs could be extrapolated. The derived disposal costs (expressed in $/MT waste) are expected to be representative of the overall industry.

Table C-46 shows the quantities of non-hazardous solid wastes generated and disposed of by the typical plant. Over 305,000 metric tons of waste are disposed of annually by this typical plant. This quantity of solid waste corresponds to a volume of over 173,000 m^3 of waste, using an average density of 1.76 Mt/m^3. Table C-47 lists the volumes assumed for each of the wastes.

It is assumed that all non-hazardous solid wastes will be disposed in a manner which meets the criteria requirements. Only those

TABLE C-44

ESTIMATED ANNUAL QUANTITIES OF NON-HAZARDOUS SOLID WASTES GENERATED BY THE IRON AND STEELMAKING INDUSTRY in 1977
(Based on Raw Steel Production of 114 Million Metric Tons)

WASTE	GENERATION FACTOR kg/MT of process	QUANTITY GENERATED Thousand Metric Tons	WASTE DISPOSITION % Recycled or sold	% Land-filled	QUANTITY LANDFILLED Thousand Metric Tons	POTENTIAL LEACHING constituent of concern[1]
SLAGS						
Blast Furnace	282.0	20,850	95%	5%	1,043	----------------
Basic Oxygen Furnace	145.0	10,204	50	50	5,102	----------------
Electric Furnace	120.0	3,042	20	80	2,434	----------------
Open Hearth Furnace	243.0	4,428	25	75	3,321	----------------
		38,524	69%	31%	11,900	
SCALES						
Soaking Pit	10.0	1,003	--%	100%	1,003	Chromium
Primary Mill	44.9	4,604	80	20	921	Oil, grease
Continuous Casting	8.7	100	80	20	20	Oil, grease
Hot Rolling Mill	10.3	710	80	20	142	Oil, grease
Cold Rolling Mill	0.1	1	60	40	---	Oil, grease
		6,418	67%	38%	2,086	
SLUDGES						
Blast Furnace	24.4	1,804	75%	25%	451	----------------
Basic Oxygen Furnace[2]	17.3	791	25	75	593	----------------
Electric Furnace	8.7	22	--	100	22	Oil, grease
Primary Mill	1.9	192	--	100	192	Oil, grease
Continuous Casting	0.1	1	--	100	1	Oil, grease
Hot Rolling Mill	1.7	68	--	100	68	Oil, grease
Cold Rolling Mill	0.2	3	--	100	3	Oil, grease
Tin Plating	5.3	31	100	--	31	Oil, grease
Galvanizing	10.8	63	100%	--%	63	Oil, grease
		2,975	56%	44%	1,330	
DUSTS						
Blast Furnace	16.2	1,198	85%	15%	180	Chromium, Lead
Basic Oxygen Furnace[3]	16.0	394	25	75	295	----------------
Electric Furnace	12.8	292	10	90	263	Chromium, lead
Open Hearth Furnace	13.7	250	15	85	212	----------------
		2,134	55%	45%	950	
MISCELLANEOUS (Non-Process)						
Flyash[4]	87.2	198	--%	100%	198	----------------
Bottom Ash[4]	21.8	50	--	100	50	----------------
Rubble (brick, lumber, dirt, etc.)[5]	30.0	3,420	--	100	3,420	----------------
		3,668	0%	100%	3,668	
TOTAL		53,471	63%	37%	19,934	

FOOTNOTES

1 The Toxicant Extraction Procedure has not yet been performed on steel mill wastes. Therefore, testing as performed by Calspan Corp, the Pennsylvania Department of Environmental Resources and the American Society for Testing and Materials was used as a basis for determining these potential lacking constituents of concern.

2 64% of Basic Oxygen Furnaces utilize wet emission controls, 35% utilize dry controls. Dust in the form of kisk will be generated whichever device is utilized.

3 Since 90% of electric furnaces utilize dry controls, assume that dry controls are used solely.

4 Generation factor in terms of kg of flyash/bottom ash per metric ton of coal fired. Assume: 2.5 million metric ton of coal consumed; b) ash content of 12%; c) 80% of ash discharged as flyash, 20% as bottom ash.

5 Generation factor is in terms of kg of rubble/metric ton of raw steel produced.

TABLE C-45

PRODUCTION DATA FOR TYPICAL INTEGRATED STEEL PLANT

Facility	Product	Annual Amounts (Metric Tons)
Coke Ovens	Coke	1,120,000
Blast Furnaces	Iron	1,600,000
Basic Oxygen Furnaces	Steel	2,000,000
Electric Furnaces	Steel	500,000
Soaking Pits	Steel Ingots	1,560,000
Primary Mills	Billets, Blooms, Slabs	1,350,000
Continuous Caster	Billets, Blooms, Slabs	790,000
Hot Rolling Mills	Sheet Steel, Bars, Rods Structural Shapes, etc.	1,800,000
Cold Rolling Mills	Sheet Steel	700,000
Tin Plating Mills	Tin Plated Sheets	100,000
Galvanizing Mills	Zinc Coated Sheets	125,000

TABLE C-46

ESTIMATED ANNUAL QUANTITY OF PROCESS SOLID WASTE GENERATED BY A TYPICAL IRON AND STEELMAKING PLANT (2.5 MMT/Year)

WASTE	GENERATION FACTOR kg/MT of process output	QUANTITY GENERATED (MT)	WASTE DISPOSITION % Recycled, or sold	% Dumped	QUANTITY DUMPED (MT)	POTENTIAL LEACHING constituent of concern[1]
SLAGS						
Blast Furnace	282.0	451,200	95%	5%	22,560	----------------
Basic Oxygen Furnace	145.00	290,000	50%	50%	145,000	----------------
Electric Furnace	120.00	60,000	20%	80%	48,000	----------------
		801,200	73%	27%	215,000	
SCALES						
Soaking Pit	10.0	15,600	---	100%	15,600	chromium
Primary Mill	44.9	60,000	80%	20%	12,120	oil, grease
Continuous Casting	8.7	6,900	80%	20%	1,380	oil, grease
Hot Rolling Mill	18.3	32,900	80%	20%	6,580	oil, grease
Cold Rolling Mill	0.1	40	60%	40%	15	oil, grease
		116,036	69%	31%	35,695	
SLUDGES						
Blast Furnace	24.4	39,000	75%	25%	9,750	----------------
Basic Oxygen Furnace[2]	17.3	22,490	25%	75%	16,870	----------------
Primary Mill	1.9	2,520	---	100%	2,520	oil, grease
Continuous Casting	0.1	80	---	100%	80	oil, grease
Hot Rolling Mill	1.7	3,130	---	100%	3,130	oil, grease
Cold Rolling Mill	0.2	110	---	100%	110	oil, grease
Tin Plating	5.3	530	---	100%	530	oil, grease
Galvanizing	10.8	1,350	---	100%	1,350	oil, grease
		69,210	50%	50%	34,340	
DUSTS						
Blast Furnace	16.2	25,900	90%	10%	2,590	chromium, lead
Basic Oxygen Furnace[3]	16.0	11,200	---	100%	11,200	----------------
		37,100	63%	37%	13,790	

1 The Toxicant Extraction Procedure (TEP) has not yet been performed on steel mill wastes. Therefore, testing as performed by Calspan Corporation, the Pennsylvania Department of Environmental Resources, and the American Society for Testing and Materials was used as a basis for determing those potential leaching constituents of concern. Further information can be obtained from the ENVIRO CONTROL, INC. report on Hazardous Wastes Listings; Fully Integrated Steel Mills.

2 64% of Basic Oxygen Furnaces utilize wet emission controls, 35% utilize dry controls. Dust in the form of kisk will be generated whichever device is utilized.

3 Since 90% of electric furnaces utilize dry controls, assume that dry controls are used solely.

TABLE C-47

Annual Volume of Wastes from a Typical Plant

Slags	Quantity(Mt)	Volume/MT (M^3/MT)	Volume (M^3)
BF	22,560	0.62	13,990
BOF	145,000	0.60	87,000
EF	48,000	0.45	21,600
Soaking Pit Slag	15,600	0.15	2,340
Scales	20,095	0.63	12,660
Sludges	34,340	0.63	21,634
Dusts			
BF	2,590	0.80	2,072
BOF	11,200	0.77	8,624
	305,785 MT		173,440 M^3

$$\text{Density} = MT/M^3 = \frac{305{,}785\ MT}{173{,}440\ M^3} = 1.76\ MT/m^3$$

blast furnaces and steelmaking slags and also those other wastes which are processed and/or stored with the purpose of utilizing them through commercial sale and/or in-plant recovery within 90 days are excepted.

Those criteria which will have the greatest impact on the industry are the ground-water criterion and to a much less extent, the floodplains criterion. It is assumed that no present or future disposal sites are or will be located in wetlands. The total national annual cost to the industry for compliance with the 4004 criteria was developed with that portion which is specifically attributable to the criteria, and which would not have been incurred to operate disposal sites according to current practices or in compliance with State solid waste regulations, isolated. Average disposal costs/MT waste are also calculated.

It is assumed that facilities will not be relocated as a result of the criteria: instead, existing facilities will be upgraded as necessary. Fifty percent of the disposal facilities are assumed to be on-site, 50% off-site. On-site is defined as a facility being located on or adjacent to the plant grounds. No differentiation is made as to whether the facility is company, contractor, or otherwise owned. On-site disposal areas typically involve the landfilling of relatively shallow ravines or simply onto flat, open land. Offsite disposal areas typically involve the landfilling of abandoned stripmines, deep ravines or valleys.

The costs were developed using four scenarios:

I off-site (lining material insitu)
II off-site (lining material non-insitu)
III on-site (in floodplain, lining material non-insitu)
IV on-site (not in floodplain, lining material non-insitu)

Ground-water protection is considered to be required in all four scenarios.

These costs represent the total criteria and comparable State regulation induced costs. That portion which is attributable to either comparable State regulations or to the 4004 criteria directly will be identified later.

For each scenario, using as a basis a landfill design life of 5 years in conjunction with the annual volume of wastes (173,000 m^3) disposed of by the typical plant, a landfill area of (450m x 225m) 100,000m^2 (25 acres) is utilized in which the solid wastes are land-filled to a depth of 10m. This landfill design life of 5 years is expected to provide a representative basis from which to extrapolate costs for steel industry disposal facilities nationwide.

3. Costs for each scenario

Costs generated for each of the four scenarios are as follows:

a. <u>Scenario I: Off-site (Lining Material Insitu)</u>

Those items for which costs were included are: site preparation, land clearing, grading and placement of clay liner, surface runoff ditching, leachate collection pond, leachate treatment, closure revegetation, monitoring, and analyses of samples from the monitoring wells. None of these items is considered to be current practice.

It is assumed that 85% of the off-site disposal areas will require additional controls to provide for ground-water protection. 50% of the off-site disposal areas contain suitable clay such that only sloping of the area will insure ground-water protection and leachate collection. The leachate collection pond is sized based on a maximum 10" monthly rainfall with a landfill infiltration rate of 25%. The leachate collected will be treated, with treatment consisting of perhaps heavy metal removal, cyanide and phenol removal, removal of dissolved solids, pH control, and oil skimming, prior to its being discharged. Treatment of the leachate will be based upon an annual average rainfall of 32" with a landfill infiltration rate of 25%. This corresponds to about 15,000 GPD. Leachate monitoring/analysis is assumed to be implemented at each site with a minimum of four wells utilized. Sampling/analysis of indicator parameters is performed on a quarterly basis along with an annual comprehensive analysis.

Closure of the site involves the placement of a 15cm layer of suitable clay and a 30cm layer of natural soil over the landfilled area followed by revegetation.

Other factors included in the estimates are a 20% contingency factor and 12% annual cost of capital factor:

Total Capital Cost	- $248,200
Annualized Capital Cost	- $ 68,850
O & M Cost	- $ 26,000
Total Annual Cost	- $ 94,850

The average cost of disposal/MT waste is $0.31/MT
The average cost of disposal/m^3 waste is $0.55/$m^3$
The average cost of waste disposal/MT raw steel production is $.04/MT

b. Scenario II: Off-site (lining material non-insitu)

A minimum of 0.6m of natural clay will be utilized as the lining material, which is assumed to be obtained from an outside source. The costed items are the same as for scenario I.

Total Capital Cost	- $712,700
Annualized Capital Cost	- $197,000
O & M	- $ 26,700
Total Annual Cost	- $223,700

The average cost of disposal/MT waste is $0.73/MT
The average cost of disposal/m^3 waste is $1.29/$m^3$
The average cost of waste disposal/MT raw steel production is $0.09/MT

c. Scenario III: On-site (in floodplain, lining material non-insitu) - see Figure C-23

It is assumed that 15% of the on-site disposal areas are located in floodplains, thereby necessitating the construction of a 3m dike around the disposal area. 100% of the on-site disposal areas will require additional controls to provide for ground-water protection. All on-site disposal areas are assumed to obtain clay lining material from an outside source as in scenario II. In addition, due to differences in the physical and hydrogeological characteristics of on-site vs. off-site disposal areas, it is assumed that additional leachate collection capability will be needed. Therefore, 4" perforated PVC pipe spaced at 15m intervals the length of the landfill site are utilized. Other items costed remain as in scenario I.

Total Capital Cost	- $944,600
Annualized Capital Cost	- $262,000
O & M	- $ 26,000
Total Annual Cost	- $288,000

The average cost of disposal/MT waste is $0.94/MT
The average cost of disposal/m^3 waste is $1.66/$m^3$
The average cost of waste disposal/MT raw steel production is $0.12/MT

d. Scenario IV: On-site (not in floodplain, lining material) non-insitu)

Item costs for this scenario are the same as for scenario III, except for deletion of the diking.

Total Capital Cost	- $878,200
Annualized Capital Cost	- $243,600
O & M	- $ 26,000
Total Annual Cost	- $269,900

The average cost of disposal/MT waste is \$0.88/MT
The average cost of disposal/m^3 waste is \$1.55/m^3
The average cost of waste disposal/MT raw steel production is \$0.11/MT

4. Steel Industry National Costs In Complying with the Criteria

The national cost to the industry was developed by using the four previously outlined scenarios in combination with the following assumptions as to the quantities of waste to be disposed at each scenario:

a) Quantity of Non-Hazardous Solid Wastes to be Disposed - 16.5 MMT

b) Off-site - 50% ———— 8.25 MMT
On-site - 50% ———— 8.25 MMT

c) Floodplains - 15% of on-site ———— 1.25 MMT
Non-Floodplains - 85% of on-site ———— 7.0 MMT

d) Ground Water Protection
On-site - 100% ———— 8.25 MMT (clay from outside source)
Off-site- 85% ———— 7.0 MMT
 a) 50% clay lining material insitu ———— 3.5 MMT
 b) 50% clay lining material non-insitu ———— 3.5 MMT

e) Off-site - 15% ———— 1.25 MMT are assumed to be presently landfilled at a site or in a manner which requires no additional upgrading.

Scenario

I	- Offsite (lining material insitu) 3.5 MMT @ $0.31/MT	= $1,085,000
II	- Off-site (lining material non-insitu) 3.5 MMT @ $0.73/MT	= $2,555,000
III	- On-site (in floodplain) 1.25 MMT @ $0.94/MT	= $6,160,000
IV	- On-site (not in floodplain) 7.0 MMT @ $0.88/MT	= $1,175,000
	Total Annual Cost	=$10,975,000

This total national annual cost is comprised of $9,500,000 capital costs, the remainder as operating and maintenance costs for sampling and analysis, well maintenance and leachate treatment.

In addition to these expenses, it is estimated site maintenance and operation costs will increase. A cost of $2.70/MT is assumed for site maintenance and operation at a sanitary landfill. This constitutes a $1.90/MT increase for on-site disposal and $1.45/MT increase for off-site disposal. This increases the total national cost of the criteria by $25.3 million to approximately $36.3 million.

5. Cost Directly Attributable to 4004 Criteria

Although the annual cost to the industry of complying with the criteria is estimated at approximately $36.3 million, that cost which is directly attributable to the Federal criteria compared to existing State regulations, must be developed.

a. Ground Water

The ground-water criterion has the greatest impact on the iron and steelmaking industry. It is assumed that 100% of on-site and 85% of off-site disposal areas will require additional site controls to provide for ground-water protection. Clay lining, leachate collection and treatment, and monitoring wells are considered the best available technology for prevention of ground-water contamination. Some sites will require just sloping, compacting, etc. of insitu clay.

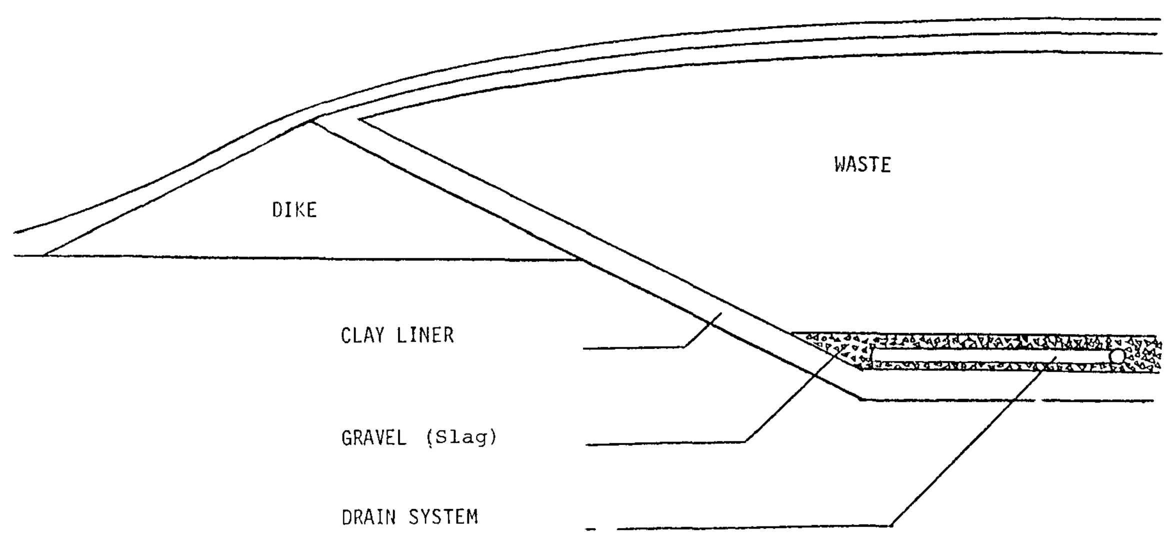


Figure C-23 Diagram of a Sanitary Landfill with Leachate Collection

REF.-RTI

Others will require the procurement of clay from outside sources with subsequent placement, grading, compacting, etc. Still other sites will require additional leachate collection capability and thus utilize piping to perform this function.

Twenty-nine of the 37 States in which iron and steelmaking disposal facilities are located are assumed to have ground-water regulations comparable to the Section 4004 criteria. Approximately 80% of the costs of complying with these criteria are assumed State attributable, the remaining 20% to Section 4004. This annual cost attributable to the Federal criteria is $2.2 million for control technology and an additional $5.1 million for site operation and maintenance.

Final closure of the site consists of cover and revegetation and was assumed by the author to be performed as an on-going process necessary for ground-water protection. Of the $2.2 million assignable to the Federal criteria for control technology, .3 million is for final closure and of the 5.1 million for site operation and maintenance .8 million is assumed attributable to closure.

b. Floodplains

The second criterion having impact on the disposal of iron and steelmaking non-hazardous solid wastes is that of floodplains. It is assumed that 15% of on-site disposal areas are located in floodplains and that all of these sites will be upgraded to prevent inundation of the disposal facility.

Twenty of the thirty-seven States in which iron and steelmaking disposal facilities are located are assumed to have a floodplain criterion comparable to the Section 4004 criteria. Ninety percent of these disposal areas situated in floodplains are assumed to be located in States which do not have floodplain criteria at least comparable to Section 4004. The national annual costs attributable to the 4004 criteria is estimated to be $67,500 for diking and $159,150 for additional site operation and maintenance costs.

c. Section 4004 Induced Costs

The combined criteria-induced costs (ground water, including closure, and floodplains) is estimated to be $7.52 million.

Using as a basis the national quantity of 15.25 million metric tons of solid waste to be disposed in upgraded sites, the additional cost attributable to Section 4004 is estimated to be $0.49/MT waste. The additional cost of disposal induced by Section 4004 per ton of raw steel production, based on an annual production of 114 MMT, is $0.07/MT of raw steel.

The current estimated disposal cost when added to the estimated costs of complying with the criteria (State reg. comparable - $29.0 million + 4004 attributable - $7.52 million) results in an annual expected steel industry disposal cost of $87.0 million. This represents a 72% increase in disposal costs, with 80% of the increase due to comparable State regulations and the remaining 20% attributable to the criteria.

CALCULATIONS

6. CALCULATIONS

TABLE C-48

CALCULATION FOR COSTS OF MODEL IRON AND STEELMAKING DISPOSAL FACILITIES

Cost Estimate

Landfill AREA	-	100,000 m^2 (25 acres)
Landfill Depth	-	10 m
Landfill Area Dimensions	-	450 m long x 225 m wide

I. Off-site (clay lining material insitus)

Site Preparation	Capital Costs		
Survey	$275/acre		$6875
Test Drilling	$ 25/m for 10 m holes		500
Sampling	$ 65/sample	2 samples/hole	260
Engineering Eval.			2000
			$9635
Land Clearing	$850/acre		$21,250
Grading	$ 0.04/m^2	1000,000 m^2	40,000
Compacting, Dist. of Clay	$ 0.08/m^3	60,000 m^3	48,000
Surface Runoff Ditching	$7.25/m	1,500 m	10,875
Leachate Collection Pond			14,080
Leachate Treatment		15,000 GPD	20,000
Monitoring	$1000/well	4 wells	4,000
Analysis/Sampling	$ 400/qtly sample	4 samples/well	6,400 } O&M
	$ 750/annual sample		3,000 } O&M
Closure	Clay - $1.00/$m^3$	15,000 m^3 clay	15,000
	Soil - $0.60/$m^3$	30,000 m^3 soil	18,000
Revegetation	$240/acre		6,000

Capital Cost = $206,840

Total Capital Cost + 20% contingency = $248,208

Annualized Capital Cost (12% at 5 yr.) = $ 68,851

O and M Costs

Sampling/Analysis	$ 9,400
Wells Maintenance	$ 1,600
Leachate Treatment	$15,000
	$26,000

Total Annual Cost..........$94,851

II. Off-site (clay lining material non in situ)

Cost Items same as for I, except

Clay liner, compacting, etc.	$6.00/m^3	60,000 m^3	$ 360,000
Closure (clay material)	$6.00/m^3	15,000 m^3	$ 90,000
			$ 450,000

Capital Cost = $ 206,840
−(48,000 + $ 15,000)
143,840
+ 450,000

$ 593,840

Total Capital Cost + 20% contingency = $712,608

Annualized Capital Cost (12% over 5 years) = $197,672

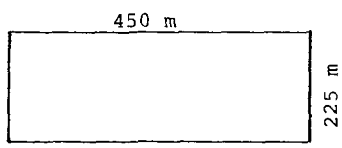
O&M Costs = $ 26,000

Total Annual Cost $223,672

III. On-site (in floodplain)

Cost items same as for II, plus diking construction and leachate collection piping.

Diking



A 3 m high dike is constructed around the landfill site

(450 x 2) + (225 x 2) = 1350 m

Diking construction	$41,00/m	1350 m	$55,350

Piping (leachate collection)

4" PVC piping at 15 m interval the length of landfill plus manifold connections at both ends.

Piping	$23.00/m	6000 m	$138,000

Capital Costs = $593,840 + $55,350 + $138,000 = $787,190

Total Capital Costs + 20% contingency	=	$944,628
Annualized Capital Cost (12% over 5 years)	=	$262,033
O&M Costs	=	$ 26,000
Total Annual Cost	=	$288,033

IV. On-site (not in floodplain)

Same as for III, except delete diking construction

Capital Cost = $787,190 - $55,350	=	$731,840
Total Capital Cost + 20% contingency	=	$878,208
Annualized Capital Costs (12% over 5 years)	=	$243,608
O&M Costs	=	$ 26,000
Total Annual Cost	=	$269,608

TABLE C-49

NATIONAL STEEL INDUSTRY COST

Assume: 16.5 MMT of waste disposed

a. 50% off-site - 8.25 MMT
   50% on-site - 8.25 MMT

b. 15% of on-site in floodplain - 1.25 MMT
   85% of on-site not in floodplain - 7.0 MMT

c. 15% of off-site - requires no additional groundwater protection controls - 1.25 MMT
   85% of off-site - additional groundwater protection controls - 7.0 MMT
   50% of off-site have dry lining material in situ - 3.5 MMT
   50% of off-site do not have clay lining material in situ - 3.5 MMT
   100% of on-site do not have clay lining material in situ - 8.25 MMT

Cost of Four Scenarios:

I.	3.5 MMT x $0.31/MT	=	$1,085,000
II.	3.5 MMT x $0.73/MT	=	$2,555,000
III.	1.25 MMT x $0.94/MT	=	$1,175,000
IV.	7.0 MMT x $0.88/MT	=	$6,160,000
	Total		$10,975,000 per year

Of this amount, $9,490,340 is for capital costs and $1,484,660 is for operation and maintenance costs.

Additional site operation and maintenance costs for a sanitary landfill.

I.	3.5 MMT x $1.90/MT	=	$6,650,000
II.	3.5 MMT x $1.90/MT	=	$6,650,000
III.	1.25 MMT x $1.45/MT	=	$1,812,500
IV.	7.0 MMT x $1.45/MT	=	$10,150,000
	Total		$25,262,500 per year

TABLE C-49

(CONTINUED)

Total cost:

I.	$1,085,000	+	6,650,000	=	7,735,000
II.	2,555,000	+	6,650,000	=	9.205,000
III.	1,175,000	+	1,812,500	=	2,987,500
IV.	6,160,000	+	10,150,000	=	16,310,000
					$36,237,500

TABLE C-50

LEACHATE COLLECTION POND

Assume:

1. Maximum monthly rainfall of 10 in.

2. Infiltration rate of 25% (2.5 in.) or 0.064 m

0.064 m over 100,000 m^2 = 6400 m^3 rainfall

Pond Dimensions: 80 m long x 40 m wide x 2 m deep

Costs:

Excavation and Diking	$2.00/$m^3$	3200 m^3	$ 6,400
Grading	$0.40/$m^2$	3200 m^2	$ 1,280
Clay Lining Compaction, etc.	$1.00/$m^3$	6400 m^3	$ 6,400
			$14,080

$$\frac{6400\ m^3}{} \Big/ \frac{ft^3}{0.028\ m^3} \Big/ \frac{7.5\ gal.}{ft^3} = 1.7 \text{ million gal/month}$$

Leachate Treatment

Assume:

1. 32" rainfall/year

2. 25% infiltration rate = 8" = 0.20 m

$$\frac{100{,}000\ m^2}{} \Big/ \frac{0.20\ m}{} \Big/ \frac{ft^3}{0.028\ m^3} \Big/ \frac{7.5\ gal}{ft^3\ \ 360\ days} = 15{,}000 \text{ GPD}$$

TABLE C-51

COST DUE TO CRITERIA

A) <u>Floodplains</u>

Capital Cost to Typical Plant - $55,350 + 20% contingency = $66,420

Annualized Capital Cost (12% over 5 years) = $ 66,420 x $\frac{1}{3.605}$ = $18,424

Annual Cost/MT waste = $18,424 ÷ 305,785 MT = $0.60/MT waste

Annual National Cost - 1.25 MMT x $0.60/MT = $75,000

Assume: 90% of Floodplain site upgrading attributable to criteria.

1.25 MMT x 0.90 = 1.125 MMT

Annual Cost Attributable to Criteria = 1.125 MMT x $0.60/MT = $67,500

B) <u>Groundwater Protection</u>

Total	-	Floodplain	=	Groundwater Protection
$10,975,000	-	$75,000	=	$10,900,000

Annual Cost/MT waste = $10,900,000 ÷ 14.5 million MT = $0.75/MT

Assume: 20% of groundwater protection upgrading attributable to criteria.

$10,900,000 x 0.20 = $ 2,180,000 = Annual Cost Attributable to Criteria.

CORRESPONDING SITE OPERATION AND MAINTENANCE COSTS
ATTRIBUTABLE TO THE CRITERIA

A) Floodplains

Annual national cost $\frac{\$75,000}{10,975,000}$ = 0.7%

.007 x 25,262,500 = \$176,800

Annual Cost Attributable to Criteria = .90 x \$172,600 = \$159,150

B) Groundwater Protection

Annual national cost $\frac{\$10,900,000}{\$10,975,000}$ = 99.3%

.993 x 25,262,500 = \$25,090,000

Assume: 20% of groundwater protection attributable to the criteria.

25,090,000 x .20 = \$5,018,000

TABLE C-52

ADDITIONAL AVERAGE UNIT COST
ATTRIBUTABLE TO THE CRITERIA

$7.42 million criteria induced costs ÷ 15.25 MMT waste

= 0.49/MT waste

$7.42 million criteria induced costs ÷ 114MMT raw steel production

= $0.02/MT raw steel

Current estimated steel industry non-hazardous waste disposal cost.

on-site + off-site

8.25 MMT x $1.60/MT + 8.25MMT x $2.50/MT = $33,836,000

Site operation and maintenance: additional 50% = $16,918,000

Total disposal cost = $50,754,000

TABLE C-53

COSTS TO COMPLY WITH THE CRITERIA

A) Total Compliance = $10,975,000 (100%)

Scenario I	= $1,085,000	(10%)	$0.31/MT
Scenario II	= $2,555,000	(23%)	$0.73/MT
Scenario III	= $1,175,000	(11%)	$0.94/MT
Scenario IV	= $6,160,000	(56%)	$0.88/MT

B) State Regulation (Comparable to 4004)

Scenario I	= 0.8	x 1,085,000	=	868,800	0.25/MT
Scenario II	= 0.8	x 2,555,000	=	2,044,000	0.58/MT
Scenario III	= 0.8	x 1,100,000	=	880,000	0.71/MT
Scenario III	= 0.1*	x 75,000	=	7,500	
Scenario IV	= 0.8	x 6,160,000	=	4,928,000	0.70/MT
				$8,728,300	

C) 4004 Induced Compliance

Scenario I	= 0.2	x 1,085,000	=	217,000	0.06/MT
Scenario II	= 0.2	x 2,555,000	=	511,000	0.15/MT
Scenario III	= 0.9*	x 75,000	=	67,500	0.23/MT
Scenario III	= 0.2	x 1,100,000	=	220,000	
Scenario IV	= 0.2	x 6.160,000	=	1,232,000	0.18/MT
				$2,247,500	

*Separate Floodplain Calculations

TABLE C-54

ESTIMATED AVERAGE UNIT DISPOSAL COSTS
(LAND, LABOR, TRANSPORTATION)

			Current Cost		Additional Cost		Total Cost	% Increase Above Current Average
A) Off-site								
	1) State	I.	$2.50/MT	+	$0.25/MT	=	$2.75/MT	10%
		II.	$2.50/MT	+	$0.58/MT	=	$3.08/MT	23%
	2) Federal 4004	I.	$2.50/MT	+	$0.06/MT	=	$2.56/MT	2%
		II.	$2.50/MT	+	$0.15/MT	=	$2.65/MT	6%
B) On-site								
	1) State	III.	$1.60/MT	+	$0.71/MT	=	$2.31/MT	44%
		IV.	$1.60/MT	+	$0.70/MT	=	$2.30/MT	44%
	2) Federal 4004	III.	$1.60/MT	+	$0.23/MT	=	$1.83/MT	14%
		IV.	$1.60/MT	+	$0.18/MT	=	$1.78/MT	11%

TABLE C-55

ESTIMATED ANNUAL COST TO THE STEEL INDUSTRY FOR DISPOSAL OF NON-HAZARDOUS SOLID WASTE IN COMPLIANCE WITH CRITERIA.

I.	3.5 MMT	x	$2.81/MT	=	$ 9,835,000
II.	3.5 MMT	x	$3.23/MT	=	$11,305,000
III.	1.25 MMT	x	$2.54/MT	=	$ 3,175,000
IV.	7.0 MMT	x	$2.48/MT	=	$17,360,000

Off-site no upgrading.

1.25 MMT	x	$2.50/MT	=	$ 3,125,000
				$44,800,000

Additional site operation and maintenance, which are assumed to be $2.70/MT for sanitary landfill:

15.25 MMT	x	$2.70/MT	=	$41,175,000
1.25 MMT	x	$ .80/MT	=	$ 1,000,000
				$42,175,000

Total Projected Cost = $86,975,000

Projected Cost - Present Cost = Increase

$86,975,000 - $50,700,000 = $36,275,000

% increase of disposal = $\frac{\$36,275,000}{\$50,700,000}$ = 72%

% increase of disposal due to comparable state reg.

$\frac{\$29,020,000}{\$50,700,000}$ = 57%

% increase of disposal due to 4004 directly.

$\frac{\$7,520,000}{\$50,700,000}$ = 15%

$\frac{\$29,020,000}{\$36,275,000}$ = 80% of increase due to comparable state regulation

APPENDIX D

CURRENT TYPES, QUANTITIES, AND CONDITIONS OF DISPOSAL FACILITIES

APPENDIX

D. CURRENT TYPES, QUANTITIES, AND CONDITIONS OF DISPOSAL FACILITIES

A. LANDFILLS

1. General Description of Practice

The term landfill is used in this EIS to denote open dumps and solid waste disposal facilities where soil cover is periodically applied over the wastes. Operations range from uncontrolled, polluting, unaesthetic, open-burning dumps to landfills which, when properly designed and operated, are nonpolluting and nuisance-free. Landfilling is a popular solid waste disposal method because of the following advantages:

- The general availability of land suitable for disposal facilities.
- Ability to use otherwise marginal or nonproductive land such as borrow pits and quarries and, through filling, to increase the utility of such land.
- Relatively low capital and operating costs.
- Traditional acceptance by the public and regulatory authorities.
- The adaptability and flexibility of operation to accommodate fluctuating quantity, quality, and type of waste.
- Pretreatment of waste is not required.

Various landfill construction and operating procedures are used, depending on the physical configuration of the facility. The operation may be referred to as cut and cover, area fill, trench and cover, and similar terminology. Common to all operations is the sequence of dumping and compacting the waste in layers and covering the waste with compacted earth. Each day's operation when covered with earth is referred to as a cell. Refuse is placed and compacted in layers until the desired height of the cell is reached (normally 6 to 14 feet); this cell height dimension is commonly referred to as a lift. Succeeding lifts may be placed until the final grade of the disposal area is achieved.

In recent years, concern for conservation of resources has generated considerable interest in resource recovery and waste reduction measures. Even if widely applied, however, such practices cannot eliminate solid waste altogether; thus, communities and industries will continue to require an environmentally acceptable means of final disposal. The largest component of municipal waste is paper, but substantial food wastes, yard wastes, glass, metals, plastics, rubber, and liquid wastes are also included. Many municipal facilities also receive industrial process residues and pollution control system sludges in addition to septic tank pumpings, sewage sludge, bulky wastes, street sweepings, and construction/demolition wastes.

The basic large-scale environmental problems associated with landfilling of solid wastes are water pollution, air pollution, public health effects, ecosystem degradation, and effects on land quality. On a national basis, land disposal is a significant contributor to ground-water and surface water contamination from landfill leachate (with large potential public health impacts), to fire and explosions (resulting from improper waste disposal and landfill gas production), and to disease vectors such as flies and rats. Of these effects, the primary problem that has been recognized to date is ground-water contamination.

Additional environmental impacts are either localized,infrequent, or they are geographically specific (such as use of wetlands for waste disposal). However, some of these impacts are potentially of great concern; therefore, they are being regulated now.

The general thrust of this EIS and the criteria is to identify and address adverse effects of improper solid waste disposal practices. Proper solid waste disposal practices, such as true sanitary landfills, do not have these problems. It is beyond the scope of this report, however, to list the positive aspects of proper solid waste disposal practices.

2. Number of Facilities, Distribution

A national inventory of landfills has not been conducted since 1967-69; however, State solid waste management programs do maintain various forms of information on landfills within their respective States. During the latter part of 1976, Waste Age magazine conducted a National Survey of Waste Control Practices. The survey was published in Jaunary, 1977 and was conducted by the Waste Age staff with the cooperation of each State's solid waste control agency as a source of information. Updated in January, 1978, this survey is the most current compilation of landfill data and has been used in this report as the national data base. Information on disposal facilities is presented by States and includes total number in each State; number permitted, or otherwise recognized as sanitary landfills in compliance with State regulations; number of authorized landfills; ownership; operation; and operating capacity. The survey presents additional information on the facilities and the State regulatory program and is included in its entirety in Appendix G.

The Fred C. Hart Associates study, "The Technology, Prevalence, and Economics of Landfill Disposal of Solid Wastes", provides an estimate of the number of on-site landfills for each two-digit SIC manufacturing industry group (Ref. 141). These facilities are apportioned to each State by using the methodology detailed in Appendix B. A summary of the information contained in the Waste Age survey and derived from the Hart study and State revisions are shown in Table D-1.

TABLE D-1

LANDFILL DATA BASE*

STATE	MUNICIPAL PERMITTED	AUTHORIZED	ILLEGAL	ON-SITE INDUSTRIAL	10 TPD	100 TPD	300 TPD	TOTAL TPD	TPY (Thousands)
ALABAMA	142	0	3	1,150	1,232	55	10	20,820	5,413
ALASKA	125	126	98	74	421	2	1	4,710	1,225
ARIZONA	0	140	0	469	591	12	6	8,910	2,317
ARKANSAS	94	0	240	652	923	52	11	17,730	4,610
CALIFORNIA	224	176	0	8,648	8,871	99	78	122,010	31,723
COLORADO	130	90	0	638	840	13	5	11,200	2,912
CONNECTICUT	93	79	0	1,580	1,668	79	5	26,080	6,781
DELAWARE	5	20	0	125	137	10	3	3,270	850
FLORIDA	177	140	0	2,218	2,429	67	39	42,690	11,099
GEORGIA	200	200	80	1,694	2,115	47	12	29,450	7,657
HAWAII	19	14	2	151	171	11	4	4,010	1,043
IDAHO	46	46	48	275	354	58	3	10,240	2,662
ILLINOIS	300	0	140	4,580	4,729	243	78	94,990	24,697
INDIANA	112	23	10	1,890	1,931	52	52	40,110	10,429
IOWA	100	1000	225	805	1,713	342	75	73,830	19,196
KANSAS	343	0	0	691	950	76	8	19,500	5,070
KENTUCKY	151	0	2200	723	2,948	90	36	49,280	12,813
LOUISIANA	65	65	235	845	1,123	62	25	24,930	6,482
MAINE	45	192	150	432	814	5	0	8,640	2,246
MARYLAND	56	0	11	757	787	21	6	11,770	3,060
MASSACHUSETTS	0	159	161	2,497	2,759	42	16	36,590	9,513
MICHIGAN	295	255	150	4,412	4,721	252	139	114,110	29,669
MINNESOTA	103	126	119	1,372	1,648	58	14	26,480	6,885
MISSISSIPPI	38	68	118	608	877	5	0	9,270	2,410
MISSOURI	12	0	48	1,514	1,655	19	9	21,150	5,499
MONTANA	96	98	31	201	419	7	2	5,490	1,427
NEBRASKA	58	400	0	382	811	15	14	13,810	3,591
NEVADA	0	20	0	91	109	2	0	1,290	335
NEW HAMPSHIRE	76	0	52	313	404	34	3	8,340	2,168
NEW JERSEY	286	20	0	3,625	3,832	57	42	56,620	14,721
NEW MEXICO	0	300	300	211	791	18	2	10,310	2,681
NEW YORK	381	254	0	7,693	8,042	261	25	114,020	29,645
NORTH CAROLINA	170	0	0	1,985	2,000	47	108	57,100	14,846
NORTH DAKOTA	80	15	40	104	226	13	0	3,560	926
OHIO	228	9	13	4,488	4,561	125	52	73,710	19,165
OKLAHOMA	202	0	0	756	894	49	15	18,340	4,768
OREGON	261	0	4	1,093	1,339	9	10	17,290	4,495
PENNSYLVANIA	160	160	45	4,368	4,638	79	16	59,080	15,361
RHODE ISLAND	13	0	12	660	675	6	4	8,550	2,223
SOUTH CAROLINA	211	0	3	871	977	39	68	34,070	8,858
SOUTH DAKOTA	30	16	254	116	386	30	0	6,860	1,784
TENNESSEE	0	144	5	1,236	1,267	102	16	27,670	7,194
TEXAS	520	573	0	3,480	4,404	124	45	69,940	18,184
UTAH	11	41	122	300	384	79	11	15,040	3,910
VERMONT	55	8	35	190	284	4	0	3,240	842
VIRGINIA	234	26	20	1,029	1,272	21	16	19,620	5,101
WASHINGTON	60	300	50	1,221	1,490	117	24	33,800	8,788
WEST VIRGINIA	75	6	180	411	608	64	0	12,480	3,245
WISCONSIN	333	1023	44	1,998	3,185	181	32	59,550	15,483
WYOMING	68	58	24	84	227	7	0	2,970	772
TOTAL	6,045	6,390	5,272	75,705	89,611	3,262	1,140	1,564,310	406,721

Table D-1 (cont'd)

*LANDFILLS - STATE QUALIFICATIONS TO DATA BASE

Alabama

Facility considered illegal unless permitted.

Delaware

Authorized facilities have permits with compliance schedules authorized.

Florida

Authorized facilities are those operating under consent order.

Georgia

Authorized facilities are those applying for permit, and may or may not be in operation. Illegal facilities are not permittable.

Iowa

Number of authorized facilities are only estimates. Number authorized is high because they do not have administrative authority over facilities on industrial properties.

Kentucky

Number of facilities may include small roadside dumps, but will be evaluated under Open Dump Inventory. If facilities are not permitted, then they are illegal.

Louisiana

Figures may be low.

Maryland

Waste Age data not updated since State requires written requests for information on waste disposal facilities and time constraints precluded this.

Table D-1 (cont'd)

Mississippi

Authorized facilities are those operating with approval or consent of local governments but without State permit.

Nebraska

Number of authorized facilities is only an estimate and may be high because the State does not have permitting authority for second class facilities and villages.

New York

Breakdown of facilities in Waste Age survey is not compatible with New York State's classifications.

Pennsylvania

Waste Age data not updated since State requires written requests for information on waste disposal facilities and time constraints precluded this.

Tennessee

State registers facilities and does not have permitting authority.

The sources recorded information of 94,013 disposal facilities within the 50 States. Approximately 35 percent of the disposal facilities reported by Waste Age were recognized as sanitary landfills in compliance with existing State regulations. These comprise approximately 6 percent of the total known and estimated landfill disposal facilities.

Only partial information (34% response) is available on facility ownership and operation, but in the information obtained in the survey, publicly owned and operated facilities outnumber privately owned and operated facilities on a 3:1 basis.

The number of landfills in each State varies considerably but generally reflects the population and area of the State; thus, the larger and more populated States have more landfills. The approximate total waste tonnage received by facilities included in the data base is 1,564,000 tons per day, at 407 million tons per year, including on-site industrial landfills.

3. Facility Conditions

a. General

Improperly controlled disposal of municipal solid waste in landfills results in damage to public health and environment in several forms. Solid waste constituents may leach into surface streams and ground-water aquifers and significantly impair their quality. The migration of explosive gases may result in injuries and fatalities, destruction of buildings, and damage to vegetation. Open burning of solid wastes may contribute to local air pollution problems, interfere with aircraft operations, and reduce highway visibility, sometimes causing automobile accidents. Facilities at which solid waste is improperly disposed may provide harborage and breeding grounds for disease vectors,vermin and parasites resulting in public health hazards. Dust, odor, litter, noise, and traffic conditions associated with solid waste disposal at landfills also have had adverse impacts on the aesthetic quality of the environment.

Landfills have frequently been located on land that is considered to have little or no value for other uses, for example: marshlands, abandoned sand and gravel pits, old strip mines, floodplains, or limestone sinkholes, all of which are susceptible to ground-water contamination problems. In one eastern State, 85 percent of the existing landfills were originally designed as "reclamation" projects to fill marshlands and abandoned sand and gravel pits.

b. Specific Environmental Impacts

Wetlands have been used extensively for solid waste disposal because the land was cheap, the resistance to disposal facility location was small, the location was close to major coastal and riverine cities, and filled-in wetlands could be used for other more direct economic activities. The effect of this practice has been to eliminate some wetlands and reduce the value or productivity of adjacent wetlands. Disposal facilities in wetlands often degrade adjacent surface water quality. The alteration and destruction of wetlands through draining, dredging, landfilling, and other means has had a cumulative adverse impact on hydrologic stability and the ecosystems involved. Recent estimates indicate that about 40 percent of the 120 million acres in this country's wetlands that existed 200 years ago have been destroyed (Ref. 109).

Disposal of solid wastes in floodplains (especially along rivers) may have several significant adverse impacts: (1) if not adequately protected from flooding, wastes in a disposal facility may be inundated by water and flow from the site, thereby impacting water quality and aquatic life in downstream waters, and also causing erosion, siltation, and flooding; (2) filling in the floodplain may restrict the flow of flood waters and/or reduce the size and effectiveness of the floodplain in assimilating flood waters which may result in higher flood levels and greater flood damages; downstream or upstream; and, (3) since floodplains generally have hydraulic connection to wetlands, surface water, and ground water, improperly locating disposal facilities in floodplains may result in leachate contamination.

Solid waste disposal in landfills has often led to surface water contamination from runoff of leachate, accidental spills, and drift of spray. One study cited 162 cases of surface water contamination from industrial waste disposal of which 49 (30%) occurred at landfills or dumps (Ref. 10).

The principal source of surface water contamination from landfills is leachate, caused by water percolating through the refuse. Leachate, a highly mineralized fluid, typically contains such constituents as chloride, iron, lead, copper, sodium, nitrate, and a variety of organic chemicals. Where manufacturing wastes are included, hazardous constituents are often present in the leachate (e.g., cyanide, cadmium, chromium, chlorinated hydrocarbons, and PCBs). The particular makeup of the leachate is dependent upon the city and/or industries using the landfill. The types and concentrations of contaminants in leachate are of great importance in determining its potential effects on the quality of surface water.

Leachate production is common in the United States because most facilities are subjected to substantial precipitation and although many have run-off/run-on controls, very few have liners to prevent percolation through the wastes. It is impractical to cover the working face, and uneven settlement, erosion, etc. result in ponding and percolation. Furthermore, wastes at many facilities have been placed directly in contact with surface or ground waters (e.g., in streams, marshes, and sand and gravel pits). Once produced, leachate usually migrates from the disposal area and enters surface or ground waters.

It may take decades or even centuries for a ground-water resource to purge itself even after a contamination source has been removed. The mechanisms of soil attenuation (e.g., adsorption, ion exchange, precipitation, or dispersion) have a limited capacity, are not always available, and are reversible since attenuation is a function of soil and leachate characteristics, thickness of unsaturated zone, soil homogeneity, flow rate, concentration, and pH. Because of this, soil attenuation alone is not always sufficient to assure prevention of ground-water contamination from a waste disposal source.

B. LANDSPREADING

1. General Description of the Practice

Landspreading of solid wastes is currently practiced using a variety of methods. The use of a particular method is dependent upon such factors as the characteristics of the waste, availability of certain land types (e.g., agricultural, damaged land) and site specific economic considerations. Three major categories of landspreading practices can be identified: food and nonfood-chain landspreading and use of land as a treatment medium.

The food-chain category includes the application of the waste to crops that are for human consumption or for use as animal feed. The nonfood-chain category includes agricultural practices not related to the human or animal food chain and nonagricultural practices such as use on recreational land or in land reclamation. The third category, using soil as a treatment medium, is distinct from the other categories in that the solid waste, typically an industrial sludge, is applied for the purpose of achieving effective pollutant disposal, with soil production essentially sacrificed.

Thus, in food-chain and nonfood-chain landspreading, the beneficial properties of certain solid wastes are exploited. These properties can enhance the quality of the soil in terms of fertilization, conditioning and pH neutralization. Examples of solid wastes having these beneficial properties are:

- Fertilization
  - Some municipal wastewater treatment sludges
  - Animal manures
  - Selected textile wastes
  - Selected food industry residues

- Soil conditioning
  - Shredded municipal solid waste
  - Fibrous wastewater sludges (e.g., pulp and paper industry)
  - Composts derived from wastewater treatment sludges and municipal solid wastes
- pH neutralization
  - Limed sludges from water treatment plants
  - Limed sludges from wastewater treatment disinfection processes.

Although the fertilizer value of solid waste is not in the same order of magnitude as most commercial fertilizers, a number of these wastes can be of significant value as low-grade fertilizers with the added benefit of enhancing the physical condition of the soil.

Of the solid wastes currently landspread, the most common are in the form of sludges. The majority of municipal and industrial waste-water treatment sludges are produced as slurries, which contain from four to fifteen percent solids and behave either as solids or liquids. Available application systems of sewage sludge, both in solid and liquid forms, are presented in Table D -2. As shown in the table, the application of solid or slurry sludges to land includes both surface spreading and soil incorporation. In a surface system, the goal is to provide uniform distribution on the land surface. Sludge spreaders or other devices are used to distribute solid waste across the surface ahead of plow blades. In soil incorporation, the sludge is sometimes mixed with soil with deep plowing equipment immediately after application.

Methods of landspreading <u>liquid</u> sludge also include both surface and subsurface applications. To date, the most commonly used surface application methods, especially by smaller communities, are tank trucks and farm tank wagons. The tank truck can also be used for sludge transport, but use of either a truck or a wagon requires suitable soil conditions. Other surface application methods include spray and ridge and furrow irrigation.

TABLE D-2
Field Application Methods

Sludge State and Mode of Transportation	Characteristics	Topographical and Seasonal Stability
Solid		
Spreading, either truck mounted or farm spreaders	Waste spread evenly over ground. Normally followed by soil incorporation, disking or plowing. The plow or disc large enou[illegible] to give complete coverage	Very light applications (less than 4.5 dry tons per hectare) need not be incorporated unless surface runoff is likely to occur
Reslurry and handle as liquid sludge		Suitable for long hauls where rail transport is available
Liquid		
Surface Application Irrigation spray (sprinkler)	Large orifices required for nozzle. Large power requirement. Wide selection of commercial equipment	Can be used on rough or steep land. Can be used year-round with provision for draining in winter. Not suitable for application to some crops during growing season. Sludges must be flushed from pipes when irrigation stops
Ridge and Furrow Irrigation	Less power requirement than spray irrigation. Land preparation needed	Between 1 [illegible] and 1-1/2 slope, depending on percent solids. Can be used in furrows between row crops during growing season. Can be used year-round with provision for draining pipes in winter
Tank Truck	Capacity, 1 [illegible] to [illegible] cubic meters. Larger volume trucks require flotation tires	Smooth and level or slightly sloping land. Not usable with row crops or on soft ground
Farm Tractor and Tank Wagon	Capacity [illegible] to [illegible] cubic meters	Smooth and level or slightly sloping land. Not usable with row crops or on soft ground
Tank Truck and Plow Furrow Cover	Capacity 1 [illegible] cubic meters. Single furrow plow mounted	Smooth and level or slightly sloping land. Not usable on wet or frozen soil
Farm Tractor and Tank Wagon Plow Furrow Cover	Sludge discharge into furrow ahead of single plow. Sludge spread in narrow swath and immediately covered with plow	Smooth and level or slightly sloping land. Not usable on wet or frozen soil
Subsurface Application Subsurface Injection Equipment	Sludge placed in channel opened by tillage tool	Smooth and level or slightly sloping land. Not usable in wet, hard, or frozen soil

Source: White, R.K., M.A. Hamdy, and T.H. Short. "Systems and Equipments for Disposal of Organic Wastes in Soil." Research Circular No. 1[illegible], Ohio Agr. Research and Development Center, Wooster, 1975. [illegible] pp.

Soil incorporation of liquid sludge has a number of advantages over surface application. Odors and pests are not a problem, nitrogen is conserved since ammonia volatilization and runoff are minimized, and the public is more receptive. Liquid sludge can be incorporated into the soil in a number of ways. The principal methods used are plow-furrow-cover and subsurface injection. Other tillage methods which adequately incorporate the sludge may be suitable (e.g., disk or chisel) but there have been no reports to date of the successful use of these methods.

The sludge application rate for any method usually depends on nutrient needs (if it is applied to cropland or vegetative terrain), sludge composition, soil characteristics, and local climate (adequate drying of applied sludge is required so that severe odor problems and insect proliferation are avoided).

2. Number and Distribution of Facilities

a. General

There are seven major municipal and industrial groups which produce the majority of wastes suitable for landspreading. Participation by other industries in landspreading is likely to continue to be quite limited.

The major groups are:

- Municipal wastewater treatment
- Food processing
- Pulp and paper
- Leather
- Textiles
- Pharmaceuticals
- Petroleum refining.

Table D-3 summarizes the estimates of quantities landspread by each group. It is obvious that the total quantity of wastes landspread is dominated by feed-lot manure. Among actual municipal or industrial processes, the major quantities of landspread solid wastes are likely to arise from municipal sludge, petroleum refining, and food processing residuals such as whey and grape pomace. Only small quantities of landspread wastes are expected from the textile, pulp and paper, pharmaceutical, and leather industries.

When one considers the relative impacts of each of these activities in terms of both the quantities of sludge landspread and the potential toxicity of the sludge, the municipal wastewater treatment sludges become a prime concern. For example, some types of municipal wastewater treatment sludges, while containing nutrients and organics of natural origin, also contain trace quantities of chemicals which are persistent and/or biologically active. Two examples are the heavy metals and refractory organic chemicals (i.e., PCB, DDT, PBB, etc.). The known detrimental impacts of these contaminants on biological systems can effectively counter the otherwise beneficial aspects from the addition of nutrients and organic matter to the soil. These impacts include: direct toxicity to plants; second order toxicity to animals; third order toxicity to people; and effects on all food chain components. Obviously, the productivity of soils having such impacts on the biota is highly compromised. Thus, because there is a high potential for many municipal sludges to be very toxic and because municipal sludge accounts for about 65 percent of the present total landspreading activity (excluding the nontoxic wastes from feedlots), this EIS places primary emphasis upon the criteria's impact upon municipal sludge landspreading.

TABLE D-3

Landspreading Activity, Dry Weight

Activity	Current Volume (000 metric tons/year)
Textiles	5
Petroleum	50
Pulp & Paper	Negligible
Leather	24
Food Processing	
- grain mills	0
- dairy products	120
- beet sugar	0
- breweries	3
- wineries	217
- distilleries	0
- meatpacking	0
- canned & frozen foods	400
- feedlots	62,000
Municipal Wastewater Treatment	
- to food chain	750
- non-food chain	250
- giveaway/sale	500
Total Except Feedlots	2,319
TOTAL	64,319

b. Municipal Wastewater Treatment Sludge

The removal of solids during the treatment of municipal wastewater results in a mixture of water, grit, screenings and biodegradable solids commonly referred to as municipal sludge. The composition and characteristics of municipal sludge can vary greatly depending upon a number of factors, including:

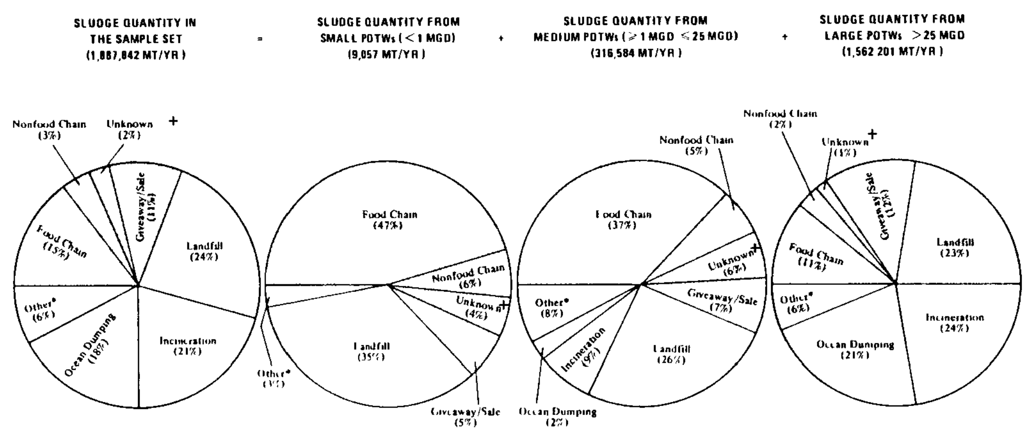
- The origin of the sludge; whether it includes solids from domestic, commercial, agricultural and/or industrial wastes.
- The type of processing the sludge has undergone; whether the sludge results from primary sedimentation, chemical precipitation, activated sludge or trickling filter/ biodisk treatment, and its degree of stabilization by either the anaerobic or aerobic digestion process.
- The age of the sludge; whether it has been lagooned for some time or whether it is fresh from the digestion process.

Sludges most commonly applied to agricultural lands or used for land restoration purposes are typically digested sludges originating from the primary and secondary treatment processes.

(1) Municipal Sludge Disposal Practices

The major disposal and utilization practices for the approximately five million dry metric tons of municipal sludge produced annually are incineration, landfill, landspreading and ocean disposal. Minor but growing disposal and use practices within the category of landspreading include nonfood-chain landspreading and giveaway and sale programs. The current distribution among the major options is shown in Figure D-1. Incineration is clearly an option for only large communities due to the capital investment required. Thus, for smaller communities other options, especially landspreading, are utilized more extensively. Moreover, since ocean disposal is mandated to cease by 1981 and air quality regulations are coming into force in many areas, it seems likely that the use of the landfilling and landspreading options will further increase.

FIGURE D-1
Distribution of Sludge Quantities
By Method of Disposal



*Includes Lagooning and Stockpiling
+Unknown means unspecified method of lanspreading or giveaway/sale.

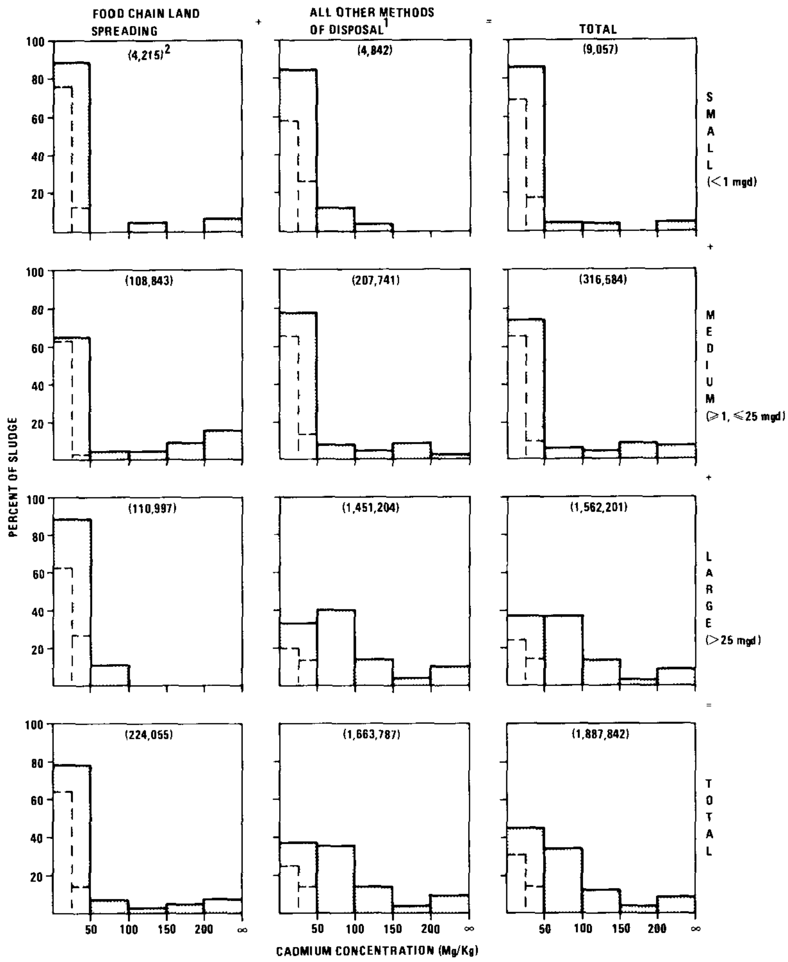
(2) Municipal Sludge Quality

Municipal sludge typically contains about 95 percent water by weight (prior to dewatering, if dewatering is to be utilized). The remaining solid portion is made up of soil, grit, organics, nutrients, and many trace elements. A factor which significantly affects the final use or disposal of municipal sludge is the trace element content. While the trace element content of sludge can vary greatly depending upon the nature of the wastewater being treated (i.e., whether it contains domestic and/or industrial wastes) the effect of this variation in trace element composition is not clearly defined due to the lack of knowledge about these sludge constituents.

The metal content of municipal sludges, and in particular their cadmium (Cd) content, have come under particularly close investigation recently due to concerns over potential health and environmental effects and the significant variability in metal concentrations found from one municipal sludge to another. The sample communities uses as a data base in the EIS analysis were examined for their sludge cadmium concentration.This data base includes more than 350 POTWs with approximately 120 of these landspreading 614 dry metric tons per day on food-chain land. Thus, the survey represents about 38 percent of the total sludge presently being landspread nationally to food-chain land.

The results of the cadmium survey are shown on Figure D-2. Note that although cadmium concentrations are high in isolated cases, nearly 80 percent of all current landspread sludge has a cadmium conconcentration less than 50 mg/kg, under the limit implied by the final cadmium criteria (as discussed in Chapter III). In fact, not surprisingly, that class of communities with the worst cadmium problems are those with treatment plants larger than 25 mgd (250,000 equivalent population) which do not now landspread to food-chain lands. This may reflect an implicit knowledge on the part of large urban communities that sludges that are laden with industrial contaminants such as cadmium are not suitable for landspreading.

FIGURE D-2
Distribution of Cadmium Concentration In Municipal Sludge By Method of Disposal and POTW Site



[1] INCLUDES CHICAGO LANDSPREADING OPERATION

[2] INDICATES DRY METRIC TONS OF SLUDGE PER YEAR INCLUDED IN SAMPLE SET

3. Conditions at Municipal Sludge Disposal Facilities

a. Surface Water

Because much prime agricultural farmland is located in floodplain areas, municipal sludge has commonly been spread in these locations. Under such circumstances, the likelihood of surface water contamination due to flood or rainfall conditions is considerably increased. Many instances have occurred where municipal sludge has either runoff or been washed into surface waters. However, at most landspreading facilities the risk of contamination of surface waters has been mitigated due to precautions taken during siting and proper management during the landspreading program.

It is probably not unreasonable to liken the potentiality of commercial fertilizer runoff from farmlands to that posed by the landspreading of municipal sludge. Although with surface water contamination due to municipal sludge, an additional potential for adverse environmental effects is created by the presence of, for example,heavy metals and toxic organics, exceeding the problems posed by too great a supply of nutrients in the water.

b. Ground Water

It is believed that current municipal sludge landspreading practices do not generally endanger the quality of ground waters. However,very few landspreading facilities are monitored for their effects on ground water.

Chemical contamination of ground water can, to a great extent, be controlled by proper siting. The depth to ground water at a facility is a vital factor to be considered.

The potential for nitrate contamination of ground water can be considerable if conditions such as a coarse soil and excessive nitrogen application from sludge exist. Generally, the nitrogen applied should not exceed the nitrogen needs of the crop grown. Any amount of excess nitrogen increases the risk of nitrate contamination of ground water.

Of the heavy metals, zinc has been found to migrate down through the surface soils at some municipal sludge landspreading facilities, but only under undesirable conditions. Nearly all movement of metals toward ground water can be prevented by proper siting, including consideration of the depth to ground water, the soil texture and soil pH, and control over contaminant application rates.

c. Soil

Excessive soil contamination has occurred at a number of municipal sludge landspreading facilities, posing problems of plant uptake of toxic elements (cadmium), potential phytotoxicity problems for sensitive crops, and the direct ingestion by grazing animals of chemicals such as PCBs.

A considerable number of landspreading facility soils have been found to contain more than 5 mg/kg of cadmium as a result of municipal sludge application. A few facilities have even been found with greater than 10 mg/kg of cadmium in the soil due to the landspreading of municipal sludge. The use of such soils for the growth of leafy vegetables, tobacco or root crops (including home vegetable gardens) may present unreasonable risk to the consumers of these foods.

Pesticide and persistent organic residues in municipal sludge have received, until now, little attention. Very few landspreading programs have monitored these contaminants. However, the Bloomington, Indiana case of the ingestion of the PCB contaminated municipal sludge by a dairy cow is well known. In this circumstance, the cow's milk was excessively contaminated with PCBs after the cow had grazed on sludge treated pasture. The problem was not discovered until after the milk was being consumed for some time by a single family.

The potential for pathogen survival in soils where landspreading is practiced has received little attention. The problems posed by the presence of fecal coliform and fecal streptococci at landspreading facilities is probably no greater than those posed by manure resulting from grazing animals or the spreading of manure on agricultural lands. From the scarce data available, it is believed that Salmonella sp., Shigella sp. and ascaris ova can quite commonly be found in soils where municipal sludge is landspread. Ascaris survival has been documented (not on sludge amended soils) as lasting as long as 7 years in soil.

Problems of odor and fly breeding at municipal sludge landspreading sites have also been recorded.

d. Summary

In any program for municipal sludge landspreading, proper site selection and facility management can preclude any of the potential adverse impacts identified in this section. And, indeed, these adverse impacts to public health and the environment are not present at most current municipal sludge landspreading facilities.

C. SURFACE IMPOUNDMENTS

1. General Description of Practice

Surface impoundments, which include a wide variety of facilities referred to as pits, ponds, lagoons, basins, and pools, are another major solid waste disposal method that can introduce contaminants into ground water.

Surface impoundments for the disposal of wastes are used in essentially all processes relating to treatment of community, industrial, and agricultural water and wastewater, and as well as in processing by major industries engaged in such activities as manufacturing, food production, mining, oil and gas production, and animal feedlot operations. Because impoundments are often unlined and leak part of their contents downward into the soil, ground-water contamination from these sources is believed to occur throughout the nation; indeed, instances are known of contamination from surface impoundments in nearly every State. Many of the bodies of contaminated ground water are localized; some are so far removed from populated areas that they constitute no immediate threat to the water supply of any community. Others, however, have developed into extensive plumes of contamination that have already degraded or may degrade the quality of local ground-water supplies. (Ref. 107).

Most plumes of contaminated ground water associated with surface impoundments have been found to be small and widely scattered throughout the country. A major difficulty in identifying the source of contamination is that the existence of a plume may not be known until the contaminated water reaches a nearby well or stream and is detected either by the taste, color, or odor of the water or by routine water sampling and analysis.

In the most definitive study on this subject to date, a surface impoundment is defined as a "natural topographic depression, artificial excavation, or dike arrangement with the following characteristics: (1) it is used primarily for storage, treatment, or disposal of wastes in the form of liquids, semi-solids; (2) it is constructed above, below, or partially in the ground, and (3) it may or may not have a permeable bottom and sides allowing infiltration of its contents into ground water." (Ref. 107).

Omitted from this study, were fresh-water impoundments such as natural lakes, reservoirs, farm ponds used for water supply, storm, water basins, and flood-control and irrigation impoundments, and otner impoundments, not designed to store or dispose of wastes. These impoundments number several million and mainly contain fresh water; hence, many States do not recognize them as potential sources of contamination.

Concrete-lined basins and prefabricated tanks, and steel vessels that are used in waste treatment and industrial processing were not included in the definition of impoundments in the recent preliminary national inventory of surface impoundments. (Ref. 107).

2. Number of Facilities, Distribution

Few States have actually counted impoundments or compiled detailed records of their construction and operation. The preliminary national inventory (Ref. 107) and revisions provided by States indicate the estimated number of surface impoundments in the United States, as illustrated in Table D-4. These numbers reflect the judgment that most impoundment sites, the term most often provided by the States, are comprised of two to three actual surface impoundments. Of an estimated 272,000 total impoundments, approximately 27,000 are municipal, 198,000 are industrial, and 46,000 are agricultural. The majority of the impoundments are at facilities related to oil and gas extraction, coal and other mining, and animal feedlots.

For purposes of analysis, each of these impoundment groups was considered for classification into size categories. All of the impoundments were put into a 2.5 acre size category,except for five percent of the industrial impoundments,which were assumed to be 50 acres. The rationale and background assumptions for these groupings are provided in Appendix C.

3. Facility Conditions

The national survey of impoundments (Ref. 107) found that most impoundments are unlined and built on permeable earth materials,with a

TABLE D-4

ESTIMATE OF NUMBERS OF IMPOUNDMENTS, FOR ALL CATEGORIES, BY STATES

State	No.	State	No.
Alabama	2,763	New Hampshire	398
Alaska	325	New Jersey	631
Arizona	387	New Mexico	16,190
Arkansas	2,233	New York	2,026
California	6,566	North Carolina	4,265
Colorado	12,756	North Dakota	6,923
Connecticut	1,537	Ohio	32,616
Delaware	209	Oklahoma	5,500
Florida	5,350	Oregon	1,798
Georgia	2,836	Pennsylvania	14,585
Hawaii	300	Rhode Island	129
Idaho	1,385	South Carolina	2,068
Illinois	6,430	South Dakota	1,713
Indiana	5,899	Tennessee	1,831
Iowa	2,918	Texas	19,841
Kansas	15,020	Utah	1,642
Kentucky	8,620	Vermont	1,251
Louisiana	24,493	Virginia	4,971
Maine	1,437	Washington	2,546
Maryland	1,213	West Virginia	4,855
Massachusetts	325	Wisconsin	2,311
Michigan	7,707	Wyoming	12,897
Minnesota	3,673		
Mississippi	3,300	Grand Total	271,567
Missouri	4,037		
Montana	1,352		
Nebraska	7,298		
Nevada	231		

TABLE D-4 (cont'd)

*SURFACE IMPOUNDMENTS - STATE QUALIFICATIONS TO DATA BASE

Georgia

State has not yet started work on SIA[1] survey

Maryland, Pennsylvania

Waste Age data not updated since States require written requests for information on waste disposal facilities and time constraints precluded this.

New York

Efforts to establish an impoundment data base are currently underway through the State Health Department.

Tennessee

SIA survey not started, estimate of total only.

West Virginia

All private/commercial/institutional facilities are included in the industrial category.

[1]SIA is Surface Impoundment Assessment

high potential for leakage. In regions where rainfall exceeds potential evapotranspiration, the dominant mechanism for wastewater loss is through seepage into ground water.

It is likely that at least some leakage into ground water is taking place from most unlined impoundments (Ref. Chapter III). In many places, impoundments could not function at all if leakage were prevented. In those instances, the owners would have to turn to costly alternatives such as treatment, liners, or recycling of wastes in order to remain in operation. Moreover, the cost for correcting an individual leaky impoundment might range from several tens of thousands to several hundreds of thousands of dollars and, in some places, the remedial action would cost in the millions. Many States require permits or have some other type of regulations concerning impoundment construction and operation, but many of these regulations are not very specific in regard to contamination prevention or are not enforced because financial resources are limited.

In addition, impoundments were found to contain fluids with almost every known chemical substance, and many of these substances were also identified in ground water contaminated by leaky impoundments. Nearly all States have reported cases of significant ground-water contamination from impoundments.

Thus far, it is primarily water in shallow aquifers which has been adversely affected by leakage from impoundments, but the potential for contamination of deeper waters could exist in some ground-water recharge areas.

Numerous EPA-documented case studies attest to air, ground-water and surface water pollution as a result of land disposal of industrial wastes. EPA's Office of Solid Waste has documented 30 case studies of industrial land disposal facilities that have created public health and environmental hazards. Also, through contract efforts, fifty randomly chosen industrial land disposal facilities were investigated and ground-water contamination was observed at 47 of these facilities.

Case studies on the different industrial waste disposal methods have shown different mechanisms for causing environmental, economic or health damage, as shown in Table D-5. This information suggests that the waste stream has often been shifted between impoundments, landfills, and other disposal methods, making it more productive to focus on protecting the particular resource from all disposal methods than focusing only on particular industrial waste disposal methods.

As previously stated, most impoundments are unlined and, therefore, may leak part of their contents down into the soil (leachate). In many areas, any contamination of ground water also threatens the quality of surface water. It has been estimated that over 380 million cubic meters (100 billion gallons) per year of industrial effluents enter the ground-water system, based on standard leakage coefficients and on the estimated 6.4 billion cubic meters (1,700 billion gallons) of industrial wastewater pumped annually to oxidation ponds or lagoons for treatment (or as a step in the treatment process). Contaminants documented as having degraded ground-water quality include phenols, acids, heavy metals, and cyanide. The potential ground-water contaminants for several selected industries are shown in Table D-6. (Ref. 7).

TABLE D-5

MECHANISMS INVOLVED IN INCIDENTS OF DAMAGE BY DISPOSAL METHOD

*FOR INDUSTRIAL WASTES**

	Disposal Method (No. of Cases)			
	Surface Impoundments	Landfills Dumps	Other Land Disposal**	Storage of Wastes
Damage Mechanisms (no. of cases)	89	99	203	15
Ground water (248)	57	64	117	10
Surface water (162)	42	49	71	-
Air (17)	3	5	9	-
Fire, Explosions (14)	-	11	3	-
Direct Contact Poisoning (52)	1	6	40	5
Wells Affected (138)+	32	28	74	4

*The tabulation refers to 406 cases studies thus far. The numbers in the matrix add up to more than 406 because several damage incidents involved more than one damage mechanism.

**Haphazard disposal on vacant properties, on farmland, spray irrigation, etc.

+ Not included as a damage mechanism.

Note: The data presented in this table have been derived solely from case studies associated with land disposal of industrial wastes.

Source: House Committee Print No. 20.

TABLE D-6

INDUSTRIAL WASTEWATER PARAMETERS HAVING OR INDICATING SIGNIFICANT GROUND-WATER CONTAMINATION POTENTIAL

PAPER AND ALLIED PRODUCTS

Pulp and Paper Industry

COD	Phenols	Nutrients (nitrogen and phosphorus)
TOC	Sulfite	Total Dissolved Solids
pH	Color	
Ammonia	Heavy metals	

PETROLEUM AND COAT PRODUCTS

Petroleum Refining Industry

Ammonia	Chloride	Nitrogen
Chromium	Color	Odor
COD	Copper	Total Phosphorus
pH	Cyanide	Sulfate
Phenols	Iron	TOC
Sulfide	Lead	Turbidity
Total Dissolved Solids	Mercaptans	Zinc

PRIMARY METALS

Steel Industries

pH	Cyanide	Tin
Chloride	Phenols	Chromium
Sulfate	Iron	Zinc
Ammonia		

CHEMICALS AND ALLIED PRODUCTS

Organic Chemicals Industry

COD	TOC	Phenols
pH	Total Phosphorus	Cyanide
Total Dissolved Solids	Heavy metals	Total Nitrogen

Inorganic Chemicals, Alkalies and Chlorine Industry

Acidity/Aklalinity	Chlorinated Benzenoids and Polynuclear Aromatics	Chromium
Total Dissolved Solids	Phenols	Lead
Chloride	Fluoride	Titanium
Sulfate	Total Phosphorus	Iron
COD	Cyanide	Aluminum
TOC	Mercury	Boron
		Arsenic

TABLE D-6 (Cont'd.)

INDUSTRIAL WASTEWATER PARAMETERS HAVING OR INDICATING

SIGNIFICANT GROUND-WATER CONTAMINATION POTENTIAL

CHEMICALS AND ALLIED PRODUCTS (Cont'd.)

Plastic Materials and Synthetics Industry

COD	Phosphorus	Ammonia
pH	Nitrate	Cyanide
Phenols	Organic Nitrogen	Zinc
Total Dissolved Solids	Chlorinated Benzenoids and Polynuclear Aromatics	Mercaptans
Sulfate		

Nitrogen Fertilizer Industry

Ammonia	Sulfate	COD
Chloride	Organic Nitrogen Compounds	Iron, Total
Chromium	Zinc	pH
Total Dissolved Solids	Calcium	Phosphate
Nitrate		Sodium

Phosphate Fertilizer Industry

Calcium	Acidity	Mercury
Dissolved Solids	Aluminum	Nitrogen
Fluoride	Arsenic	Sulfate
pH	Iron	Uranium
Phosphorus		

APPENDIX E

STATE ADMINISTRATIVE COST ASSOCIATED WITH THE CONDUCT OF THE INVENTORY

APPENDIX

E. STATE ADMINISTRATIVE COST ASSOCIATED WITH THE CONDUCT OF THE INVENTORY

INTRODUCTION

The purpose of this analysis is to estimate the cost that will be incurred by the States in classifying solid waste disposal facilities for the Open Dump Inventory. The cost estimates pertain to those tasks which the States will need to perform in order to (A) review existing legislative authority and correct deficiencies, (B) develop phasing schemes for the inventory, (C) conduct on-site inspections, (D) analyze facility data and present conclusions and (E) hire and train staff to complete items (A)-(D). For the purpose of this analysis, the inventory work stops at the point where the decision is made whether or not to place a facility on the Open Dump Inventory and before due process procedures begin.

In developing cost estimates, some assumptions had to be made. The major assumptions were:

1. Data on the number of facilities, their size, their location (i.e. in a floodplain or wetland) and their need to be upgraded or closed is all taken from Chapter I, or the methodologies as presented in Appendix B.

2. All facilities in need of upgrading for the ground-water or gas criteria will require sampling and analysis work.

3. Hourly labor rates were calculated as:

Personnel	Annual Rate	Hourly Rate x factor of 2.0
A. Inspector	$12,000	$11.50
B. Evaluator/ Supervisor	$20,000	$19.25

The 2.0 multiplier is for factoring in overhead and fringe benefits.

A. STATE LEGISLATIVE AUTHORITIES

In order to conduct the inventory, States will need to review certain legislative authorities and remedy deficiencies. At minimum, these authorities are (1) the right of access to inspect all disposal facilities (including industrial disposal facilities) and (2) the ability to require ground-water monitoring.

After EPA promulgates the Criteria for Classiciation of Solid Waste Disposal Facilities, a State would:

Task

Review and clarify legislative needs with USEPA regional and headquarters offices.

Review existing authorities against those needed.

Submit listing of authorities and deficiencies for USEPA regional office review.

Timing: 1 week

Cost: $19.25 per hour x 40 hours - $770. per State
x 50 = $38,500.

Once a State received concurrence from the USEPA regional office as to its areas of legislative deficiency, the State would begin to write new legislation. The time estimate used to compute the cost per State to correct legislative deficiencies consists of the time necessary for the State solid waste management agency to draft legislation plus time for participating in the law-making process. See Table E -1 for the costs associated with these activities.

TABLE E -1

STATE LEGISLATIVE AUTHORITIES

SITE ACCESS AND MONITORING

Authority	Cost per State[1]	No. of Deficient States[2]	Total Cost
Site Access	$6,737	4	$ 26,948
Monitoring	$6,737	19	$128,000
		Grand Total	$154,948

In summary, the costs are estimated to be $38,500 for the identification of legislative deficiencies and $154,948, as reported in Table VI-1, for correcting legislative deficiencies, for a grand total of $193,448.

B. DEVELOPMENT OF THE PHASING OF THE INVENTORY

In accordance with the proposed Guidelines for the Development and Implementation of State Solid Waste Management Plans, the orderly time phasing of the inventory is to be based on the State's regulatory and financial abilities, as well as the expected and known potential for health and environmental damage. It is expected that the process to determine priorities for the conduct of the inventory would be carried out by existing State personnel. The process could be divided into the following parts:

---

1 Based on an assumed 350 hours at $19.25 per hour.

2 Based on information gathered as part of EPA Contract No.68-01-4767, as of October, 1978. The statutory right of access is vested with local governments in four States. Very few State solid waste management agencies have been granted the specific authority "to monitor" but 31 States have legislation which calls for "monitoring as deemed necessary by the Agency".

Part 1 - Review of State Solid Waste Management Agency Records

This would involve reviewing permit data and any inspection data including gas and ground-water information.

Part 2 - Coordination with Other State and Federal Programs

Existing information from other State and Federal programs will need to be assembled and reviewed to determine if it is relevant to making open dump determinations. The programs include:

a. National Flood Insurance Program - defines the extent of 100-year interval flood.

b. Clean Water Act -
   Section 402 - NPDES permit requirements
   Section 404 - controls the discharge of dredged and fill materials
   Section 208 - areawide and statewide wastewater treatment plans.

c. Safe Drinking Water Act-Surface Impoundment Assessment program to assess the health hazard of the estimated 271,566 surface impoundments.

d. Safe Drinking Water Act - National Primary Drinking Water Regulations - sets allowable contaminant levels for drinking water.

e. Endangered Species Act, Section 7 - controls the placement of disposal facilities so as not to "jeopardize the continued existence of endangered species."

f. Clean Air Act - Section 110; facility must comply with State Implementation Plans.

g. Federal Aviation Administration Order 5200.5 - applies to disposal facilities within 10,000 feet of airfields. *FAA Regulations Part 77* applies to objects affecting navigable airspace and is a surface extending outward and upward from a periphery of a horizontal surface at a slope of 20:1 for a horizontal distance of 4,000 feet.

h. Federal Food, Drug, and Cosmetic Act establishes maximum cadmium and pH limitations for animal feed and milk.

To accomplish the work under parts 1 and 2 a period of two hours per known site is thought to be needed. The cost is computer as: Two hours at $11.50 per hour x [18,500 municipal landfills + 75,505 industrial landfills + 309[3] landspreading facilities + 271,566 surface impoundments] = $8,419,840.

Part 3 - Environmental and Health Prioritization

All criteria have screening (elimination from further consideration) techniques. The most costly of these will be the ground-water and gas screening techniques. Based on an estimate of three hours per site to perform ground-water screening, the total cost for ground-

[3] 309 is thought to be a "low" estimate. Indications are there may be an additional several hundred small landspreading facilities across the nation.

water screening would be $12.7 million ($11.50 x 3 hr. = $34.50 x [18,500 + 75,705 + 309 + 271,566] = $12,629,760). It is assumed that gas screening will be performed at landfill facilities only. Based on an estimate of three hours per facility to perform gas screening, the total cost for gas screening would be $3.25 million ($34.50 x [18,500 + 75,705] = $3,250,072). The total costs for both ground-water and gas screening are considered to be "high cost" estimates. In reality, it probably will not be necessary to screen all facilities as some may be screened by class or location, or some facilities may already have a monitoring program.

Part 4 - Prepare Recommendation for Time-Phasing of the Inventory.

Typical tasks might be:

a. Review of regulatory program, staffing and budgetary constraints, and environmental problems.

b. Consider additional site information such as expected life, public awareness and pressure to take action, and ability to take corrective action.

c. Prepare initial time-phasing recommendations and discuss with appropriate State and EPA regional officials.

d. Revise, finalize, and issue phasing document.

This activity is estimated to consume four weeks per State at the supervisory level for a national total cost of $154,000 (160 hours x $19.25 x 50 States - $154,000).

Part 4 would be repeated in each of the projected 5 years of the inventory with a review of the previous year's progress as the basis for the next year's planning. The inventory is projected for five years based on the announcement in the President's FY80 Budget that Subtitle D funds will be phased out over the next five years.

In summary the costs for the development of the phasing of the inventory are:

Parts 1 and 2	\$ 8,419,840	
Part 3	\$12,629,760	ground-water screening
	\$ 3,250,072	gas screening
Part 4	\$ 154,000 x 4 = 616,000	
	\$ 616,000	
Grand Total	\$25,069,672	

C. ON-SITE INSPECTIONS

Time estimates are based on the current thinking as to the procedures that could be used to evaluate disposal facilities for the Open Dump Inventory. In general, time estimates refer to actual time spent at the site. It is assumed that initial site inspections will be made in conjunction with routine inspections that are conducted as part of on-going State permit programs.

The time estimates for performing on-site inspections at landfills, landspreading facilities, and surface impoundments follow.

Municipal and Industrial Landfills

257.3-1 Floodplains.

Determine if the facility is protected against "wash-out" by inspecting the levee and/or other containment structures.
Time estimate: two hours.

257.3-2 Endangered and Threatened Species.

If a facility is in a critical location; then a specialist, potentially from another State agency, would be called upon for expert advice. Full evaluation could take up to one month per facility (173 hours).

257.3-2 Surface Water.

Determine conformance with wetlands provision. Time estimate: one hour.

257.3-4 Ground Water.

For the purposes of this study it is assumed that ground water will have to be sampled and analyzed at all facilities requiring monitoring under the scenario presented in Appendix B.

Municipal Landfills

Size	Number	Wells Per Facility
10 TPD	2,138	3
100 TPD	596	4
300 TPD	164	7

Industrial Landfills

Size	Number	Wells Per Facility
10 TPD	31,865	3
100 TPD	52	4
300 TPD	0	7

A ground-water sample analysis for the indicator parameters of chloride, iron, specific conductance and pH. is estimated to be $18[4] per 300 ml sample. Together with an estimated one hour to draw the sample, the cost per sample per well is $18.00 + $11.50 = $29.50. The sample will be drawn four times to account for seasonal variations in precipitation and temperature.

To sample and analyze ground water for the second, third, and fourth times would involve costs not included in the $29.50. These

[4] Estimates from the following laboratories:
KAPPE Associates, Inc., Rockville, Md.
Penniman and Browne, Inc., Baltimore, Md.

additional costs would be for an estimated two hours travel time for inspector and a vehicle mileage charge. The total additional cost is calculated as:

$23.00	two hours travel time
16.00	20¢ per mile for 80 miles[5]
$39.00	Travel Cost.

The total ground-water sampling and analysis costs are shown in Table E-2. For the purpose of calculating the total costs shown in Table E-2, it was assumed that all facilities requiring monitoring under the scenario presented in Appendix B would be sampled and analzed four times. In reality, all these facilities may not need to be sampled four times. On the other hand, sampling and analysis at some facilities may need to include parameters in addition to chloride, iron, specific conductance and pH. to test for the other contaminants specified in the criteria. There is no reasonable methodology available for estimating the number of facilities that fall into each of these categories.

257.3-5 Application to Land Used for the Production of Food-Chain Crops.

Criteria does not apply to landfill facilities.

257.3-6 Disease.

Check for signs of disease vectors during appropriate seasons. Determine if cover is adequate and if the facility minimizes the availability of food and harborage for disease vectors.
Time estimate: one-half hour.

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[5] Assumes that there would be a qualified laboratory within a 40 mile radius of most disposal facilities.

TABLE E-2

GROUND-WATER SAMPLING AND ANALYSIS COSTS

Municipal Landfills

Facility Size	Number of Facilities	Cost Per Facility Size	Total Cost Per Facility Size
10 TPD	2,138	$471[6]	$ 1,006,998
100 TPD	596	589	351,044
300 TPD	164	943	154,652

Industrial Landfills

Facility Size	Number of Facilities	Cost Per Facility Size	Total Cost Per Facility Size
10 TPD	31,865	471	$15,008,415
100 TPD	52	589	30,628
300 TPD	0	943	0
		TOTAL	$16,551,737

[6] $29.50 x 3 wells = $ 88.50 1st visit
88.50 + 39.00 = $127.50 x 3 = $382.50 2nd, 3rd, and 4th visit.
$471.00 per facility with 3 wells.

257.3-7 Air.

Check that the facility controls air emissions in accordance with the State Implementation Plan and that the facility does not open burn solid waste.
Time estimate: one-quarter hour.

257.3-8 Safety.

a. Explosive gases

For purposes of this cost analysis it is assumed that gas sampling and analysis will be required at all facilities which are estimated to need upgrading to meet the gas criteria. It is assumed that meters will be used in testing for explosive gases at structures and in the field. The cost for sampling and analysis is calculated as follows.

<u>Explosive gases</u>

Materials:	$0	(it is assumed that in general States have meters or will have access to them as needed.)
Labor:		Two hours for sampling structures at each facility. One-quarter hour per test location (in the field).

All labor costs are included at the rate of $11.50 per hour. The total gas sampling and analysis costs are shown in Table E-3.

TABLE E-3

GAS SAMPLING AND ANALYSIS

Municipal Landfills

Facility Size	Number of Facilities	Cost Per Facility Size	Total Cost Per Facility Size
10 TPD	6,053	$ 34.50[7]	$ 208,829
100 TPD	1,713	46.00	78,798
300 TPD	622	57.50	35,765

Industrial Landfills

Facility Size	Number of Facilities	Cost Per Facility Size	Total Cost Per Facility Size
10 TPD	7,558	$ 34.50	$ 260,751
100 TPD	13	46.00	598
300 TPD	0	57.50	0
		TOTAL	$ 584,741

[7] Cost at 10 TPD Facility:
Explosive Gases - 2 hrs. + 1/4 hr. x 4 test locations = 3 hrs x 11.50 = $34.50

As reported in Table E-3, the total cost for gas sampling and analysis is estimated to be $584,741.

c. Fires.

Determine if the facility poses a hazard to the safety of persons and property from fires.
Time estimate: one-half hour.

d. Bird Hazards.

If FAA lists a facility as posing a threat to aircraft, inspector should review the operating procedures at the facility with the owner/operator. Also, measure the distance to the runway.
Time estimate: one hour.

e. Access.

Determine if facility access is controlled so as to protect the public from on-site exposure to potential health and safety hazards.
Time estimate: one-half hour.

Table E-4 presents the total cost of conducting on-site assessments for municipal and industrial landfills.

TABLE E-4

COST TO CONDUCT ON-SITE ASSESSMENTS

FOR MUNICIPAL AND INDUSTRIAL LANDFILLS

Criterion	Hours Per Criterion	Cost Per Site	Number of Sites	Total Cost
Floodplains	2	$ 23.00	28,445	$ 654,235
Endangered Species	173	$1,989.00	= 50[8]	99,450
Surface Water	1	11.50	84,130	967,495
Ground Water				
10 TPD	12(+lab+travel)	471.00	34,003	16,015,413
100 TPD	16(+lab+travel)	589.00	648	381,672
300 TPD	28(+lab+travel)	943.00	164	154,652
Application to Land	N/A			
Disease	.5	5.75	94,205	541,678
Air	.25	2.87	94,205	270,368
Gases				
10 TPD	5+materials	34.50	13,611	469,580
100 TPD	8+materials	46,00	1,726	79,396
300 TPD	11+materials	57.50	622	35,765
Fires	.5	5.75	94,205	541,678
Bird Hazard	1	11.50	200[9]	2,300
Access	.5	5.75	94,205	541,678
			GRAND TOTAL	$20,755,359

[8] No reasonable methodology is available for estimating the number of facilities affected by this criterion,although the number is expected to be minimal.

[9] FAA estimates of the total number of disposal facilities throughout the country that are near airports. It has not been estimated how many of these facilities are landfills, landspreading facilities or surface impoundments.

Landspreading Facilities

257.3-1 Floodplains

This part of the criteria does not apply to landspreading facilities.

257.3-2 Endangered and Threatened Species

If the facility is in a critical location, then a specialist, potentially from another State agency would be called upon for expert advice. Full evaluation could take up to one month per facility (173 hours).

257.3-3 Surface Water

Determine conformance with wetlands provision.
Time estimate: one hour.

257.3-4 Ground Water

It is assumed there will be minimal potential for ground-water contamination from landspreading facilities. If a State suspected that a facility is a source of ground-water pollution then it is assumed that the following steps would be taken:

a. Determine if loading rates exceed the nitrogen requirement of the crop (analysis for nitrogen).

b. Identify the source of the waste material and assess the potential for soluble pollutants.

c. Calcuate the soil water balance.
Time estimate: three hours.

257.3-5 Food Chain Crops

Assess use of crops grown at the facility and note the presence of grazing animals. Check waste handling and methods of incorporation and collect samples of both waste and soil. Identify the source of waste and assess the potential for pesticide and persistant organic contamination. Calculate loading rates from operating records, field inspection reports, and lab analysis results.

At each landspreading facility the following lab costs would be incurred.

Laboratory Analysis	
Nitrogen in waste material	$40.00
Cadmium	$10.00
pH and CEC	$12.00[10]
Total lab cost	$62.00

Time estimate: six hours.

257.3-6 Disease.

Assess the level of stabilization.
Time estimate: one hour.

257.3-7 Air.

It is anticipated that no facility will need to be evaluated for compliance with State Implementation Plans.

257.3-8 Safety.

a. Explosive gases.

This part of the criteria does not apply to landspreading facilities because the material is in an aerobic state and gases will not be produced.

---

10 State of Maryland, State Chemists Office.

c. Fires.

This part of the criteria does not apply to landspreading since there should be nothing to support combustion.

d. Bird Hazards.

If FAA lists a facility as posing a threat to aircraft, inspector should review the operating procedures at the facility with the owner/operator. Also, measure the distance to the runway.
Time estimate: one hour.

e. Access.

Determine if facility access is controlled so as to protect the public from on-site exposure to potential health and safety hazards.
Time estimate: one-half hour.

Table E-5 presents the total cost of conducting on-site assessments for landspreading facilities.

TABLE E-5

COST TO CONDUCT ON-SITE ASSESSMENTS

FOR LANDSPREADING FACILITIES

Criterion	Hours Per Criterion	Cost Per Site	Number of Sites	Total Cost
Floodplains	NA			
Endangered Species	173	$1,989.	[11]	$ -
Surface Water	1	11.50	309	3,554
Ground Water	3	34.50	[8]	Minimal
Application to Land	6(+lab fee)	131.00	309	40,479
Disease	1	11.50	309	3,554
Air	NA			
Gases	NA			
Fires	NA			
Bird Hazard	1	11.50	[11]	-
Access	0.5	5.75	309	1,777
			TOTAL	$49,364

[8] No reasonable methodology is available for estimating the number of facilities affected by this criterion, although the number is expected to be minimal.

[11] Number included in Table E-4.

Surface Impoundments

257.3-1 *Floodplains.*

Determine if the facility is protected against "wash-out" by inspecting levees and/or other containment structures.
Time estimate: two hours.

257.3-2 Endangered and Threatened Species

If the facility is in a critical location, then a specialist, potentially from another State agency, would be called upon for expert advice. Full evaluation could take up to one month per facility (173 hours).

257.3-3 Surface Water.

Determine conformance with wetlands provision.
Time estimate: one hour.

257.3-4 Ground Water.

For the purposes of this study it is assumed that ground water will have to be sampled and analyzed at all facilities requiring monitoring under the scenario presented in Appendix B.

Surface Impoundments

Size	Number	Wells Per Facility
2.5 acres	156,162	3
50 acres	5,894	7

A ground-water sample analysis for the indicator parameters of chloride, iron, specific conductance and pH. is estimated to be $18 per 300 ml sample. Together with an estimated one hour to draw the sample, the cost per sample per well is $18.00 + $11.50 = $29.50. The sample will be drawn four times to account for seasonal variations in precipitation and temperature.

To sample and analyze ground water for the second, third, and fourth times would involve costs not included in the $29.50. These additional costs would be for an estimated two hours travel time for the inspector and a vehicle mileage charge. The total additional cost is calculated as:

$23.00	two hours travel time
$16.00	20¢ per mile for 80 miles
$39.00	Travel Cost

The total ground-water sampling and analysis costs are shown in Table E-6. For the purpose of calculating the total costs shown in Table E-6, it was assumed that all facilities requiring monitoring under the scenario presented in Vol. II, Chapter D would be sampled (and analyzed) four times. In reality, all these facilities may not need to be sampled four times. On the other hand, sampling and analysis at some facilities may need to include parameters in addition to chloride, iron, specific conductance and pH. to test for other contaminants specified in the criteria. There is no reasonable methodology available for estimating the number of facilities that fall into each of these categories.

TABLE E-6

GROUND WATER

SAMPLE AND ANALYSIS COST
SURFACE IMPOUNDMENTS

Size	Number of Sites	Cost Per Site Size	Total Cost Per Site Size
2.5 acres	156,162	$471	$73,552,302
50 acres	5,894	$943	5,558,042
		Total	$79,110,344

257.3-5 Application to Land Used for the Production of Food-Chain Crops.

Criteria does not apply to surface impoundments.

257.3-6 Disease.

The disease vectors under consideration in the criteria are assumed not to be a problem at surface impoundments.

257.3-7 Air.

Check for hydrocarbon emissions from evaporation of certain waste types with Colormetric Indicator Tubes.
Time estimate: one hour.

257.3-8 Safety.

a. Explosive gases.

It is assumed that the gas criteria will apply at only a limited number of surface impoundments. Since the assessment for gas is site specific and the number of facilities is expected to be small, no cost estimate was developed.

b. Fires.

Determine if the facility poses a hazard to the safety of persons and property from fires.
Time estimate: one-half hour.

c. Bird Hazards.

If FAA lists a facility as posing a threat to aircraft, inspector should review the operating procedures at the facility with the owner/operator. Also, measure the distance to the runway.
Time estimate: one hour.

d. Access.

Determine if facility access is controlled so as to protect the public from on-site exposure to potential health and safety hazards. Time estimate: one-half hour.

Table E-7 presents the total cost of conducting on-site inspections for surface impoundments.

TABLE E-7

COST TO CONDUCT ON-SITE ASSESSMENT FOR SURFACE IMPOUNDMENTS

Criterion	Hours Per Criterion	Cost Per Site	Number of Sites	Total Cost
Floodplains	2	$ 23.00	55,436	$ 1,275,028
Endangered Species	173	1,989.	11	-
Surface Water	1	11.50	26,272	302,128
Ground Water				
2.5 acres	12(+lab+travel)	471.00	156,162	73,552,302
50 acres	28(+lab+travel)	943.00	5,894	5,558,042
Application to Land	NA			
Disease	NA			
Air	1(+materials)	Site Specific	8	-
Gases	Site Specific	Site Specific	8	-
Fires	5	Site Specific	8	-
Bird Hazard	1	11.50	11	-
Access	.5	5.75	271,566	1,561,504
			GRAND TOTAL	$82,249,004

8 No reasonable methodology is available for estimating the number of facilities affected by this criteria, although the number is expected to be minimal.

11 Number included in Table E-4.

D. FACILITY EVALUATIONS

After the field work has been completed, the facility evaluations must be made. The steps involved are assumed to be:

	Hours[12]	Rate	Unit Cost
a. Written evaluation	4	$11.50	$46.00
b. Meeting with owner	2	11.50	23.00
c. Prepare final report	1	11.50	11.50
d. Decision on intention to place on "open dump" list	1	19.25	19.25
	Cost Per Facility		$99.75

Nationally the cost would be:

$99.75 x [18,500 + 75,705 + 309 + 271,566] = $36,516,480.

E. HIRING AND TRAINING INSPECTORS

In order to estimate the cost for hiring and training inspectors a comparison was made between the total number of inspectors needed to conduct the inventory and the number of inspectors currently available. Table E -8 indicates the total number of inspectors that will be needed to conduct the inventory. (Assuming that the inventory will be conducted over a five-year period, total hours were divided first by five and then by 2,080 hours per year to arrive at the total annual need for inspectors.)

Information in the January 1979 edition of Waste Age Survey was used as the basis for estimating the number of inspectors that are currently working in the States. The Survey lists personnel by different categories. It is assumed that inspectors are included under the category entitled "enforcement". The Survey estimates the

12 More extensive evaluations, deliberations, etc., are anticipated at facilities ranked as open dumps than as sanitary landfills. These estimates are averages.

the number of personnel in enforcement to be 356. If it is assumed that two-thirds of the current inspectors (235) will be assigned to work on the inventory, there is a need for 520 additional inspectors. (755 - 235 = 520)

Hiring and training these inspectors could cost as much as $3,000 each. One thousand dollars is estimated for the cost of advertising positions, interviewing personnel and processing paperwork involved in hiring a new employee. Two thousand dollars is estimated for a two-week training period consisting of classes, closely-supervised field work, and orientation to the site classification manual. It is recognized that training of existing personnel will be needed and thus, in computing the cost nationally, the training cost is multiplied by the total number of inspectors. Total national cost for hiring and training inspectors is:

Hiring	$1,000 per inspector	x 520 =	$ 520,000
Training	$2,000 per inspector	x 755 =	$1,510,000
	TOTAL		$2,030,000

Table E -9 presents the estimate of the total number of supervisors that will be needed to conduct the inventory. No reliable data was readily available regarding the number of existing supervisory personnel in the States, although one supervisor per State is thought to be reasonable.

In a review of the cost estimates pertaining to tasks which States will need to perform in order to (A) review existing legislative authority and correct deficiencies, (B) develop phasing schemes for the inventory, (C) conduct on-site inspections, (D) analyze site data and present conclusions and (E) hire and train staff to complete items (A) - (D) the total cost is reported as $168 million.

Given that it is not feasible to evaluate all solid waste disposal sites in the United States (and in light of the announcement in the President's FY80 Budget that Subtitle D funds will be phased out over the next 5 years), the importance of the phasing process cannot be underestimated. It is here that States will make the decision concerning which sites will be evaluated.

TABLE E -8

NEED FOR INSPECTORS
OPEN DUMP INVENTORY

Task	Hours Per Task	Number of Facilities	Hours	Persons Per Year
B. Phasing the Inventory				
Review records and coordinate with other programs	2	366,080	732,160	70
Ground water screening	3	366,080	1,098,240	106
Gas screening	3	94,205	282,615	27
C. On-Site Inspections				
Landfills				
Floodplains	2	28,445	56,890	5
Endangered Species	173	50	8,650	1
Surface Water	1	84,130	84,130	8
Ground Water				
10 TPD	12	34,003	408,036	39
100 TPD	16	648	10,368	1
300 TPD	28	164	4,592	1
Disease	0.5	94,205	47,102	5
Air	0.25	94,205	23,551	2
Gases				
10 TPD	3	13,611	40,833	4
100 TPD	4	1,726	6,904	1
300 TPD	5	622	3,110	1
Fires	0.5	94,205	47,102	5
Bird Hazard	1	200	200	1
Access	0.5	94,205	47,102	5
Landspreading				
Surface Water	1	309	309	1
Ground Water	3	Minimal	-	-
Application to Land	6	309	1,854	1
Disease	1	309	309	1
Access	0.5	309	155	1

TABLE E-8 (Continued)

NEED FOR INSPECTORS
OPEN DUMP INVENTORY

Task	Hours Per Task	Number of Facilities	Hours	Persons Per Year
C. On-Site Inspections (Continued)				
Surface Impoundments				
Floodplains	2	55,436	110,872	11
Surface Water	1	26,272	26,272	3
Ground Water				
2.5 acres	12	156,162	1,873,944	180
50 acres	28	5,894	165,032	16
Air	1	Minimal	-	-
Access	0.5	271,566	135,783	13
D. Facility Evaluations				
Written evaluation	4	366,080	1,464,320	141
Meeting with owner	2	366,080	732,160	70
Prepare final report	1	366,080	366,080	35
TOTAL NEED				755

TABLE E-9

NEED FOR SUPERVISORS IN THE
OPEN DUMP INVENTORY

Task	Hours Per Task	Number of Tasks	Total Hours
A. State regulatory authorities	40 350	50 (States) 23 (States)	2,000 8,050
B. Phasing of the Inventory Part 4	160	50 States x 5 years	40,000
D. Facility evaluations	1	366,080	366,080
		Total Supervisors	416,130 = 40 persons/yr.

F. SUMMARY

A summary of all State administrative costs to conduct the inventory is presented in Table E-10.

TABLE E-10

CLASSIFICATION CRITERIA
EIS-STATE ADMINISTRATIVE COST SUMMARY (in thousands)

Element of Cost	National Total Cost
A. Legislative Authority	$ 193.4
B. Phasing the Inventory	25,069.7
C. On-Site Inspections	
Landfills	20,755.4
Landspreading	49.4
Surface Impoundments	82,249.0
D. Facility Evaluations	36,516.5
E. Hiring and Training Inspectors	2,030.0
Total	$166,863.3

APPENDIX F

SLUDGE DATA FOR POTW's IN THE RCRA 4004 SAMPLE SET

Note:

1. Footnotes for disposal practices include:

   a- Food-chain landspreading
   b- Non-food-chain landspreading
   c- Unknown landspreading practice
   d- Giveaway/sale

2. It is assumed that industrial pretreatment will result in a 50% reduction in cadmium concentration in the POTW influent

Sludge Data for POTW's in the RCRA 4004 Sample Set

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
✓Detroit, MI												
Primary	800	436	Incineration	80								
Primary		109	Landfill	80								
Secondary		254	Incineration	150								
Secondary		64	Landfill	105								
Los Angeles, CA/ Orange County												
Hyperion	350	127	Ocean	135								
Joint	355	50	Ocean	68								
		125	Landfill	68								
		125	Compost[d]	68								
Fountain Valley	50	15	Landfill	200								
		15	Land Applied	200								
Huntington Beach	150	12.5	Landfill	85								
		12.5	Land Applied	85								
✓Chicago, IL												
Northside	300	114	To W. SW	180								
Calumet	200	73	Landfill	40								
Hanover Park	6	4	To Northside	30								
Lemont	1	.5	Landfill	16								
Egan	16	9	To Northside	92								
W. Southwest	820	160	Land Applied[d]	225/113	160/0	160	160/0	160/160	160/160	160/160	160/160	160/160
		105	Heat dry[d]	225								
		72	Landfill	225								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Washington, DC												
Blue Plains	305											
raw		13	Incineration	10								
raw		20	Land Applied[c]	10								
raw		134	Landfill	10								
digested		32	Land Applied[b]	19								
digested		32	Land Applied[a]	19/10								
Milwaukee												
Jones Island	130	161	Heat Dry[d]	76								
		8	Landfill	76								
South Shore	70	82	Land Applied[a]	40/20								82/0
Philadelphia, PA												
N.E.	200	68	Ocean	25								
		14	Composting[d]	25								
S.W. & S.E.	295	63	Ocean	20								
		25	Composting	20								
New York City												
Bowery Bay	125	11.8	Ocean	124								
Coney Island	99	10.9	Ocean	11								
Hunt's Point	160	10.9	Ocean	31								
Jamaica Bay	100	17.3	Ocean	34								
Newtown Creek	296	51.8	Ocean	169								
Oakwood Beach	19	3.2	Landfill	12								
Owl's Head	100	21.8	Ocean	19								
Port Richmond	22	2.5	Ocean	6								
Rockaway	19	1.9	Ocean	30								
Tallman's Is.	67	2.7	Ocean	59								
26th Ward	80	14.5	Ocean	159								
Ward's Is.	240	28.2	Ocean	9								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Metro. Boston												
Deer Is.	343	78	Ocean	82								
Nut Is.	127	44	Ocean	61								
Newark, NJ	255	105	Ocean	32								
Denver, CO	130	100	Land Applied[a]	20/10								
San Jose/ Santa Carla	100	100	Lagoon	45								
Dallas, TX												
Dallas Central	150	30	Land Applied[b]	Unknown								
Southside	5	0										
Houston												
Northside	70	16	Heat Dry[d]	20								
		48	Landfill									
Sherwood Oaks	.5	.25	Land Applied[d]	22								
		.25	Landfill									
W.C.I.D. 69	.8	.35	Land Applied[d]	8								
		.35	Landfill									
Northeast	1.5	.1	Land Applied[d]	15								
		.9	Landfill									
Inter. Airport	.4	.04	Land Applied[b]	15								
		.36	Landfill									
W.C.I.D. 20	.2	.1	Land Applied[b]	25								
		.1	Landfill									
✓Indianapolis, IN												
Belmont	114	73	Incineration	240								
Southport	45		To Belmont									

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
✓Cleveland, OH												
Southerly	100	36.1	Landfill	Unknown								
		29.4	Incineration	Unknown								
Easterly	135	To Southerly		Unknown								
Westerly	35	4		Unknown								
Strongville	2	To Westerly		Unknown								
Portland, OR												
Columbia	82											
Primary		4	Land Applied[b]	29								
		38	Lagoon	29								
Secondary		20	Lagoon	69								
Tryon Creek	5											
Primary		2	Land Applied[b]	7								
Secondary		2	To Columbia	7								
Atlanta, GA												
R.M. Clayton	81	32	Incineration	Unknown								
Intrenchment Creek	14	6	Landfill	Unknown								
South River	15	.2	Land Applied[d]	Unknown								
Utoy Creek	23	18	Incineration	Unknown								
Baltimore, MD												
Back River	280	55	Landfill	15								
Patapsco	17	6	Landfill	9								
Sayreville, NJ	79	56	Ocean	59								
East Bay, CA	75	53.6	Landfill	60								
Little Ferry, NJ	60	52.7	Ocean	58								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Elizabeth, NJ	60	51.8	Ocean	75								
San Francisco, CA												
Southeast	19	20	Landfill	28								
		13.7	Lagoon	28								
		6.8	Incineration	28								
		5	Land Applied[d]	28								
Northpoint	59	59	To S.E. Plant	Unknown								
Richmond Sunset	22	4.5	Land Applied[b]	Unknown								
UNKNOWN		45	Land Applied[a]	19/10								
Westchester, NY												
Yonkers	70	29.1	Ocean	15								
Rye	2.6	1.3	(To Yonkers)	Unknown								
		.9	Incineration	Unknown								
Port Chester	7.1	.2	(To Yonkers)	Unknown								
Peekskill	2.9	1.9	(To Yonkers)	Unknown								
New Rochelle	15.8	8.6	Landfill	Unknown								
Mamaroneck	16.6		(To New Roch.)	Unknown								
Miami												
Virginia Key	70	33.6	Landfill	149								
		.4	Land Applied[d]	149								
Central Contra Costa Cty, CA	34	39.1	Incineration	6								
Syracuse, NY	80	36.4	Landfill	5								
✓ Battle Creek, MI	12	30.5	Stockpiling	4								
✓ Grand Rapids	47	30.3	Incineration									

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
UNKNOWN		30	Land Applied[d]	11								
Bridgeport, CT												
Eastside	8	6.3	Landfill	1000								
Westside	31	23.4	Landfill	31								
✓ Kokomo, IN	17	28.4	Landfill	164								
✓ Appleton, WI		27.8	Land Applied[a]	85/43				27.8/0		27.8/0	27.8/0	27.8/27 8
✓ Flint, MI	22 5	27.5	Stockpiled	17								
Salt Lake City, UT	41	27.5	Stockpiling	Unknown								
Seattle, WA	150	27.4	Land Applied[b]	57								
✓ Warren, MI	30	27.3	Incineration	140								
✓ Pontiac, MI	25	27.2	Incineration	19								
Macon, GA												
Flat River	2.5	2	Landfill	5								
Poplar St.	12.5	1	Landfill	42								
		1	Land Applied[d]	42								
Rocky Creek	12	21	Lagoon	Unknown								
Colorado Springs, CO	25	25	Land Applied[c]	56								
✓ Saginaw, MI	30	25	Landfill	48								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
✓LaCrosse, WI												
Primary		4.1	Land Applied[a]	14/7								
Secondary		19.4	Land Applied[a]	8/4								
UNKNOWN		23	Land Applied[a]	9/5								
UNKNOWN		23	Land Applied[a]	13/7								
Tampa, FL	40	23	Land Applied[d]	10								
Springfield, MA	38	20.6	Landfill	276								
Newton, IA												
#1	3	7	Land Applied[a]	692/346	7/7	7/7	7/7	7/7	7/7	7/7	7/7	7/7
#2	4	11	Land Applied[a]	692/346	11/11	11/11	11/11	11/11	11/11	11/11	11/11	11/11
Palo Alto, CA,	28	18.2	Incineration	Unknown								
UNKNOWN		18	Land Applied[d]	160/80		18/0	18/0	18/18	18/0	18/18	18/18	18/18
Linden, NJ	11.5	17.1	Ocean	38								
✓Ann Arbor, MI												
Primary	17	2.45[c] 9.85[d]	Land Applied	9								
Secondary		3.4										
✓Wyoming, MI	13.5	7.6[a] 7.6[d]	Land Applied	Unknown								
✓Madison, WI	36	12[a] 3[b]	Land Applied	25/13								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Chicopee, MA	8	15	Landfill	126								
Nassau Cty , NY												
Cedarcreek	21	4.3	Ocean	28								
Bay Park			To Cedarcreek									
Inwood			To Cedarcreek									
Cedarhurst	.8	1.1	Incineration	Unknown								
Belgrave	1.4	.9	Ocean	Unknown								
Oyster Bay	1.6	2.7	Landfill	Unknown								
Great Neck	1	21	Landfill	Unknown								
Port Wash.		4.4	Incineration	Unknown								
Atlantic-West Beach	.8	.1	Ocean	620								
Long Beach	6.4	.6	Ocean	6								
Glen Cove	16	.8	Ocean	15								
Lawrence	.9	.1	Ocean	Unknown								
Northampton, MA	4	14.4	Landfill	6								
Reno, NV	20	14.2	Landfill	16								
Sioux Falls, SD	10.5	14	Landfill	Unknown								
✓Kalamazoo, MI	34	13.6	Incineration	12								
✓Niles, MI	2	13.3	Landfill	14								
Hartford, CT												
MDC	500	11.4	Incineration	33								
E. Hartford	6.1	1.4	To MDC	Unknown								
Stamford, CT	16	12.1	To Goshen Plant, NY	150								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) — MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
✓Kenosha, WI		12.1	Land Applied[a]	22/11								
Muscatine, IA	7	5.8[a] 5.8[d]	Land Applied	2/1								
Springfield, MO												
#1	30	5.3[a] 5.3[d]	Land Applied	56/28 56						5.3/0	5.3/0	5.3/5.3
#2	3.5	.3[a] .3[d]	Land Applied	Unknown Unknown								
✓Anderson, IN	18.5	11	Landfill	15								
✓Grand Haven, MI	3.3											
Primary		4.9	Landfill	Unknown								
Secondary		5.8	Landfill	Unknown								
Binghamton, NY	18.5	3.27[a] 3.27[b] 3.27[d]	Land Applied	5/3								
✓Jackson, MI	15	9.1	Land Applied	500/250	9.1/9.1	9.1/9.1	9.1/9.1	9.1/9.1	9.1/9.1	9.1/9.1	9.1/9.1	9.1/9.1
UNKNOWN		9	Land Applied[a]	10/5								
UNKNOWN		9	Land Applied[a]	269/135	9/0	9/9	9/9	9/9	9/9	9/9	9/9	9/9
Naugatuck	4.7	9	Landfill	1								
Stratford, CT	8	8.5	Land Applied[b]	50								
Camden, NJ	29	8.5	Composting	30								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Danville, VA	18	4.15[a] 4.15[d]	Land Applied	5/3								
Mayville, WI		8.3	Land Applied	15/8								
Columbus, IN	8	4.0[a] 4.0[d]	Land Applied	9/5								
Englewood, CO	15	8	Landfill	38								
UNKNOWN		8	Land Applied[a]	176/88		8/0	8/0	8/8	8/0	8/8	8/8	8/8
UNKNOWN		8	Land Applied[a]	17/9								
E Lansing, MI	10	8.0	Incineration	6								
Marion, IN	10	7.4	Land Applied[d]	128/64		7.4/0	7.4/0	7.4/7.4	7.4/0	7.4/7.4	7.4/7.4	7.4/7.4
S. San Fran.- San Bruno, CA	8.5	3.6[c]	Land Applied	17								
Union Sanitary Dist., CA												
#1 Newark	7.0	1.35[b] 1.35[d]	Land Applied	Unknown								
#2 Irving	7.0	.90[b] .90[d]	Land Applied	Unknown								
#3 Alvardo	4.0	1.25[b] 1.25[d]	Land Applied	Unknown								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) — MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Boulder, CO												
75th Street	10.5	6.0	Landfill	1.0								
E. Pearl St.	4.0	1.0	Land Applied[d]	Unknown								
Richmond, IN	9	6.8	Stockpiling	Unknown								
Port Huron, MI	14	6.7	Incineration	8								
Hayward, CA	10	3.2[b] 3.2[d]	Land Applied	37								
Annapolis, MD		6.1	Incineration	6								
Monroe, MI	13	6.0	Landfill	8								
Trenton, MI	5.5	5.9	Incineration	13								
Fond du Lac, WI		5.9	Land Applied[d]	144/72		5.9/0	5.9/0	5.9/5.9	5.9/0	5 9/5.9	5.9/5.9	5.9/5.9
Mt. Clemons, MI	4 5	5.7	Landfill	12								
Holland, MI	5.75	2.75[a] 2.75[d]	Land Applied	11/6								
Muskegon, MI		5.4		166								
Easton, PA	4.9	5.4	Landfill	6								
Janesville, WI		2.6[a] 2.6[b]	Land Applied	89/45				2.6/0		2.6/0	2.6/0	2 6/2 6

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Frankfort	4.5	5	Land Applied[b]	Unknown								
UNKNOWN		5	Land Applied[a]	95/48				5/0		5/0	5/0	5/5
UNKNOWN		5	Land Applied[a]	683/342	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
New Haven												
East Shore	10	1.1	Sludge to E. St.									
Boulevard	14.4	1.6	Sludge to E. St.									
E. St. SPCF	18	2.3	Incineration	16								
UNKNOWN		5	Land Applied[a]	16/8								
Manitowoc, WI		4.9	Land Applied[a],	275/138	4.9/0	4.9/4.9	4.9/4.9	4.9/4.9	4.9/4.9	4.9/4.9	4.9/4.9	4.9/4.9
New Albany	6	4.8	Landfill	Unknown								
Neenah-Menasha, WI		4.7	Land Applied[d]	5/3								
Waterbury, CT	19.7	4.5	Incineration	160								
Meriden, CT	10	4.5	Landfill	14								
Westfield, MA	2.5	4.5	Landfill	78								
Bristol												
Main	4.8	2.2	Landfill	5								
Forestville	4.9	2.2	Landfill	19								
Billings, MT	13	4.4	Landfill	Unknown								
Waukesha, WI		2.15[b] 2.15[d]	Land Applied	15								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Hagerstown, MD		4.1	Land Applied[c]	14								
Greenwich Central, CT	9	4.1	Landfill	13								
Burlington, VT												
North Plant	1.5											
Digested		.70[a]	Land Applied	9/5								
Waste Act		.60[b]		7								
Main Plant	3.5											
Digested		1[a]	Land Applied	14/7								
Waste Act		1.15[b]		12								
East Plant	.9											
Digested		.30[a]	Land Applied	12/6								
Waste Act		.30[b]		11								
UNKNOWN		2 2	Land Applied[d] Landfill	4/2 4								
UNKNOWN		4	Land Applied[a]	61/31						4/0	4/0	4/4
UNKNOWN		4	Land Applied[a]	38/19								4/0
UNKNOWN		4	Land Applied[a]	11/6								
Frederick, MD		3.9	Landfill	361								
Las Virgenes	4.5	3.7 .2	Land Applied Landfill	9								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Enfield	4	3.04[a] .76[d]	Land Applied Incineration	5/3								
Noblesville, IN	1.5	3.8	Land Applied[a]	Unknown								
Chippewa Falls, WI	3.5	1.9[a] 1.9[b]	Land Applied	Unknown								
Butte, MT	7	3.7	Land Applied[a]	Unknown								
Danbury	8.2	3.7	Landfill	45								
Marshall, MO	3	1.8[a] 1.8[d]	Land Applied	16/8								
Marquette, WI	3.5	3.6	Stockpiling	2								
Cromwell	21.9	3.5	Incineration	73								
Killingly, CT	2.1	3.5	Landfill									
Manchester, CT	7.5	3.4	Landfill	15								
New Castle, IN	6.5	3.4	Land Applied[a]	Unknown								
Fairfield, CT	7.2	3.3	Land Applied	31								3.3/0
Milford Harbor Gulf Pond Town Mead Beaver Br.	 .8 2.8 1.9 1.0	 .4[b] 1.3[b] .9[b] .5[b]	 Land Applied	 Unknown 17 23 320								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Great Neck Sewer Dist., NY	2.5	3.1	Landfill	Unknown								
Norwalk, CT	13.5	3.1	Incineration	28								
Middleton, CT	4	3.0	Landfill	8								
UNKNOWN		3	Land Applied[a]	12/6								
UNKNOWN		3	Land Applied[a]	7/4								
New London, CT	3.7	1.5[b] 1.5[d]	Land Applied	9								
UNKNOWN		3	Land Applied[a]	10/5								
Mishawaka, IN	11	3.0	Land Applied[a]	Unknown								
Midland, MI	7.5	.28[c] 2.52[d]	Land Applied	10								
Sheboygan, WI		2.8	Land Applied[a]	22/11								
Logansport, IN	?	2.7	Unknown	663								
Sod Run, MD		2.6	Land Applied	9/5								
Cumberland, MD		2.4	Landfill	9								
Xenia Ford Run	2.5	.7[d] .7[d]	Land Applied	Unknown								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Xenia (Cont'd.) Grady Run		.5[a] .5[d]	Land Applied	80/40				.5/0		.5/0	.5/0	.5/.5
Ft. Atkinson, WI		1.2[a] 1.2[b]	Land Applied	8/4								
Windham-Willimantic	3.0	2.3	Stockpiled	5								
Rapid City, SD	8	1.1[a] 1.1[b]	Land Applied	0/0								
Brookfield, WI		2.1	Incineration	12								
Adrian, MI	3	2.0[c]	Land Applied[c]	200								
UNKNOWN		2	Land Applied[a]	8/4								
UNKNOWN		2[a]	Land Applied[a]	169/85		2/0	2/0	2/2	2/0	2/2	2/2	2/2
Wilmington, OH	1.5	1.8[a] .2[d]	Land Applied[e] Landfill	10/5								
Spencer	1.1	.66[a] .66[b] .66[d]	Land Applied	7/4								
UNKNOWN		2	Land Applied[a]	16/8								
UNKNOWN		2	Land Applied[a]	9/5								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
UNKNOWN		2	Land Applied[a]	19/10								
Burlington, IA	5.5	1.9	Land Applied[b]	16								
Vernon, CT	4.2	1.9	Incineration	36								
West Haven, CT	8.2	1.9	Incineration	29								
Ft. Madison, IA	2.5	1.8	Landfill	24								
Grinnell, IA	1.3	1.8[a]	Land Applied[a]	8/4								
Southington, CT	4	1.8	Landfill	500								
West Bend, WI		.59[a] 1.19[bd]	Land Applied	141/71		.59/0	.59/0	.59/.59	.59/0	.59/.59	.59/.59	.59/.59
Ithaca, NV	6	1.8	Land Applied[c]	662								
Norwich, CT	3.7	1.7	Landfill	11								
Cambridge, MD		1.7	Landfill	13								
Patuxent, MD		1.6	Land Applied[a]	3/2								
Cadillac	1.5	1.6[b]	Land Applied[b]	13								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Ankeny, IA												
#1	.3	.1[3]a .1 d	Land Applied	Unknown								
#2	1.4	.4[3]a .4 d	Land Applied	Unknown								
#3	.9	.25 a .25 d	Land Applied	Unknown								
#4	.07	.05[3]a .05 d	Land Applied	Unknown								
Groton, CT Groton City	1.3	.6	Landfill	67								
Ft. Hill WPCF	1.2	.9	Landfill	17								
Traverse City, MI	2.7	1.5	Land Applied[b]	16								
Mt. Pleasant, MI	3	1.5	Landfill	14								
Kendallville, IN	1.5	.75[a] .75[d]	Land Applied	50/25								75 0
Monroe, WI Primary Secondary		.46[a] .46[b] .46[d]	Land Applied	12/12 17								
Stafford, CT	1.8	1.4										
Waste Act			Landfill	9								
Filter Vac.			Landfill	5								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Hancock, MI	1.8	1.4	Land Applied[c]	Unknown								
Marshall, MI	2.25	1.4	Landfill	16								
Creston	1.5	.65[a] .65[d]	Land Applied	176/88		.65/0	.65/0	.65/.65	.65/0	.65/.65	.65/.65	.65/.65
Whitewater, WI		1.3	Land Applied[a]	2/1								
Plattesville, WI		.65[a] .65[b]	Land Applied	10/5								
Peru, IN	2	1.3	Land Applied[c]	154								
Wallingford, CT	2.9	1.3	Landfill	7								
Putnam, CT	1.7	1.3	Lagoon	10								
Prairie du Chien, WI		.40[a] .40[b] .40[d]	Land Applied Landfill	6/3								
Hartford, WI		1.2	Land Applied[a]	Unknown								
Beaver Dam, WI		1.1	Land Applied[a]	75/38				1.1/0		1.1/0	1.1/0	1.1/1.1
Green Bay, WI		.6 .6	Landfill Incineration	5								
Kaukauna, WI		1.1	Land Applied[a]	3/2								
Glastonbury, CT	1.1	1.0	Landfill	180								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
UNKNOWN		1	Land Applied[a]	7/4								
Hopkinsville, KY	2.4	1	Landfill	6								
UNKNOWN		1	Land Applied[a]	1/1								
Litchfield, IL	2	.1	Land Applied[a]	6/3								
UNKNOWN		1	Land Applied[a]	22/11								
Two Rivers, WI		1	Land Applied[a]	20/10								
Boone, IA	1.5	.50[a] .50[d]	Land Applied	3/2								
Charles City, IA	1.6	.50[a] .50[d]	Land Applied	11/6								
UNKNOWN		1	Land Applied[a]	18/9								
UNKNOWN		1	Land Applied[a]	970/485	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
UNKNOWN		1	Land Applied[a]	16/8								
Emmettsburg, IA	.6	.5[a] .5[d]	Land Applied	4/2								
Oskaloosa, IA	1.6	.5[a] .5[d]	Land Applied	7/4								
Torrington, CT Main Waste Vac.	4.0	.9	Incineration	46 21								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) — MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Burrville	.3	.1	Unknown	12								
Ft. Fairfield Maine		.45 .45	Landfill Land Applied[ae]	14/7								
Salisbury, MD		.9	Landfill	63								
Albion, MI	2	.9	Landfill	48								
Sault St. Marie, MI	2.6	.45[c] .45[d]	Land Applied	2								
Menasha, WI E. Plant W. Plant		.6 .15 .15	Land Applied[a] Landfill Land Applied	32/16 16								.6/0
Ansonia	2.1	.9	Landfill	32								
Oconto, WI		.26[a] .26[b] .26[d]	Land Applied Landfill	Unknown								
Derby	1.7	.8	Landfill	0								
Rocky Hill, CT	3.5	.8	(To Hartford)									
Three River, MI	1.2	.8	Land Applied[a]	44/13								
Menomonee, WI		.8	Land Applied[a]	28/14								.8/0
Branford	1.5	.35[a] .35[d]	Land Applied	17/9								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Plainfield North Village	.5 .4	.4 .3	Lagoon Landfill	50 0								
Winchester-Winstead, CT	1.6	.7	Landfill	18								
Menomonee, MI	3.5	.35[a] .35[d]	Land Applied	4/2								
Ypsilanti, MI	7	.7	Landfill	Unknown								
Cedarburg, WI		.23[a] .23[b] .23[d]	Land Applied	1/1								
Framington, CT	1.3	.6	Landfill	16								
New Canaan, CT	1.4	.6	Landfill	28								
Easthampton	1.9	.6	Lagoon	10								
Maryland City, MD		.6	Land Applied[a]	7								
Essexville, MS	.9	.6	Landfill	13								
Iron Mt., MI	1.6	.3[a] .3[d]	Land Applied	6								
Ripon, WI		.6	Land Applied[a]	377/189	.6/0	.6/.6	.6/.6	.6/.6	.6/.6	.6/.6	.6/.6	.6/ 6
Montezuma	2	.6	Land Applied[b]	Unknown								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) — MAXIMUM Cd ADDITION (KgCd/HA/YR): 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Chilton, WI		.5	Land Applied[a]	115/58		.5/0		.5/0	.5/0	.5/.5	.5/.5	.5/.5
Merrill, WI		.5	Land Applied[a]	18/9								
Carroll, IA	1	.25[a] .25[d]	Land Applied	203/102	.25/0	.25/.25	.25/0	.25/25	.25/.25	.25/.25	.25/.25	.25/.25
Plainville, CT	1.2	.5	Landfill	130								
UNKNOWN		.5	Land Applied[a]	10/5								
UNKNOWN		.5	Land Applied[a]	9/5								
Watertown, CT	1.1	.25[b] .25[d]	Land Applied	16								
UNKNOWN		.5	Land Applied[a]	7/4								
Richmond, VT	.1	.5	Land Applied[a]	0/0								
UNKNOWN		.5	Land Applied[a]	23/12								
Crawfordsville	1.5	.25[a] .25[d]	Land Applied	15/8								
UNKNOWN		.5	Land Applied[a]	9/5								
Lebanon, IN	1.5	.5	Land Applied[a]	40/20								.5/0
UNKNOWN		.5	Land Applied[a]	8/4								
Charlotte, MI	.7	.5	Land Applied[a]	Unknown								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) — MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Dexter, MI	.2	.5	Landfill	Unknown								
Berlin, WI		.5	Land Applied[a]	2/1								
Northaven, CT	1.2	.5	Landfill	19								
Westport, CT	.8	.4	Land Applied[b]	18								
Lanse, MI	.5	.13[a] .13[b] .13[d]	Land Applied	8/4								
Windsor, CT	.8	.4	Landfill	18								
Milford, MI	7.5	.4	Landfill	2								
Rodeo	.6	.2[b] .2[d]	Land Applied	Unknown								
Bethel	.8	.4	Landfill	Unknown								
Portland, CT	.8	.4	Landfill	18								
Simsbury Waste Act Digested	.5	.4	Landfill	36 7								
Thomaston, CT	.9	.4	Landfill	26								
Litchfield, CT	.7	.3	Landfill	150								
Montville, CT	.3	.3	Lagoon	Unknown								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Plymouth, CT	.7	.1[a] .1[b] .1[d]	Land Applied	1200/600	.1/.1	.1/.1	.1/.1	.1/.1	.1/.1	.1/.1	.1/.1	.1/.1
Ridgefield, CT	.5	.3	Landfill	Unknown								
Windsor Lakes, CT	1.4	.15[b] .15[d]	Land Applied	14								
Barre City, VT Primary Secondary	2.3	.15[a] .15[d]	Land Applied	4/2 10								
Federalsburg, MD		.3	Landfill	21								
Tipton, IN	1.4	.26[a] .045[d]	Land Applied Landfill	11/6								
Howell, MI	.8	.3	Land Applied[a]	Unknown								
UNKNOWN	1.5	.3	Land Applied[a]	13/7								
Manistique, MI	1.5	.15[b] .15[d]	Land Applied	4								
Ashland, WI		.2 .2	Land Applied[a] Landfill	9								
Plymouth, WI		.3	Land Applied[a]	11/6								
Watertown, WI		.3	Land Applied[a]	1/1								
Waupun, WI		.3	Land Applied[a]	0/0								.3/0

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT)							
					MAXIMUM Cd ADDITION (KgCd/HA/YR)							
					2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Jefferson, WI		.3	Land Applied[a]	42/21								.3/0
Clinton	5	.23[a] .07[d]	Land Applied	8/4								
W.C.I.D.	.2	.1[b] .1	Land Applied Landfill	25								
Cheshire	.3	.2	Land Applied[a]	10/5								
Griswold Jewett City	.3	.2	Land Applied[a]	33/17								.2/0
New Milford, CT	.5	.2	Landfill	14								
Norfolk, CT	.4	.2	Landfill	0								
North Canaan, CT	.3	.2	Landfill	27								
Gladstone, MI	.7	.2	Land Applied[c]	4								
Salisbury, CT	.3	.1 .1	Landfill Land Applied[c]	39								
S. Windsor, NY	.2	.2	Landfill	18								
E. Windsor Warehouse Broadbrook	.4	.2	To Broadbrook Landfill	15 4								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Suffield, CT	.4	.2	Landfill	13								
St. Ignace	.7	.1[c] .1[d]	Land Applied	4								
Stonington, CT												
Main	.2	.1	Landfill	24								
Mystic	.2	.1	Landfill	16								
Constantine, MI	.36	.1	Land Applied[a]	Unknown								
Ironwood, MI	1.1	.1	Landfill	4								
Beacon Falls	.1	.1	Landfill	11								
Canton, CT	.2	.1	Landfill	0								
Skelton, CT	2.3	.1	Landfill	62								
Sprague, CT	.2	.1	Landfill	0								
Thompson, CT	.1											
Waste Act		.1	Land Applied[a]	25/13								
Digested		.1	Land Applied[a]	9								
Berwick, ME	.6	.1	Landfill	3								
Ocean Pines, MD		.1	Land Applied[a]	4/2								
Thurmont, MO		.1	Landfill	6								
Norway, MI	.2	.16	Land Applied[b]	2								

CITY, STATE	FLOW (MGD)	SLUDGE QUANTITY (DRY MT/DAY)	DISPOSAL PRACTICE	Cd CONTENT OF SLUDGE (Mg/Kg, WITHOUT/WITH PRETREATMENT)	SLUDGE QUANTITY WHICH CANNOT BE LANDSPREAD (DRY MT/DAY WITHOUT PRETREATMENT/DRY MT/DAY WITH PRETREATMENT) MAXIMUM Cd ADDITION (KgCd/HA/YR) 2.0		1.25		1.0		0.5	
					10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA	10MT/HA	20MT/HA
Escanaba, MI Primary	1.8	.25[a] .25[d]	Land Applied	Unknown								
		.9	Landfill	15								
Scarborough, ME		.05[a] .05[b]	Land Applied	8								
Owosso, MI	2.3	.1	Land Applied[b,d]	350								
Morrisville, VT	.3	.05[a] .05[d]	Land Applied	Unknown								
West Rutland, VT	.2	.05[a] .05[d]	Land Applied	0 0								
Antigo, WI		.017[a] .017[b]	Land Applied	14/7								
		.017	Landfill									
Baraboo, WI		.007[a] .014	Land Applied[a] Landfill	304/152	.007/.007	.007/.007	.007/.007	.007/.007	.007/.007	.007/.007	.007/.007	.007/.007
Brillion, WI		.02	Landfill	58								

APPENDIX G

1977 UPDATE TO THE 1976 WASTE AGE SURVEY

1977 update for land disposal practices survey

State officials seemed anxious to talk to us in late 1976 when we did the last disposal practices survey update. This year, however, many waste control agency administrators were anything but delighted to see our new inquiries. "I want to work with you on this," we heard again and again "But I don't have the time any more So many forms, polls, surveys, requests for information . . ." the voice always trailing off, disheartened Fortunately we were able to persuade, cajol, or flatter every state agency into lending us some of its valuable time to complete this survey.

We've thanked state officials before for their generous help in completing these time-devouring surveys, but those thanks bear repeating That top state agency personnel are willing to volunteer their services to help generate a national data base demonstrates, we think, the solid waste control professionals' continuing commitment to improving public understanding of solid waste handling

In addition to complaints about pressures on their time, many state agency officials offered this comment "I don't know anymore." Many items specifically answered one year ago now list as N/As

It doesn't take a degree in government affairs to deduce that we have entered the RCRA (Resource Conservation and Recovery Act) world RCRA's demands (and the increasing public interest in disposal practices) have caused heavier workloads on state agencies More, anticipation of or confusion about the definitions RCRA will use for key concepts like "sanitary landfill" has thrown many state agencies into doubt about the significance of their information

Hence, we are reluctant to make any claims about the comprehensiveness of this year's figures As you will see from the following pages, there are too many N/As to allow the 1977 survey to be thought of as the complete national picture In these cases, N/A is literal—"not available " It's not that we didn't get the information, it's that the information isn't there

We'd planned this survey for 1977 (previously, updates were done only in even-numbered years) hoping to grab a "last look" at the state of waste control, as it is conceived now, because the concepts certainly will be altered by RCRA What we discovered is that, as far as statistics are concerned, waste control is in a bit of disarray. Considering the pervasive impact of RCRA, perhaps that should not have come as a surprise

Despite this, it is useful to make some general observations about the new lines of figures First, the total for "known land disposal sites," perhaps the survey's key item, declined from 15,821 in 1976 to 14,126, a 10.7 per cent drop. Our last survey showed the 1976 figure declined from the 1974 total of 18,539 sites, a decrease of 14 6 per cent. But since this year's decline took place over one year rather than two, it seems reasonable to conclude that the number of land disposal sites is shrinking ever more rapidly (Or at least that statistical recognition of them is dropping. If, as is possible, RCRA defines every "pit, pond, and lagoon" as a "land disposal site," then this total will inflate to many times its present size.) In sum, the surveys show a 23 8 per cent decrease in the number of "known" land disposal sites in just three years

SURVEY begins on page 36

Another anticipated trend borne out by the new figures is that toward larger, more expensive state waste control agencies. The number of reported state solid waste employees increased from 858 to 1,000 in one year, a 16 5 per cent jump Since 1974, state solid waste employees have increased in number 34 9 per cent, an astounding figure even by government's ever-inflating standards It seems clear that state budgets have jumped, too, although we did not total that column because three N/As there dilute the figures We estimate the total to be $28 million, a whopping 45 per cent above last year's $19 million

Also of interest is that seven states switched their position to "supports" as regards interstate transfer of wastes, while two shifted to "discourages " Thirty-four states now are listed as supporting the controversial interstate transfer, 12 as discouraging it and the rest taking neutral positions (Among the unconcerned is Alaska, of course Hawaii, perhaps playfully, changed its position from neutral to "discourages ")

A continuing hangup for this survey is the states' various legal (or regulatory) definitions We asked again the number of "authorized" landfills and the

(Notes, continued on page 42)

EXCLUSIVE WASTE AGE SURVEY

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	State Population (Provisional 1975 Data)	Metropolitan Population (Provisional 1974 Data)	Number of Cities Over 5000	Square Miles of Area	Revision State Solid Waste Legislation Since 1976?	State Solid Waste Budget—$ 1976	1977
REGION #1							
Connecticut	3,095,000	2,849 200	42	5,009	Yes	320,000	N/AV
Maine	1,059,000	322 100	27	33 215	Yes	130,000[2]	120,000
Massachusetts	5 828,000	5,610,900	93	8 257	No	425,000	662,625
New Hampshire	818 000	399,100	15	9,304	No	75,000	112,000
Rhode Island	927,000	854,400	15	1,214	No	349,000	385,000
Vermont	471,000	—	12	9,609	Yes	90,000	122,500
	12,198 000	10,035,700	204	66 608		1,389,000	
REGION #2							
Delaware	579,000	395 300	5	2 057	No	100,000	310,000
New Jersey	7,316 000	6,799,800	206	7 836	No	560,000	907,000
New York	18,120,000	16 057,900	210	47 939	Yes	871,548	1,475,638
	26,015,000	23 253,000	421	57 832		1,531,548	
REGION #3							
Maryland	4 098,000	3,495,400	45	10,577	No	218,445	257,525
Pennsylvania	11 827 000	9 545 800	271	45,333	No	1,333,000	1 573,315
Virginia	4,967,000	3,228,300	46	39 838	No	200,000	250,000
West Virginia	1 803 000	659 500	29	24 181	Yes	±126,000	192,000
	22 695 000	16,929,000	391	119,929		1,877,445	
REGION #4							
Alabama	3,614 000	2 204 600	56	51 609	No	67,180	105,000
Florida	8 357 000	6 778 200	100	58 560	Yes	361,000	906,754
Georgia	4 926,000	2 760 300	62	58,876	No	2,716,627	1,778,095
Kentucky	3,396 000	1 563 700	43	40 395	No	501 000	501,100
Mississippi	2,346,000	604,700	39	47 716	No	120,000	150,000
No Carolina	5,451 000	2,436,400	66	52,712	No	238,000	±300 000
So Carolina	2 818 000	1 338,700	41	31 055	No	307,042[3]	N/AV
Tennessee	4,188,000	2,600,200	55	42 244	No	314,400	2,817,500
	35 096,000	20,286 800	462	383,167		4,625,249	
REGION #5							
Illinois	11,145,000	9,064,700	199	55,930	No	801,000	1,000,000
Indiana	5 311,000	3,507,400	83	36,291	No	278,200	300,000
Michigan	9,157,000	7,442,100	116	58,216	No	524,000	966,700
Ohio	10 759,000	8,600,500	193	41,222	No	535,000	354,000
Minnesota	3,926,000	2,473,200	77	84,068	Yes	420,000	651,907
Wisconsin	4 607 000	2 752 500	80	56 154	No	500 000	950,000
	44,905,000	33,840,400	748	331,881		3,056,200	
REGION #6							
Arkansas	2,116 000	793,000	37	53,104	No	100,000	273,350
Louisiana	3 791 000	2,370 900	56	45,106	No	70,000	263,000
New Mexico	1 147 000	378,900	23	121 666	No	136,460	250,000
Texas	12,237 000	9,418 800	183	267 338	Yes	713,580	1,020,000
Oklahoma	2,712 000	1 507,300	52	68,887	No	120,000	275,000
	22,003,000	14,468,900	351	556,101		1,140,040	
REGION #7							
Iowa	2 870 000	1,055,100	58	56,032	Yes	285,000	200 000
Kansas	2 267 000	976 300	46	82 264	Yes	118,000	244,000
Missouri	4,763,000	3,050,100	81	69,686	No	197,000	430,000
Nebraska	1,546 000	685,100	24	77 227	Yes	132 334	224,000
	11,446 000	5,766,600	209	285,209		732,334	
REGION #8							
Colorado	2 534 000	2,030,200	34	104,247	No	150,000	200 000
Montana	748 000	178 800	14	147 138	Yes	750,000	1 203 478
Utah	1 206 000	928 500	24	84 916	No	81 000	139 843
Wyoming	374 000	—	16	97 281	No	53,592	99,324
No Dakota	635 000	79 000	12	70,665	No	65,000	84,000
So Dakota	683 000	98,400	12	77 047	Yes	117 000	128 720
	6 180 000	3 314 900	104	581 294		1,216,592	
REGION #9							
Arizona	2 224 000	1,598 000	19	113 909	No	158,758	117,000
California	21 185,000	19,448 800	266	158,693	Yes	2,000,000	2,800,000
Hawaii	865 000	691,200	9	6,424	No	50 000	70,000
Nevada	592 000	462 200	7	109 788	Yes	96,392	124,284
	24 866 000	22,201 000	301	388,814		2,305,150	
REGION #10							
Alaska	352 000	148 800	5	586 400	No	312,000	N/AV
Idaho	820,000	131 500	18	83 557	No	134,000	156,271
Oregon	2 288 000	1 368 700	35	96 248	Yes	387 953	725 000
Washington	3 544 000	2 495 500	45	68 192	No	550 000	550 000
	7 004 000	4 144 500	103	834 397		1 383 953	
District of Columbia	716 200	716 200	1	69	Yes		150 000
GRAND TOTAL	213 124 200	154 957 200	3 295	834 466		19 257 511	

OF U.S. DISPOSAL PRACTICES

(8) Number of State Solid Waste Employees 1976	(8) 1977	(9) 1977 Utilization of State Solid Waste Personnel† A	B	C	D	E	F	G	(10) State Attitude Toward Regional Authority	(11) State Attitude Toward Interstate Transfer	(12) Number of Sites With Impermeable Linings In 1974	(13) Number of Landfill Impermeable Linings Installed Since 1976	(14) Number of Sites With Leachate Treatment Facilities In 1974
18	19	2	1	0	8	4	4	0	Encg	Sup	0	0	0
7	7	50	25	75	3	1	1 5	0	Encg	Disc	0	0	0
14	23	6	0	1	3	8	5	0	Encg	Disc	0	0	0
5	10	2	1	0	0	4	3	0	Encg	Sup	0	0	0
5	5	0	0	0	1 6	2	2	0	Encg	Disc	0	0	0
5 3	6 3	1 8	0	0	1 6	1 8	1 1	0	Encg	Disc	1	0	0
54 3	70 3	12 3	2 25	1 75	16 6	20 8	16 6	0			1	0	0
10	11	1	0	1	4	1	4	0	Encg	Sup	0	1	1
35	59	7	0	2	4	19	11	16	Encg	Disc	1	3	1
54	93	N/A	N/A	N/A	N/A	N/A	N/A	N A	Encg	Sup	3	5	0
99	163	8	0	3	8	20	15	16			4	9	2
16	19	1	0	0	8	4	6	0	All	No Pos	0	0	2
66	63	3	1	1	8	38	12	0	Encg	Sup	6	7	6
10	8	1	0	0	0	5	2	0	Encg	Disc	1	4	1
9	8	5	5	0	1	4	2	0	Encg	Disc	0	0	9
101	98	5 5	1 5	1	17	51	22	0			7	11	18
5	7	0	1	0	2	3	1	0	Encg	Sup	0	0	1
17	29	5	1	0	2	5	3	13	Encg	Sup	0	0	6
35	35	2	1	0	2	20	8	2	Encg	Sup	0	0	0
30	23 5	2	2	1	1	12	5	5	Encg	Sup	0	0	4
10	12	2	2	0	1	5	2	0	Encg	Disc	0	0	0
12	10	1	1	0	2	4	2	0	All	Sup	0	0	0
29	29	2	2	0	17	4	4	0	Encg	Sup	0	0	0
20	32	3	2	2	16	2	7	0	Encg	Sup	0	0	2
158	177 5	17	12	3	43	55	32	15 5			0	0	13
38	51	3	0	0	0	3	13	32	All	Sup	1	0	0
13	16	N A	N/A	N/A	N/A	N/A	N/A	N/A	Encg	Sup	0	0	0
13 5	28	1	0	0	7	9	6	5	Encg	Sup	3	3	3
17 6	16	1	0	3	1	5	2	4	All	Sup	0	0	2
27	19	2	0	0	0	2	6	9	Encg	D sc	2	0	1
24	38	3	3	1	11	8	6	6	Encg	All	0	15	2
133 1	168	10	3	4	19	27	33	56			6	18	8
8	13	2	1	0	2	5	3	0	Encg	Sup	0	0	1
3 5	4	1	0	0	1	1	1	0	Encg	Sup	1	1	0
10	12	1	1	0	3	5	2	0	Encg	Disc	0	0	0
63	47	6	1	5	1 5	11	11	16	Encg	Sup	2	0	12
9	13	2	1	0	4	4	2	0	Encg	Sup	0	UK	0
93 5	89	12	4	5	11 5	26	19	16			3	1	13
14	10	2	0	0	4	3	1	0	Encg	Sup	0	0	0
6	7	3	0	0	0	4	0	0	All	Sup	0	0	0
13	22 5	3	5	0	5	5	5	4	All	Sup	0	0	3
7	9	2	0	1	1	3	2	0	Ing	Sup	0	0	0
40	48 5	10	5	1	10	15	8	4			0	0	3
6	8	1	5	5	3	2	1	0	Encg	Sup	0	5	0
10 5	11	5	5	0	2	3	4	1	Encg	Sup	0	0	0
4	5	1	5	0	1	1	1 5	0	All	Disc	0	0	0
2	3	25	25	0	1	75	75	0	Encg	Sup	UK	0	0
3	4 5	0	5	0	0	1	2	1	Encg	Sup	0	0	0
6	5 8	1 6	2	5	5	2	1	0	All	Sup	0	0	0
25 5	37 3	4 35	2 45	1	7 5	9 75	10 25	2			0	5	0
6	8	3	0	0	1	1	3	0	Encg	Sup	0	0	0
73	60	12	4	5	4	10	10	15	Encg	Sup	0	0	0
4	4 5	1	0	0	2	1	1 5	8	All	Disc	0	0	0
2 9	4 9	1	0	0	5	2	1 4	0	Encg	Sup	0	0	0
85 9	77 4	17	4	5	5 7	14	15 9	15 8			0	0	0
10	11	1	1	0	2	5	2	0	Ign	Ign	0	0	1
9	6 5	2	0	5	2 5	1	5	0	All	Sup	0	0	0
20	25	6	0	1	6	9	3	0	Encg	Sup	0	0	0
23	21	2	0	0	10	4	2	3	All	All	0	0	3
62	63 5	11	1	1 5	20 5	19	7 5	3			0	0	4
8	8								Disc	Sup		0	
858 3	1000 5												

†A Planning
B Training
C Research
D Technical Assistance
E Enforcement
F Administration
G Other

EXCLUSIVE WASTE AGE SURVEY

	(15) Number of Leachate Treatment Facilities Installed in Landfills Since 1976	(16) Application of Daily Cover Over Milled Refuse Is	(17) Number of Known Land Disposal Sites 1976	1977	(18) No. of Sites Licensed Permitted Or Otherwise Recognized As Sanitary Landfill In Compliance With State Regulations 1976	1977	(19) Number of Authorized Landfills 1976	1977
REGION #1								
Connecticut	1	Req	170	164	54	104	70	58
Maine	0	Req	445	383	15	100	445	383
Massachusetts	0	Req	360	375	100	190	200	[illegible]
New Hampshire	0	Req	165	[illegible]	61	60	56	[illegible]
Rhode Island	0	Req	35	29	35	15	35	[illegible]
Vermont	0	Cs Det	98	105	60	70	60	70
	1		1 273	1 207	325		966	
REGION #2								
Delaware	1	Cs Det	30	25	30	5	30	25
New Jersey	2	Req	338	296	210	271	278	271
New York	1	Cs Det	662	635	421	381	421	635
	4		1 030	956	661		729	
REGION #3								
Maryland	1	Cs Det	79	67	49	56	49	56
Pennsylvania	17	Cs Det	415	365	111	160	200	160
Virginia	4	Cs Det	235	223	210	223	210	23
West Virginia	4	Req	207	250	52	50	60	50
	26		936	935	422		519	
REGION 4								
Alabama	0	Req	140	132	126	117	134	29
Florida	0	NR	355	330	238	111	66	[illegible]
Georgia	0	Req	625	480	122	196	122	146
Kentucky	0	Cs Det	334	327	144	146	167	162
Mississippi	1	Req	274	N A	78	N A	78	65
No. Carolina	0	Cs Det	170	170	170	170	170	170
So. Carolina	0	NR	222	211	217	211	217	211
Tennessee	1	Req	126	148	112	139	121	139
	2		2 256	1 798	1 207		1 075	
REGION #5								
Illinois	0	Req	465	450	287	300	330	300
Indiana	0	Req	149	173	126	149	126	131
Michigan	2	Req	[illegible]	N A	295	94	445	302
Ohio	0	Cs Det	250	250	242	237	242	228
Minnesota	0	Req	405	348	135	103	135	126
Wisconsin	17	Cs Det	1 300	1 267	289	288	1 300	1 267
	19		3 269	2 488	1 374		2 578	
REGION #6								
Arkansas	0	Cs Det	400	460	74	91	87	91
Louisiana	0	N R	265	365	60	65	60	65
New Mexico	0	N R	540	600	50	300	319	300
Texas	0	Cs Det	1 097	1 070	293	510	1 045	1 070
Oklahoma	0	Cs Det	507	188	165	188	165	188
	0		2 809	2 683	642		1 676	
REGION #7								
Iowa	0	Req	300	327	94	105	108	105
Kansas	0	NR	198	126	103	126	198	126
Missouri	0	Cs Det	253	217	117	124	117	124
Nebraska	0	Req	400[1]	455	62	65	200	400
	0		1 151	1 125	376		623	
REGION #8								
Colorado	0	Cs Det	231	216	67	120	126	N A
Montana	0	Cs Det	245	227	124	98	124	N A
Utah	0	Cs Det	200	174	9	11	13	41
Wyoming	0	Cs Det	100	150	10	68	65	58
No. Dakota	0	NR	200	135	23	95	60	80
So. Dakota	0	Cs Det	300	300	28	30	34	16
	0		1 276	1 202	261		422	
REGION #9								
Arizona	0	Cs Det	144	140	78	78	N A	N A
California	3	Cs Det	430	400	UK	16	430	N A
Hawaii	0	Cs Det	30	35	21	33	21	19
Nevada	0	Cs Det	120	129	32	N A	120	D NA
	3		724	704	131		571	
REGION #10								
Alaska	0	Cs Det	400	350	84	126	300	126
Idaho	0	Req	120	140	40	46	47	46
Oregon	0	Cs Det	167	158	167	153	167	153
Washington	0	Cs Det	410	410	50	60	320	300
	0		[illegible]	[illegible]	[illegible]		[illegible]	
District of Columbia	0	Cs Det		[illegible]		N A		[illegible]
GRAND TOTAL	[illegible]		15 62[illegible]	14 12[illegible]	[illegible]		9 93[illegible]	

OF U.S. DISPOSAL PRACTICES

Publicly Owned And Operated 1976	1977	(20) Publicly Owned and Contractually Operated 1976	1977	Privately Owned And Operated 1976	1977	(21) Number of Landfills With Daily Operating Capacities of** A	B	C	D	E	F	G	(22) Number of Landfill Closures Since 1976
35	103	3	10	16	17	75	50	15	1	2	1	0	12
14[15]	375	0	0	1[15]	8	379	3	1	0	0	0	0	2
90	335	—	N A	10	40	300	30	13	10	5	2	0	15
57[10, 5]	45	1	4	3	9	40	8	7	1	0	0	0	0
22	20	1	2	12	6	19	3	3	2	1	1	0	2
30	76	10	7	20	22	101	4	0	0	0	0	0	5
248		15		62									36
4	2	6	1	20	2	11	3	6	2	0	1	2	1
100	N A	0	N A	110	N A	160	20	17	11	11	10	42	15
336	5[15]	0	N A	85	120	N A	N A	N A	N A	N A	N A	N A	47
440		6											63
45[5]	54	1[15]	2	3[15]	13	32	10	9	8	6	2	0	6
49[5]	157	12	10	50[15]	159	327	67	18	5	2	11	0	10
190	161	0	3	20	59	195	10	5	6	6	1	0	3
31	26	0	0	21	24	38	10	2	0	0	0	0	0
315		13		94									19
117	20	6	9	3	0	72	34	12	4	3	2	0	6
209[5]	308	0	1	29[15]	21	220	35	28	26	10	4	7	75
99	400	2	20	21	100	N A	N A	N A	N A	N A	N A	N A	75
71	68	1	2	72	74	N A	N A	N A	N A	6	2	0	6
70	63	0	0	8	5	67	1	0	0	0	0	0	0
155	140	0	8	15	22	17	15	30	100	6	2	0	2
81	74	1	2	135	135	106	16	22	45	19	3	0	11
102	112	4	0	6	27	30	30	60	4	3	7	5	4
904		14		289									179
63	70	20	8	204	193	100	50	100	20	20	10	0	75
02	32	50	18	44	72	37	18	22	28	12	3	2	14
145	140	5	0	145	162	UK	UK	UK	UK	UK	UK	UK	70
105	105	0	UK	137	132	72	67	37	40	6	0	15	6
45	52	30	5	60	46	278	28	28	5	5	4	0	57
214	1 106	3	3	72	158	1 000	100	50	20	5	2	0	56
604		108		662									278
52	63	1	2	21	26	74	12	2	3	0	0	0	N A
45	43	0	2	15	20	N A	N A	N A	5	3	2	0	15
46	296	4	4	0	0	290	6	3	0	1	0	0	16
265	428	3	5	25	77	912	92	23	27	9	7	0	24
110	26	0	0	55	62	129	28	17	11	3		0	22
518		8		116									77
58	65	13	30	13	10	72	20	7	5	1	0	0	1
65	102	32	14	6	10	0	3	0	1	0	3	117	3
36	39	9	16	72	69	186	18	2	8	4	0	0	10
55	36	2	2	5	27	61	2	0	0	0	2	0	0
224		56		96									14
33	N A	1	N A	33	N A	202	5	4	2	3	0	0	15
89	217	25	2	10	8	218	3	4	2	0	0	0	16
8'	35	1'	6	0	0	65	60	18	5	5	1	0	26
5	60	0	6	5	62	93	3	2	0	0	0	0	10
21	55	0	0	2	25	72	6	2	0	0	0	0	1
8	19	16	2	4	5	27	2	1	0	0	0	0	2
164		43		54									70
64	134	8	16	6	5	123	5	6	2	4	0	0	5
No Upd	N A	*No Upd*	N A	*No Upd*	N A	N A	N A	N A	N A	N A	N A	N A	0
17	17	0	0	4	2	13	2	0	0	1	1	0	1
19	123	8	3	5	3		1	1	0	0	0	0	4
100		16		15									10
5	30	39	20	40	96	347	1	1	0	1	0	0	12
5	10	34	34	1	2	26	16	3	1	0	0	0	15
94[1]	91	26	24	47	38	148	2	2	4	0	2	0	14
40	50	5	5	5	5	140	50	10	5	3	3	199	20
144		104											61
	1		0		0	0	0	0	0	0	1	0	0
													0
3 661		383		1 696									807

TONS PER DAY
A 0 50
B 50 100
C 100 200
D 200 500
E 500 1 000
F 1 000 or more
G Unknown

SURVEY NOTES . . .

(Continued from page 35)

number of "licensed, permitted, and otherwise recognized" sites This comparison is meaningful to some state officials and causes ;others to scratch their heads in bewilderment With the expectation of RCRA's definitions brooding over this year's survey, these numbers became confused Therefore, we did not attempt to total columns beyond number (17) In the latter columns, particularly question (21), some states could supply only figures for acknowledged "sanitary" landfills, some for all landfills, some for permitted landfills, and so on, and these different categories were impossible to correlate We suggest readers will find these latter columns most useful if regarded as significant only within states or regions. Anyone wishing to project a national trend from the latter columns should remember the doctrine of caveat emptor

We hope this update will provide a helpful information base for all professionals in the waste control field For good or ill, it probably is the last "pre-RCRA" statistical look at our nation's land disposal practices. The next look—RCRA's open-dump inventory—will tell us everything we always wanted to know about solid waste but couldn't afford to ask We realize the open-dump inventory may put our survey out of business But then, considering the $50 million pricetag put on the inventory by EPA officials, it ought to.

Abbreviations

All	Allows
Cs Det	Case Determination
Disc	Discourages
Encg	Encourages
Ign	Ignores
N/A =	Not Available
No Nd =	No Need
NR -	Not Required
Req -	Required
Sup	Supports
UK	Unknown
D/N A =	Did Not Apply
No Upd -	Not Updated

Footnotes

(1) Editor supplied number based on typical responses from similar programs
(2) 1974 number utilized where new data was not supplied
(3) Surveillance
(4) Inspection and Permits
(5) Hazardous waste
(6) Clay liners only
(7) Program development
(8) 11 permits—3 hazardous waste
(9) Financial assistance
(10) Includes 5 sites privately owned and publicly operated
(11) Abandoned auto program
(12) Data management and demonstration studies
(13) Spray irrigation
(14) Recirculation method not reported
(15) Number reported here by state was total for all sites which editor proportioned to equal answer in question #14

NOTES ABOUT THE QUESTIONS

COLUMN (5)

Several states reported legislation pending

COLUMN (6)

States were asked to supply total figures, including one-time state or federal grants, without listing source. Several reported federal grants pending.

COLUMN (8)

Most states have other employee support not indicated by these figures—county, regional, and local health and environmental control personnel Several states reported new positions expected soon, and these were included in the figures New York and Indiana reported tthat their workers have no "formal assignments " Their entries as N/As mean that employees are not tied to any given slot—not that the agency heads don't know what their people are doing

COLUMN (12)

Reprinted from earlier survey

COLUMN (13)

The 1974 to 1976 figure showed 82 new liners; the new one-year figure shows 44, so the pace should be considered unchanged Some reponses included artificial linings, asphalt, rubber, etc, but never recompacted on-site soils

COLUMN (14)

Reprinted from earlier survey

COLUMN (16)

Eight states changed to determining cover requirements on a case-by-case basis, while six made daily cover mandatory Two dropped cover requirements In Region Six, four of the five states changed procedures. We would be pleased to hear readers' theories on what this signifies.

COLUMN (17)

This column includes whatever the sampled states classified as a "land disposal site." It is bound to change because of new definitions being considered in many quarters Many of the entries are estimates

COLUMN (20)

Many of these numbers are estimates In many cases, we were told, far more was known about sites either publicly owned and operated or privately owned and operated than of the public-private hybrids

In some cases, the total sites listed in the breakdown is greater than the total for "known sites" in column (17) This is because (20) often represents the respondent's best estimate, and the round numbers are intended to represent proportions rather than exact guesses In the last survey, we corrected this column (on a proportional basis) to match the total in (17) This year, we reproduce the state's listing. Perhaps a contrast between the two approachs will benefit the user ■

APPENDIX H

LANDFILL GAS INCIDENTS: BACKGROUND MATERIAL

City of Richmond
Department of Public Works

900 E. Broad Street, Richmond, Virginia 23219
804 • 649-4664

March 5, 1979

Mr. David H. Armstrong
Emcon Associates
1420 Koll Circle
San Jose, California 95112

Re: Landfill Gas Control System Costs

Dear Mr. Armstrong:

As discussed in our phone conversation of March 1, 1979, I am enclosing a report outlining our experiences in the early phases of our gas control work. I hope it will be of some use to you.

I have made marginal notes to indicate the costs of various items that we know. Also the cost breakdown of the project we now have under bids is attached for your use.

Please note that some of the comments made concerning communications are peculiar to our case and should not be taken as general statements.

If we can help you further, please advise.

Sincerely,

D. O. Nuttall, Sr. CE
Division of Sewers

DN/st
Enclosure

REPORT SUMMARIZING THE LANDFILL GAS CONTROL PROGRAM OF THE CITY OF RICHMOND, VIRGINIA

PREPARED BY
THE CITY OF RICHMOND DEPARTMENT
OF PUBLIC WORKS
FOR
THE NATIONAL ASSOCIATION OF COUNTIES'
TECHNICAL ASSISTANCE SEMINAR IN
DENVER, COLORADO ON SEPTEMBER
27, 28 and 29, 1977

I. HISTORY/BACKGROUND

The City of Richmond, Virginia first became aware of the potential hazards of sanitary landfill-produced methane gas in early January of 1975 when an explosion in an apartment building inflicted minor burns on a resident and blew doors and windows from the apartment. The building, which is located within a matter of feet of the edge of the City-operated Fells Street Landfill, was all-electric and was not served by natural or bottled gas. Fire personnel detected combustible gas in the first floor walls and exterior weep holes of the building. This combination of circumstances led the City to investigate the landfill as a potential source of the explosive gas. Test borings revealed subsurface gas concentrations well in excess of the lower explosive limit (L.E.L) immediately surrounding the building. As roughly two-thirds of the landfill perimeter bordered fully developed residential and commercial neighborhoods, the potential magnitude of hazardous exposure to the areas became evident.

Recognizing that the scope and the complexity of this problem exceeded the expertise of City and other local engineers, EPA was contacted for the names of consultants with experience in dealing with landfill gas problems. EPA offered the names of two firms, although the City has since become aware of others (see Appendix). The City interviewed and accepted work proposals from the two firms who both proposed to evaluate the problem in a similar manner. A contract was entered into with the consultant agreeing to accept professional services liability as a contract provision (also see Problems Encountered). The consultant conducted on-site studies in mid-1975.

Although the City has identified and is dealing with landfill gas problems at five sites, major emphasis has been placed on two of them: the Whitcomb and the previously discussed Fells landfills. The Whitcomb landfill covers approximately 14 acres with a maximum 40 foot depth. Less than half of its perimeter fronts on developed land and a City school is located on one developed side. The landfill was closed out in the late 1950's and the land is now used primarily for recreational purposes. The Fells landfill covers approximately 39 acres to a maximum 80 foot depth. Approximately two thirds of its perimeter fronts on developed land and, as at Whitcomb, a City school is located on one developed side. A portion of the landfill has been closed and is now used for school and recreational facilities. The active portion is scheduled to be closed within several years.

The tests which the consultant performed consisted primarily of sampling subsurface gases through plastic tubing buried generally to depths of 5, 10 and 20 feet (see sketch in Appendix). These samples were collected in plastic bottles and analyzed in the consultant's lab for methane, carbon dioxide, nitrogen and oxygen by gas chromatography. After several rounds of sampling, the methane concentrations were plotted on a site plan and used to construct "isogas" lines, or contours showing the trend of methane generation/migration around the landfills. Methane, the consultant determined, had been migrating several blocks outside of the landfill limits through natural ground.

Included in the consultant's report to the City were the following recommendations: 1) residents and businesses in the affected areas should be advised of the potential hazard and asked to keep buildings well ventilated, 2) continuous, automatic methane detection systems should be installed in the school buildings, 3) building permits should not be issued in the affected areas until the applicant demonstrates that there is either no methane problem on the site or that the problem will be addressed by the inclusion of protective features in the building design, and 4) the City should begin a two-phase program to eliminate the movement of methane outside of the landfills using a subsurface vacuum barrier induced by electric blowers through transmission headers to gas extraction wells.

The City implemented the first recommendation with the door-to-door distribution by Fire inspectors of notices advising residents of the problem and precautions which they should take. (Sample notices included in the Appendix.) An emergency telephone number was provided should residents detect unusual odors or have any questions. Fire inspectors began, and are continuing, to "spot check" homes with portable meters on a regulator basis or on request. The border of these activities was generally along the "zero" methane gas contour.

The City began implementation of the second recommendation by authorizing it's consultant to design the proposed automatic detection systems for the school buildings. Sensing heads were installed in virtually every room of the buildings. Changes in combustible gas concentrations at the sensors induce a voltage variation in the control wires which tie the sensors to a central control panel in the buildings. Visual alarms are set at a 5% L.E.L. threshold and audible alarms at 10% L.E.L. Both systems, which operate continuously, are linked to the School Board's radio room for remote monitoring at night and on week-ends.

The City's Building Commissioner's office was advised of the methane-affected areas as a first step in implementing the consultant's third recommendation. Building permit applicants inside the established "zero" gas contour are now required to engage the services of a certified professional engineer to first determine whether a methane problem exists on the site of the proposed work. Should methane in concentrations less than 2% L.E.L. be detected, a permit is issued without further requirements. This limit of allowable methane concentration was recommended by the City's consultant. Should this limit be exceeded, the following three features must be included in the building design: 1) adequate ventilation, 2) automatic methane detection, and 3) sealing of ground-level or basement floors. When these requirements have been addressed, the permit is issued. Two such permits have been issued. In both cases, the special features were required. (Also see Problems Encountered).

The City initiated implementation of the gas migration control program by entering into a contract with it's consultant for the design of two "pilot" control systems. The primary purpose of these small scale systems was to provide a means for evaluting the performance of a gas collection system in local soil, groundwater and climatic conditions. These systems have been constructed on the grounds of the two schools in order to afford protection to the buildings at the earliest possible date. This consideration, however, was secondary to the primary purpose of collecting performance data to be used in the design of full-scale control systems around the landfills.

The pilot control systems were constructed during the winter of 1976-77 and were tested by the consultant during May and June of 1977. The systems consist of four major components: 1) gas extraction wells, 2) gas collection headers, 3) vacuum blowers, and 4) waste gas burners. The gas extraction wells, of which five were constructed at each site, were drilled with a 30 inch auger to groundwater or natural ground (typically 15 feet to groundwater at the two sites). Perforated PVC pipe was installed generally below the ten foot level and tied to nonperforated PVC pipe above the ten foot level. The wells were then backfilled with large ballast stone around the perforated pipe and compacted soil around the nonperforated pipe. In this manner, gas is drawn from the lower depths in an effort to prevent atmospheric air from being drawn through the ground surface into the system. (Also see sketch in Appendix.)

The gas collection headers are polyethylene pipe ranging in diameter from 8 to 24 inches. Polythylene pipe was selected by the consultant because of its flexibility, a necessity in settlement-ridden landfill areas, and its high resistance to chemical attack, needed because of the acids which condense in the pipe from the moist landfill gas. The consultant also made provision to remove the condensate by specifying overflow traps at low points in the headers. Each gas collection well is connected to the header by branch tees and individual control valves.

Centrifugal blowers create vacuum through the collection headers and wells to the ground surrounding the wells. (Subsurface negative pressures were measured by the consultant in the previously mentioned sampling probes during the pilot systems testing.) A fiberglass blower housing was specified to the resist chemical attack.

Waste gas burners are used to flare the extracted gas, when combustible mixtures are present. This feature is solely for aesthetic purposes as odor problems have been reported at sites where the landfill gases are released to the air.

The City's consultant's report on the pilot systems testing revealed that the Whitcomb system had adequately controlled the methane migration to provide full protection to the school. It was determined, however, that the Fells system required modification in order to provide a continuous barrier to gas movement. A relatively nonproductive well has been abandoned and replaced with two additional wells which appear to be adequately protecting the school. Six wells are now in service in the Fells system. In addition to other design and operating criteria, the consultant has determined that the optimum well spacing for the sites under study is approximately 200 feet.

The City's consultant is currently (September, 1977) designing the full-scale control systems which will fully control methane gas migration from both landfill sites. The City expects to advertise for competitive construction bids around the latter part of 1977.

II. PROBLEMS ENCOUNTERED/RECOMMENDATIONS

The City of Richmond has experienced many peculiar problems since it began its landfill gas control program in early 1975. Most of these problems are directly or indirectly related to the City government's responsibility to protect the public's health and safety. However, this responsibility has also become a matter of liability in Richmond's case as the landfills are owned and operated by the City. (In Virginia, cities and counties are independent corporations. Although some regional authorities and commissions exist, Richmond has found little cooperation from it's less densely populated neighboring counties in establishing refuse disposal sites outside of the City limits. As a result, Richmond has landfilled areas in developed neighborhoods and development has spread to and, in at least one case, directly over landfills which were once in relatively isolated areas. This practice, of course, was well established long before the potential hazards of landfill gas were appreciated).

A problem which the City encountered early in its gas control program was the question of the consultant's professional liability. As was previously mentioned, the City's consultant was selected, in part, as a result of the second prospect's refusal to accept a standard hold harmless clause in his contract. An article by Myron Nosanov and Robert White (see Appendix) addresses the issue from one consultant's point of view. (The City later discovered that it's consultant did not carry adequate liability insurance and is now reimbursing him for his annual policy premium). Potential contracting authorities may find this issue to be an obstacle in selecting a consultant.

It could be argued that placing liability on the consultant dealing with a problem as hazardous, inexact and relatively new in technological terms as methane gas migration would encourage the consultant to be unduly conservative in his design and recommendations. This would place additional burden on the contracting authority in implementing the consultant's recommended programs. In any case, the contracting authority must be prepared to accept the consultant's judgment. To refuse acceptance would shift the liable exposure to the contracting authority. It is recommended that such possibilities be weighed when selecting a consultant.

As was previously discussed, the City distributed notices of precaution to residents in the migration-affected areas. Although this was considered a responsible action to take, it was not without disadvantages. Some misunderstanding resulted as a few residents believed methane to be poisonous or that it was traveling from the landfills through the air into residential areas. Also, public calls were made for the City to provide relief to residents having incurred excessive heating costs resulting from following ventilation precautions advised by the City. Richmond has learned that insuring that the affected people receive correct information is an important facet of conducting it's gas control program.

The conditional issuance of building permits near landfill areas has caused several Richmond property owners to incur excessive building costs through no fault of their own. Two owners have requested reimbursement by the City for added expenses. One case has been settled out of court while the other remains unresolved. This potential exposure should be considered by the appropriate authority prior to restriction of development. The County of Los Angeles has adopted an ordinance addressing such development (see Appendix).

As several thousand miles separate the City of Richmond and the consultant, there have been occasions when communication and expediency could have been better served had a local consultant been retained. Ready accessibility of the consultant and his staff, as in any business association, is highly desirable. The use of local consultants may not always be possible, but is advantageous and should be considered.

In summary, many sensitive administrative and legal problems may be encountered in dealing with landfill gas migration. As discussed above, the City of Richmond has experienced several in spite of the benefit of the guidance of an experienced consulting engineer. This points to the importance of employing the services of experienced individuals or firms as some problems may be found to be inherent to methane hazards and could be anticipated with experience. Still other problems, it will likely be found, are peculiar to local social and political conditions and may not be so readily predicted, even with the benefit of expert guidance.

City of Richmond
Department of Public Safety
Office of the Director

RICHMOND VIRGINIA

501 North 9th Street, Richmond, Virginia 23219
703 · 649-5621

December 5, 1975

Dear Resident:

As you are aware, notices were distributed in your neighborhood in July and August advising residents to take precautions against the possible accumulation of methane gas. Although we know of no change in the general migration of methane gas in the area, this is to remind you that the need for ventilation is even greater during cold weather. Accordingly, you are again advised to take the following precautions:

1. All basements and crawl spaces should be opened for natural ventilation.

2. All living areas should be ventilated. Where forced air ventilation is not provided, our consultant's staff advises that windows should be opened at least one inch, preferably from the top. Storm windows should also be opened at least one inch. Closet doors should be left open as well.

3. Should you have any questions concerning methane gas in your building, or should you note any unusual odors, please call 649-1111 immediately.

Concentrations of methane gas may be odorless and are not usually dangerous in a well vented area. According to the independent consultant, it is most important that your home, apartment, dwelling or other structure be kept well ventilated at all times.

As a step to alleviate the problem, City Council has authorized initial funding for the establishment of a gas control system. In the meantime, we sincerely appreciate your cooperation in the following the above safety precautions.

Jack M. Fulton

Jack M. Fulton
Director of Public Safety

RECEIVED
MAR 5 1979
EMCON ASSOCIATES

louisville and jefferson county planning commission
900 fiscal court building • louisville, kentucky 40202 • 581-6230

March 1, 1979

Mr. David H. Armstrong
EMCON Associates
1420 Knoll Circle
San Jose, California 95112

Dear Mr. Armstrong:

In reply to your letter of February 21, 1979, I have compiled some specific costs related to resolution of the Lee's Lane landfill gas migration problem. Information with regard to property value deterioration is not available at this time. Also, it is impossible to assess legal costs because of the potential for further legal action.

A study to determine the extent of the gas migration, the composition of the gas, and the depth to which it extended was done at a cost of $60,000. An environmental review necessary to receive funding for the gas ventilation system costs an additional $5,000. The contract for designing a gas ventilation system was performed for $29,370. Actual cnstruction of the gas ventilating system is costing approximately $250,000. Operation and maintenance of the system is expected to cost about $5,000 per year for the next ten years. To date, five families have been relocated and a sixth family will be relocated soon. The total cost of the relocation effort is about $175,000.

Costs to date are therefore:

1.	Study to determine composition and migration -	$60,000
2.	Environmental review -	5,000
3.	Design contract price -	29,370
4.	Estimated construction costs -	250,000
5.	Operation and maintenance (10 years) -	50,000
6.	Approximate relocation cost (including property acquisition, replacement housing payment, and moving expense) -	175,000
7.	TOTAL -	$569,370

This information was gathered from the Housing Authority of Jefferson County and the Jefferson County Public Works Department. If property value deterioration or legal fees information becomes available, we will forward the information to EMCON. Hopefully, the ventilation system will resolve the gas migration problem. A similar system is working well at another landfill in Jefferson County. If the system does not resolve the problem, however, more extensive costs may well be incurred.

We are glad to be able to assist in this study of the landfill gas problem. Please contact me if you require further assistance.

Sincerely,

David J. Mansen

David J. Mansen
Deputy Director

DJM/tb

cc: Ed Robinson, Jefferson County Public Works Department
Dave Ripple, Director of Advance Planning, Planning Commission
Jude Clark, Planner I, Planning Commission

CITY OF NASHUA, NEW HAMPSHIRE

OFFICE OF CITY ENGINEER

February 16, 1966

Mr. James I. Waller
Director of Safety
Winston-Salem, North Carolina

Dear Sir:

The land fill that has been built on in Nashua is the only one that has developed a gas problem. The other areas without buildings, although they are generating gas, difuse the gas into the open air and no dangerous density has been noted.

At our shopping center area, the gas problem was noted early in the construction stage and the following additional precautions were required.

(1) A permanent gas sensing devise was installed in the only basement area. Perforated pipes were laid under the concrete floor and the trenches for the pipes were backfilled with pea stone. This pipe grid was vented through the roof.

(2) The greatest part of the building was slab construction and in the concrete sidewalk, self-closing test tubes were constructed every fifteen feet the full length of the building so that periodic checks could be made of the gas density.

(3) The parking lot, which is located over the area of the land fill that was the deepest, was vented by storm drainage system, backfilled with crushed stone. The underground electrical cable to the parking area light standard was also backfilled with crushed stone, and a hole was left in the center of the light standard bases and the standards were topped with a ventilating cap which allowed any gasses trapped in the area by the asphalt surfacing to have a way out.

For the first year the test spots were checked monthly by the Fire Prevention Bureau. The owner of the shopping center was required to have periodic tests made by qualified "Leakage Control" consultants.

During the first year no dangerous concentrations of gasses were noted, although gas was detected and the venting systems were doing what they were supposed to do.

CITY OF NASHUA, NEW HAMPSHIRE

OFFICE OF CITY ENGINEER

I hope that this information will help you with your problem. I'm sure that there is some consultant for leakage control in your area who could help you with your specific problem.

Very truly yours,

Joel B. Hill
City Engineer

JBH/ac

PORTABLE GAS DETECTION EQUIPMENT

SUPPLIER	MODEL	PRICE	COMMENTS
MSA[1]	Spotter Methane Detector	$255.00	0 - 5% methane
	502	460.00	Dual Scale: 0-2% and 1.5-5% CH_4
	53	310.00	0-100% 87 volume 0-100% LEL
	250		0-100% LEL 0-25% Oxygen
	Combustible Gas Indicator Models 20,21,30,40		4 Models
	Explosimeter (model 24) Indicator		Factory preset for alarm at 100% of LEL - can be modified, however
Lumidor Products	Gas - Pro No. LP-PGA-9		
JW[2]	H		
	HPK	788.55	Gas kit with case & assessories
	G		
	HPK	728.00	With integral pump (special LEL scale)
	L		
	GPK	671.00	With case and accessories
Enmet[3]	CGS 10	395.00	20% LEL methane
	CGS 8	295.00	20% LEL methane
Bio Marine Industries[3]	911 (combustible gas detector)	225.00	0-100% LEL, 0-5% CH_4
	901 (combination combustible gas/O_2 detector)	515.00	0-100% LEL, 0-5% CH_4
	922 (combination combustible gas/O_2 detector	495.00	0-100 LEL, 0-5% CH_4, 0-4% O_2

PORTABLE GAS DETECTION EQUIPMENT

SUPPLIER	MODEL	PRICE	COMMENTS
	900 (Combination conbustible gas/O_2 detector with alarms)	$615.00	0-100% LEL, 0-5% CH_4, 0-4% O_2
	902 (combination combustible gas/O_2 detector)	995.00	0-100% LEL, 0-4% CH_4, 0-25% O_2
Carle [4]	9704 (Basic 645 chromatograph)		
Southern Cross Corporation	Pin Pointer Model SCC		0-1 LEL natural gas, 0-100% natural gas
Gastech[4]	GX-3	845.00	Simaltaneous CH_4/O_2 detection 0-100% LEL

FOOTNOTES:

1. Prices current as of January 1979
2. Prices current as of 1978
3. Prices current as of August 1977
4. Prices current as of December 1978

PERMANENT GAS DETECTION EQUIPMENT

SUPPLIER	MODEL	CHANNELS	PRICE	COMMENTS
Dictaphone[1]	810	1	$ 715.00	
	820	2	990.00	Without cabinet and alarms - remote calibration, 2 levels plus "trouble"
	880	8	4,230.00	
Gastech, Inc.[1]	1220	1	585.00	One level with cabinet
	1220	2	690.00	
	1620	4	1,500.00	2 levels with cabinet
General Moniotors[1]	180	1	876.00	2 yr. guarantee, reliable, less draft, only product
	520	2	1,280.00	
	160	10	6,378.00	
MSA[1]	510	1	955.00	
	510	2	1,660.00	
	510	3	2,365.00	
	510	4	3,070.00	
	510	5	3,775.00	
Scott	Series 9000	1		0-100% LEL
Enmet[2]	ISA-330D		795.00	Scale on methane indicating meter ranges from 10-60%; 0-20% LEL available for more sensitive work
	ISA-44-5		3,785.00	

FOOTNOTES:

1. Prices current as of January 1979
2. Prices current as of August 1978

APPENDIX I

ACRONYMS AND GLOSSARY OF TERMS

ACRONYMS

BNA	Bure'au of National Affairs
BOD	Biochemical Oxygen Demand
CEC	Cation Exchange Capacity
CFR	Congressional Federal Register
CPE	Chlorinated polyethylene
CWA	Clean Water Act
DDT	Dichloro-diphenyl-trichloroethane
DOE	Department of Energy
DOI	Department of the Interior
EIA	Economic Impact Analysis
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPDM	Ethylene propylene rubber
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
FFDCA	Federal Food, Drug and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act (of 1947)
FR	Federal Register
FWPCA	Federal Water Pollution Control Act
HUD	Housing and Urban Development
MCL	Maximum Contaminant Levels
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulation
NTIS	National Technical Information Service
O&M	Operation and maintenance
PCB	Polychlorinated biphenols
PE	Polyethylene
POTW	Publicly Operated Treatment Works
ppb	Parts per billion
ppm	Parts per million
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act

SDWA	Safe Drinking Water Act
SMSA	Standard Metropolitan Statistical Area
STP	Sewage Treatment Plant
tpd	Tons per day
TDS	Total Dissolved Solids
UICP	Underground Injection Control Program
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

GLOSSARY OF TERMS AND PHRASES

Agricultural Surface Impoundment - An impoundment used in the treatment of wastes from feedlots and other agricultural operations (Ref. 141).

Animal Feed* - Any crop grown for consumption by animals, such as pasture crops, forage, and grain.

Approved State Solid Waste Management Plan* - A plan developed according to guidelines promulgated pursuant to Section 4002(b) of the Act and approved by the Administrator pursuant to Section 4007 of the Act.

Aquifer* - "A geologic formation, group of formations, or portion of a formation capable of yielding usable quantities of ground water to wells or springs."

Attenuation - The ability of soil to remove or transform ions passing through the soil by a variety of physical, chemical, and biological mechanisms.

Base Flood* - A flood that has a one 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. In any given 100-year interval such a flood may not occur, or more than one such flood may occur.

Beneficial Utilization - The application of solid waste to land for the purpose of utilizing nutrients or conditioning the soil.

* The sources of definitions designated with an asterisk (*) are subsections 157.2 and 257.3 of the criteria for Classification of Solid Waste Disposal Facilities and Practices (40 CFR Part 257). The text of the criteria is presented in Appendix A.

Bird Hazard - As used in reference to a facility, this means: (1) attracts birds that feed on putrescible waste, or (2) disrupts normal bird flight patterns, or (3) alters bird roosting and watering sites; thereby causing bird populations to develop such that approaching or departing aircraft are placed in a position where bird/aircraft collisions that may cause damage to the aircraft and/or injury to its occupants are likely.

Cadmium Concentration - The total cadmium in mg/kg dry weight of solid waste.

Cation Exchange Capacity (CEC)* - The sum of exchangeable cations a soil can absorb, expressed in milliequivalents 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 ("Method of Soil Analysis, Agronomy Monograph No. 9," C. A. Black, ed.; American Society of Agronomy, Madison, Wisconsin, 1965, pp. 891-901).

Contaminate* - "Contaminate" means introduce a substance that would cause:

(1) the concentration of that substance in the ground water to exceed the maximum contaminant level specified in Appendix I of the criteria, or

(2) 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 of the criteria.

Contiguous Zone - The entire zone established or to be established by the United States under Article 24 of the Convention of the Territorial Sea and the Contiguous Zone (Clean Water Act, Public Law 92-500, as amended by Public Law 95-217) (Ref. 125).

Destruction or Adverse Modification* - A direct or indirect alteration of critical habitat which appreciably diminishes the value of that habitat for survival and recovery of a listed species.

Discharge of Dredged Material - Any addition of dredged material into the waters of the United States. The term includes, without limitation, the addition of dredged material to a specified disposal site located in waters of the United States, and the runoff or overflow from a contained land or water disposal area. Discharges of pollutants into waters of the United States resulting from the onshore subsequent processing of dredged material that is extracted for any commercial use (other than fill) are not included within this term and are not subject to Section 402 of the Federal Water Pollution Control Act, even though the extraction and deposit of such material may require a permit from the Corps of Engineers. The term does not include plowing, cultivating, seeding, and harvesting for the production of food, fiber, and forest products (33 CFR Part 323).

Disease Vector* - Any organism that is capable of transmitting disease, including birds, rodents, flies, and mosquitos.

Disposal* - 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 (Ref. 6, Public Law 94-580, 90 Stat. 2799, 42 U.S.C. 6903).

Dredged Material - Material that is excavated or dredged from waters of the United States (33 CFR Part 323).

Facility* - Any land and appurtenances thereto used for the disposal of solid wastes.

Fill Material - A material used for the primary purpose of replacing an aquatic area with dry land or of changing the bottom elevation of a waterbody. The term does not include any pollutant discharged into the water primarily to dispose of waste, as that activity is regulated under Section 402 of the Federal Water Pollution Control Act Amendments of 1972 (33 CFR Part 323).

Floodplain* - 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.

Food-Chain Crops* - Tobacco, crops grown for human consumption, and animal feed for animals whose products are consumed by humans.

Ground Water* - Water below the land surface in the zone of saturation.

Impoundment - See Surface Impoundment

Incorporate into the Soil* - The injection of solid waste beneath the surface of the soil or the mixing of solid waste with surface soil.

Industrial Surface Impoundment - An impoundment used for temporary storage, settling, aeration, or disposal by evaporation or seepage of industrial process and non-process wastes.

"Jeopardize the Continued Existence of"* - To engage in an activity or program which reasonably would be expected to reduce the reproduction, numbers, or distribution of endangered and threatened species to such an extent as to appreciably reduce the likelihood of the survival and recovery of that species in the wild.

Lower Explosive Limit (LEL) - Minimum concentration which will explode due to a spark or flame.

Municipal Landfill - A site for disposal of solid wastes which is operated under municipal funding (Ref. 141).

Municipal Surface Impoundment - An impoundment used in primary, secondary, and advanced municipal wastewater treatment for temporary storage, settling, aeration, or disposal by percolation or evaporation (Ref. 141).

Navigable Waters - The waters of the United States, including the territorial seas (as defined in the Clean Water Act, Public Law 92-500, as amended by Public Law 95-217).

Non-Point Source - Any origin from which pollutants emanate in an unconfined and unchannelled manner, including but not limited to leachate seeps.

On-Site Industrial Landfill - A disposal site for solid industrial process wastes which is owned by the waste-producing plant (Ref. 141).

Open Burning* - 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, or (3) control of the emission of the combustor products.

Open Dump - A facility for the disposal of solid waste which does not comply with the Criteria published under Section 4004 of RCRA. Typically, such facilities are disposal sites where discarded materials are deposited with little or no regard for pollution control or aesthetics, where the wastes are left uncovered, and where frequently the use of the site for waste disposal is neither authorized nor supervised.

Pasture Crops* - Crops such as legumes, grasses, grain stubble and stover which are consumed by animals while grazing.

Periodic Application of Cover* - The application of soil or other suitable material over disposed solid wastes at such frequencies and in such a manner as to impede vectors and infiltration of precipitation; reduce and contain odors, fires, and litter; and enhance the facility's appearance and future utilization.

Permeability - The capacity of a medium to conduct or transmit fluids.

pH* - The logarithm of the reciprocal of hydrogen ion concentration.

Plume - "A body of contaminated. . .water originating from a specific source and influenced by such factors as the local ground-water flow pattern, density of contaminant, and duration of the aquifer" (Ref. 7, p. 500).

Point Source - Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture (Clean Water Act, Public Law 92-500, as amended by Public Law 95-217).

Pollutant - Any dredged soil, solid waste, incineration residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal and agricultural waste discharged into water (Ref. 125, Public Law 92-500, as amended by Public Law 95-217).

Practices - The act of disposal of solid waste.

Putrescible Wastes* - Solid wastes which contain 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.

Recharge - "The addition of water to the ground-water system by natural or artificial processes" (Ref 7, p. 501).

Recharge Zone - An area through which water enters an aquifer.

Root Crops* - Plants whose edible parts are grown below the surface of the soil.

Runoff - "Direct or overland runoff is that portion of rainfall which is not absorbed by soil, evaporated or transpired by plants, but finds its way into streams as surface flow.

That portion which is absorbed by soil and later discharged to surface streams is ground-water runoff" (Ref. 7, p. 501).

Sanitary Landfill - A facility for the disposal of solid waste which meets the "Criteria for Classification of Solid Waste Disposal Facilities and Practices" (Ref. 62, RCRA, Public Law 94-580).

Sludge* - 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 effects.

Soil pH* - 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).

Sole Source Aquifer - A water-bearing geologic formation that is the principal source of drinking water for the population of a given area. The contamination of such a water source would create a significant hazard to public health.

Solid Waste* - Any garbage, refuse, sludge from a waste treatment plan, 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 material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under Section 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) (Ref. 62, RCRA, Public Law 94-580).

State* - 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 (Ref. 62, RCRA, Public Law 94-580, 90 Stat. 2801, 42 U.S.C. 6903).

Surface Impoundment - "A natural topographic depression, artificial excavation, or dike arrangement having the following characteristics: (1) it is used primarily for storage, treatment, or disposal of wastes in the form of liquids, semi-solids, or solids; (2) it is constructed on, below, or partly in the ground; and (3) it is generally wider than it is deep. Excluded from this definition are: (1) concrete-lined basins and prefabricated above-ground tanks and steel vessels that are used in waste treatment and industrial processes, and (2) fresh-water impoundments such as natural lakes, reservoirs, and farm ponds that are used for water supply, collection of storm-water runoff, flood control, and irrigation" (Ref. 107, p. 7).

Underground Drinking Water Source* - (1) An aquifer supplying drinking water for human consumption, or (2) an aquifer in which the ground water contains less than 10,000 mg/l total dissolved solids.

Variance - A license to pollute for a limited time, typically a year, usually with the agreement that the polluter will institute procedures to clean up (Ref. 140, p. 372).

Waters of the United States comprise (1) the territorial seas with respect to the discharge of fill material; (2) coastal and inland waters, lakes, rivers, and streams that are navigable waters of the United States, including adjacent wetlands; (3) tributaries to navigable waters of the United States, including adjacent wetlands (manmade nontidal drainage and irrigation ditches excavated on dry land are not considered waters of the United States under this definition); (4) interstate waters and their tributaries, including adjacent wetlands; and (5) all other waters of the United States not identified in paragraphs (1) through (4) above, such as isolated wetlands and lakes, intermittent streams, prairie potholes, and other waters that are not part of a tributary system to interstate waters or to navigable waters of the United States, the degradation or destruction of which could affect interstate commerce (33 CFR Part 323).

Wetlands - Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil condition. Wetlands generally include swamps, marshes, bogs, and similar areas (33 CFR 323 - Permits for Discharges of Dredged or Fill Material into Waters of the United States, Ref. 116).

APPENDIX J

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APPENDIX K

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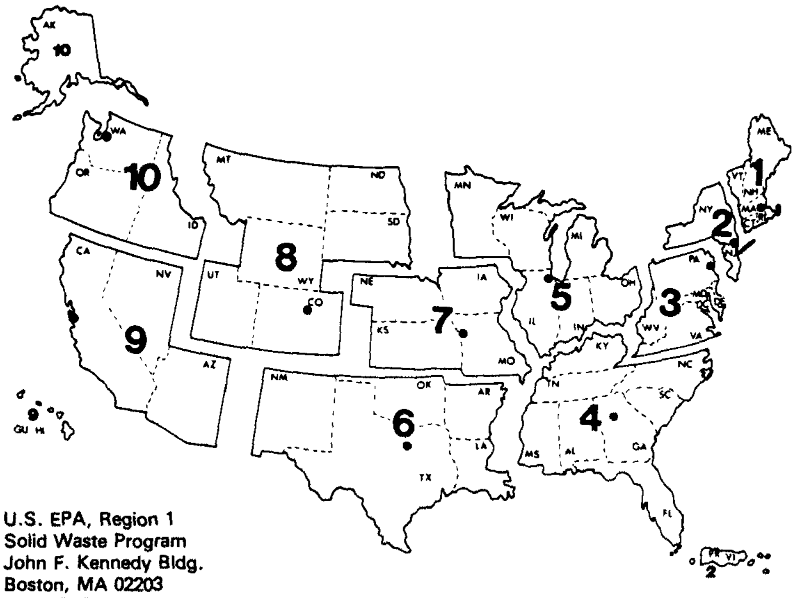

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