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"NO MIGRATION" VARIANCES TO THE HAZARDOUS WASTE LAND DISPOSAL PROHIBITIONS: A GUIDANCE MANUAL FOR PETITIONERS

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What is a "No Migration" Variance?

A "no migration" variance is a formal decision that can be rendered by the EPA to allow the land disposal at a particular facility of specific, prohibited wastes not meeting the treatment standards established by EPA. The statutory language requires anyone pursuing a "no migration" variance to demonstrate "to a reasonable degree of certainty that there will be "no migration" of hazardous constituents from the disposal unit or injection zone for as long as the waste remains hazardous." The EPA codified this language on November 7, 1986 (40 CFR 268.6). The EPA has interpreted the statutory language to mean that it must be demonstrated, to a reasonable degree of certainty, that hazardous constituents will not exceed Agency-approved human health-based levels (or environmentally protective levels, if they are appropriate) beyond the boundary of the disposal unit. In most cases, the disposal unit boundary is defined as the outermost limit of engineered components, but may be defined differently in some site-specific cases. **This definition of "no migration" does not allow fate and transport of hazardous constituents above acceptable health-based levels outside the boundary of the unit.**

What are the Land Disposal Prohibitions?

In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA) authorizing EPA to establish nationwide standards for the management of hazardous wastes. Regulations promulgated under RCRA in Title 40 of the Code of Federal Regulations, Part 261 (40 CFR 261), include lists of designated hazardous wastes and methods for identifying wastes exhibiting hazardous characteristics. Under the Hazardous and Solid Waste Amendments of 1984 (HSWA), RCRA Sections 3004 (d), (e), and (g) were to include provisions prohibiting the land disposal of all such "listed" and "characteristically hazardous" wastes unless they meet technology-based treatment standards. In order to be land disposed, wastes included in the EPA's land disposal prohibitions will have to be treated by best demonstrated available technology (BDAT) to meet the treatment standard established by the EPA or meet the standard as generated, unless a "no migration" variance is obtained. Prohibited wastes cannot be stored on the land (unless storage is in containers or tanks and is for the purpose of accumulating sufficient quantities to facilitate proper recovery, treatment, or disposal) without a "no migration" variance. The land disposal prohibitions become effective on the dates indicated below.

November 8, 1986	-	Solvents and Dioxins
July 8, 1987	-	California List*
August 8, 1988	-	At Least One-Third of All Other Listed Wastes
June 8, 1989	-	At Least Two-Thirds of All Other Listed Wastes
May 8, 1990	-	All Remaining Listed Wastes and All Characteristic Wastes

A complete schedule of the land disposal prohibitions can be found in 40 CFR 268.10 through 268.13. These prohibitions apply to all hazardous wastes identified under RCRA as of November 8, 1984. For hazardous wastes identified in 40 CFR 261 after that date, EPA must make prohibition determinations within 6 months of the date of listing or identification of the new hazardous wastes. Nevertheless, the statute does not impose an automatic prohibition on land disposal if EPA misses a deadline for any newly listed or identified waste.

Direct land disposal of an untreated waste that does not meet the BDAT treatment standard may be allowed nationally by EPA for up to 2 years if treatment capacity is inadequate. Effective dates have been extended by 2 years for many California List and First Third wastes. In addition, two 1-year case-by-case extensions of the effective dates of prohibitions may be granted under certain circumstances. The applicant must demonstrate that adequate capacity to treat, recover, or dispose the waste is not available by the effective date and that he has entered into a binding contractual commitment to provide such capacity. (EPA is developing a guidance document for case-by-case extensions.) All other RCRA hazardous wastes that do not meet the BDAT treatment standard will be banned from land disposal unless a "no migration" variance is received from the EPA.

* Based on regulations developed by the California Department of Health Services for hazardous waste land disposal restrictions in the State of California.

Who Can Receive a "No Migration" Variance?

A "no migration" variance petition can be submitted by anyone who temporarily stores or disposes of hazardous wastes in or on the land. The petition for a "no migration" variance can be submitted by any interested hazardous waste facility owner or operator, either individually or collectively. The petition must clearly demonstrate that the land-based storage or disposal method to be employed protects human health and the environment This requires showing, to a reasonable degree of certainty, that hazardous constituents will not exceed human health-based levels (or environmentally protective levels, if they are more stringent) beyond the edge of the disposal unit The petition must also provide long-term assurance that the "no migration" variance criteria will be met. (Of course, in the case of petitions for temporary placement, long-term assurances would not be necessary.) The variance only becomes effective after EPA reviews the petition, solicits public comments, and publishes a final determination in the Federal Register In most cases, the variance will require monitoring to demonstrate continuing compliance (see substantive and procedural requirements in the Land Disposal Restrictions First Third Rule, August 17, 1988, 53 FR 31138)

In the November 7, 1986 Final Rule (51 FR 40572), the Agency identified several scenarios that may satisfy the "no migration" standard. These scenarios are not the only situations where "no migration" may be demonstrated successfully The first is the placement of compatible non-volatile waste in a massive and stable geologic formation such as a salt dome. In this case, the Agency would expect the "no migration" demonstration to focus on the stability, extent, and homogeneity of the host formation, as well as potential for releases during placement

The second scenario is the placement of a waste consisting of fairly immobile constituents in a monofill located in an arid area that has no ground-water recharge. The petitioner would need to demonstrate that hazardous constituents will not migrate out of the unit above health-based (or environmentally protective) levels. Such a demonstration may be successful due to the well-defined characteristics of the waste constituents in a monofill

In the third scenario, a treatment facility renders the waste nonhazardous through active chemical, physical, or other processes An example is the neutralization of a corrosive waste, which does not contain hazardous constituents above health-based levels, in a surface impoundment This scenario is especially applicable to wastes that are considered hazardous due only to their ignitable, reactive, or corrosive characteristics

In the fourth "no migration" scenario, hazardous waste is stored temporarily on the land for the purpose of accumulating sufficient quantities of the waste to allow for proper recovery, treatment, or disposal within the meaning of RCRA Section 3004(j). The waste is stored in a totally enclosed indoor waste pile with a floor or bottom liner, where engineered containment systems and air pollution controls are effective over the period the waste remains in storage Inspections of the building are performed frequently to ensure that precipitation is not entering the unit. The waste pile is clean-closed at the end of the storage period.

Except for temporary storage operations, it should not be assumed that man-made barriers or engineered systems (e.g., liner systems) alone will meet the "no migration" standard. Although artificial barriers in conjunction with partial waste treatment or barriers that are expected to last substantially longer than the hazardous life of the waste may enhance a petition, artificial barriers alone cannot be relied upon to provide the long-term assurances required For this reason, "no migration" variances generally are not envisioned for conventional land disposal units (e g., landfills and surface impoundments) For temporary land-based storage purposes only, the containment of hazardous waste within engineered barriers (meeting minimum technology requirements) will be considered in making the "no migration" demonstration, provided that wastes are to be removed after a reasonably short storage period that may be conservatively projected to be well before the failure of the engineered barrier system

An additional "no migration" scenario is the placement of hazardous waste (particularly that from petroleum refining) in a land treatment unit. Under carefully controlled conditions, the wastes are biodegraded in the treatment zone with no releases at concentrations constituting migration to any environmental media, including air. The owner/operator manages the land treatment unit so that nondegradable hazardous constituents are not allowed to accumulate within the unit to levels exceeding health-based levels.

In addition, the Agency cautions potential petitioners that the burden of proof in demonstrating "no migration" will be substantially greater for facilities with a history of continuing mismanagement of hazardous waste and serious compliance problems, as evidenced by State or EPA monitoring and inspection reports (Minor infractions in compliance should not affect EPA's review of a petition.) This does not mean such facilities will be required to meet a more stringent standard, but that more information and analysis may be necessary, both in the petition and during operation under the variance, to confirm to the Agency's satisfaction that migration is not occurring and will not occur in the future For example, more frequent waste stream analysis, or even sampling by an independent party could be required under the terms of the variance

Similarly, for a unit that has experienced releases (migration) in the past, the owner or operator petitioning for a variance will be under a greater burden of proof to demonstrate both 1) that the same type of release will not occur in the future, and 2) that past and future releases can be separated. The second item could be particularly relevant for the ground water medium, for example, where contamination from the unit that has already been detected in ground water could continue to appear in monitoring wells after a variance has been granted It would be difficult to prove whether the contamination was from a past or present release. Likewise, for a unit located in a waste management area where releases have occurred from other units, it also could be difficult to differentiate between releases, particularly if the other units contained the same hazardous constituents as the unit in question.

In either case, the owner or operator is discouraged from submitting a "no migration" petition unless he or she can conclusively demonstrate not only that future migration will not occur, but also that past releases detected through monitoring either are not from the unit for which a variance is sought, or that they will not obscure or interfere with the ability of monitoring devices to detect future releases If there is uncertainty, the assumption will be that the release is from the unit in question, and the variance likely will be denied or, if already granted, revoked.

What is the Definition of the "Unit Boundary?"

For surface impoundments, landfills, and waste piles, the unit boundary (and consequently, the point of compliance (POC)) generally is defined by the outermost extent of the engineered barrier(s) that contain the waste. For example, in demonstrating "no migration" from a unit via ground water or subsurface soil, the unit boundary would consist of the outer liner present in a surface impoundment, landfill, or waste pile In demonstrating "no migration" from the unit via surface water or surface soil, the exterior of any dikes, ditches, or berms present at the edge of the "hazardous waste management unit" constitute the point of compliance. In demonstrating "no migration" from the unit via the air pathway, the outer limit of any engineered barrier over the unit (roof, dome, etc) would constitute the point of compliance

While engineered barriers form a useful way to delineate the boundary of a hazardous waste management unit, the Agency recognizes that these engineered components do not always exist. For example, most units are not enclosed to protect from migration via air In this case, the downwind edge of the unit at a height of 1.5 meters constitutes the point of compliance for demonstrating "no migration" via air. (A height of 1.5 m corresponds with a typical inhalation height and facilitates the application of standard modeling and monitoring methods)

In cases where units are unlined (e.g., a unit obtaining an exemption from liner requirements under Section 264 221 (b) or (d)), EPA will use best professional judgment to set the unit boundary. Land treatment units have a subsurface point of compliance at the base of the maximum treatment zone (not exceeding 5 feet in depth from the initial soil surface) or immediately outside of any liner that may exist. Finally, for some miscellaneous units such as those regulated under Subpart X, the unit boundary should be decided on a site-specific basis. In the case of geologic repositories, for example, EPA believes it is appropriate to give some credit for the encapsulating or confining formation In all cases, however, the Agency will demarcate the unit boundary and point of compliance for demonstrating "no migration" via all media in a suitably stringent manner.

Although engineered barriers frequently are used to define the unit boundary, engineered barriers such as liners alone are inadequate to prevent migration of hazardous wastes from a land disposal unit Except for temporary storage units, the "no migration" demonstration must rely upon other assurances to demonstrate "no migration" from the unit. Other assurances may include treatment, waste removal after temporary storage, and characteristics of the waste, unit, or environment.

How are Levels of Constituents Evaluated?

A successful "no migration" demonstration must show that actual or predicted concentrations of hazardous constituents or emission rates at the edge of the disposal unit do not exceed Agency-approved health-based levels or environmentally-based levels for ground water, surface water, soil, and air. If health-based criteria do not exist for a constituent, the applicant may propose his own health-based levels using the toxicity testing guidelines contained in 40 CFR Parts 797 and 798, and the Agency guidelines for assessing health risks (51 FR 33992, 34006, 34014, and 34028). If no health-based level can be determined for a constituent, that constituent must not exceed analytical detection limits. Use of analytical detection limits should be based on methodology prescribed in "Test Methods for Solid Waste, Physical/Chemical Methods" U S EPA Publication No SW-846, Third Edition, with the lowest possible detection level indicated therein for each hazardous constituent. If health-based levels are below analytical detection limits for a constituent, the petitioner must demonstrate, using modeling, that the health-based levels will be met Nevertheless, in any compliance monitoring required for the unit where health-based levels are below detection limits, meeting detection limits would constitute compliance with the demonstration In calculating these concentrations, the petitioner should use site-specific data to evaluate how the hazardous constituents will be apportioned between media, where the constituents are released into several media When site-specific data are not available, worst-case assumptions must be used

In reviewing the petition, EPA will compare the calculated concentration of hazardous constituents to Agency-approved levels For example, the Agency would compare the constituent concentrations in leachate to the Maximum Contaminant Levels (MCLs), or Ambient Water Quality Criteria (AWQC). MCLs and AWQCs receive first priority for use as allowable exposure levels, where they exist. If an MCL or an

AWQC is not available for a constituent, the appropriate health-based levels would be the Reference Dose (RfD) for noncarcinogens and the Risk Specific Dose (RSD) for carcinogenic compounds These health-based criteria have been calculated by assuming chronic (lifetime) exposure by ingestion or inhalation of contaminated media For carcinogens the maximum residual risk level is 1×10^{-6} Class A and B carcinogenic constituents, and 1×10^{-5} for Class C carcinogens

For a "no migration" petition, it is necessary to evaluate the concentration of contaminants in air, surface water, and soil as well as in ground water The Agency has published health-based levels for soil ingestion and inhalation for a subset of the hazardous constituents listed in Appendix VIII of 40 CFR 261 The interim draft RCRA Facility Investigation (RFI) Guidance (EPA 530/SW-89-031, February, 1989) contains tables of health-based criteria, both it and the interim draft Surface Impoundment Clean Closure Guidance, U S EPA, October, 1987 also have explanatory text on the assumptions used to calculate the numbers. More information on these health-based numbers is also available in the Superfund Public Health Evaluation Manual, U S. EPA, 1986, and the Integrated Risk Information System (IRIS); U.S. EPA, 1988 IRIS is available through various on-line networks such as DIALCOM Inc., the Public Health Network, and the National Library of Medicine's TOXNET Because all health-based numbers are subject to review and change, EPA recommends that the petitioner contact EPA's Characterization and Assessment Division in Washington, D C , at (202) 382-4761 to obtain up-to-date information on health-based levels.

The Agency believes that human health-based exposure levels generally will be protective of both human health and the environment. Nevertheless, the Agency may determine that an exposure level for a constituent should be lowered from the human health-based standard in order to protect against detrimental environmental effects around the unit (e g., those that may pose a threat to endangered species, or sensitive ecosystems). EPA will provide the opportunity for notice and comment on such an exposure level within the petition process.

In addition to comparing individual constituents to the appropriate health-based level, the Agency may also consider additivity in evaluating the risk posed by concentrations at the unit boundary For example, if the petition identifies two constituents that appear at the unit boundary at levels which are below health-based limits for each of the constituents, the Agency also may consider the potential threat posed by adding the two constituents. The Agency intends to consider additivity only for constituents in the same environmental medium (e g , air) For more information on the EPA's policy on chemical mixtures, the petitioner should refer to the Guidelines for the Health Risk Assessment of Chemical Mixtures (51 FR 34014).

Petitioners for units in areas where background levels of a hazardous constituent exist should demonstrate that the incremental contributions of contaminants from their unit will not, in and of themselves, exceed health-based levels. For example, if the air inhalation health-based level for Substance X is 10 ppm, and background levels of that constituent are 5 ppm, "no migration" could be successfully demonstrated by projecting and monitoring concentrations at the unit boundary not exceeding 15 ppm The net contribution of Substance X from the unit then would not exceed the health-based level of 10 ppm In other words, high background levels of a hazardous constituent will not prevent the granting of a "no migration" variance; however, neither will they allow releases attributable to the unit that exceed health-based levels, regardless of how high background levels might be.

How Long is "As Long As the Wastes Remain Hazardous?"

This is a waste- and site-specific determination For some waste types that degrade naturally to health-based levels in a relatively short time period, the petitioner may only have to demonstrate such degradation and show "no migration" from the unit during the degradation period On the other hand, where nondegradable constituents such as metals will exist within the unit, the petitioner will potentially have to make the difficult demonstration that "no migration" will occur for many thousands of years, unless such constituents are removed at closure or the unit is capped with clean soil. (Capping will be acceptable only where there is not leaching potential as determined using a leachability test or modeling procedure that the Agency determines is valid for the particular types of hazardous constituents present.) Note that the UIC program considers a demonstration of "no migration" for 10,000 years to be sufficient, given the nature of wastes that are disposed of through underground injection.

What is the Relationship Between Land Treatment Units and "No Migration"?

Land treatment units are subject to all of the general provisions of the land disposal restrictions program, since they are considered to be disposal units under RCRA 3004(k) Thus, in order to apply prohibited wastes which do not meet the BDAT performance standards, an owner or operator of a land treatment unit must receive a "no migration" variance

The petitioner for a land treatment unit must demonstrate that the "no migration" standard is met for all media The land treatment demonstration (LTD) need not be complete in order to receive a "no migration" variance The "no migration" variance will be granted based upon certain basic monitoring and modeling data However, the variance will be conditioned upon completion of the LTD within a specified time period (usually two years after the date of granting of the "no migration" variance), or else the variance will be revoked This requirement is intended to ensure completion of the Land Treatment Demonstration in a timely fashion, while nevertheless recognizing that the land treatment unit must operate in order to generate the relevant information and data. However, it should be clarified that this provision is not intended to effect any time extension of the requirement to have an approved "no migration" variance prior to land disposal of restricted hazardous waste. Land treatment units are required to have an approved "no migration" variance prior to receipt of restricted hazardous waste, regardless of whether or not the Land Treatment Demonstration is complete. Furthermore, petitioners with incomplete Land Treatment Demonstrations also must meet all of the same information requirements to fulfill "no migration" petition criteria.

Many wastes that are currently land-treated contain significant amounts of volatile constituents and/or metals. The petitioner must demonstrate a sufficient level of degradation and/or immobilization of waste constituents and metals within the treatment zone to assure that hazardous constituent concentrations will remain lower than human health-based or environmentally-based standards at the treatment zone/soil boundary For land treatment units, the "disposal unit" consists of the treatment zone (plus the liner, if any exists). For volatile constituents, the applicant must demonstrate that the health-based or environmental levels are not exceeded at the downwind edge of the unit boundary at a height of 1.5 meters. This demonstration should be made by using site-verified emission and dispersion models, emission monitoring and/or ambient air monitoring. In addition, an applicant may need to pretreat a volatile waste (e g., air stripping with appropriate air pollution controls) in order to successfully demonstrate "no migration" of the contaminant to the air. (For more information on "no migration" demonstrations for the air medium, see the Appendix) The applicant should attach all relevant parts of his land treatment demonstration permit application to the "no migration" petition, including biotoxicity studies, degradation studies, and general site information regarding ground water, surface water, climate, and soil

If it has been completed, the LTD can be used as a basis upon which to build a "no migration" petition However, the information that is typically provided in the LTD is largely current sampling and monitoring information The petition must contain sufficient modeling and theoretical, long-term projections to insure that migration will not occur to any medium "for as long as the wastes remain hazardous " Because the LTD does not address the air medium, the air demonstration must also be added. Finally, if accumulations within the unit of nondegradable hazardous constituents exceed health-based levels for soil ingestion at the end of the post-closure period, a leachability test or modeling procedure that the Agency determines is valid for the particular types of constituents present must be performed to determine their leachability Such tests may include soil column studies on zone of incorporation soils, or other methods approved by the Agency Dependent on the results of this leachability test or procedure, the unit's post-closure plan must require either that the unit be capped with clean soil at the end of the post-closure care period (if nondegradable constituents are not leachable above health-based levels), or that hazardous constituents be removed, at the end of the post-closure care period, to below health-based levels (if nondegradable constituents are leachable above health-based levels). If health-based levels have not been achieved a vegetative cover, as required at Part 264 280(c)(2), must still be maintained during closure and post-closure, as well as on the clean soil cap It should be noted that land treatment units (and other land disposal units), that will close with nondegradable hazardous constituents in place at concentrations above health-based levels must comply with 40 CFR Part 264 119(b) requirements for a deed notice that the site has been used for hazardous waste management. This provision is intended to prevent future human intrusion into the site after the post-closure care period has ended.

What is the Relationship between "No Migration" Variances, RCRA Permits, and Other Federal Laws?

"No migration" variances may be issued for units functioning under interim status, units with permits under RCRA, or for new units seeking Part B permits Because much of the information that must be included in a RCRA Part B application must also accompany the petition for a "no migration" variance, facility owners and operators are encouraged to submit petitions with the relevant Part B data summarized, and copies of critical Part B materials attached as needed

Under 40 CFR 268 6(a)(5), before being issued a "no migration" variance, the petitioner must provide EPA with sufficient information to assure the Administrator that land disposal of the prohibited waste(s) will comply with other applicable Federal laws. These may include the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act, the Endangered Species Act, the National Historic Preservation Act, the Wild and Scenic Rivers Act, the Coastal Zone Management Act, the Fish and Wildlife Coordination Act, the Atomic Energy Act, and the Marine Protection, Research and Sanctuary Act. This also includes other provisions of RCRA, such as regulations under Section 3004(n) limiting volatile organic air emissions from TSDFs. The operation for which a variance is sought must also be in compliance with applicable State and local laws and ordinances.

Can Generic Petitions be Submitted Covering Several Similar Units or Facilities?

Yes, but generic petitions are likely to raise practical difficulties, and are discouraged in most cases. The usefulness of a generic petition is limited since petitions must include site- and waste-specific data. Accordingly, petitioners would have to demonstrate that each scenario covered under a generic petition is essentially the same A demonstration that the hydrogeological characterization of each site would be essentially the same would require the detailed assessment of each site addressed in the petition, furthermore, it is unlikely that such a demonstration could actually be made. As a result, the Agency expects few, if any, generic petitions for land disposal units An exception may be made for temporary storage units. For example, several identical indoor waste piles containing identical wastes at the same clean-up site could be covered under one petition Even so, identical units at different facilities likely would require different petitions because of variations in locational and environmental conditions

When Does a Variance Become Effective and How Long Does it Last?

Variances will be effective only after issuance; submittal of a petition will not exempt a facility from complying with applicable land disposal prohibitions.

Variances will be valid for up to 10 years, but not longer than the term of the facility's RCRA permit The variance will automatically expire upon termination or denial of a RCRA permit, or when the volume of waste for which the variance was issued is reached EPA may revoke a unit's "no migration" variance if the Agency determines migration has occurred or that such a variance is no longer protective of human health or the environment Owners and operators desiring to renew expired variances must re-petition the Agency Petitions to renew must undergo the same notice and comment procedure as did the original petition

Additional Requirements for No Migration Variances

<u>Monitoring Plans for Land Disposal Units</u>

40 CFR Sections 268.6(a)(4) and 268 6(c)(1) require that petitions include plans for continued monitoring of media of concern to verify compliance with the "no migration" demonstration. The monitoring plan must be designed to detect migration "at the earliest practicable time" The Agency intends this to mean at, or as near as possible to, the unit boundary In certain limited cases the Agency may determine that monitoring of one or more media at an individual site is unnecessary, or technically infeasible or impractical. Monitoring of hazardous waste units and/or the waste stream going into the unit also may be required, unless unnecessary, or technically infeasible or impractical.

<u>Reporting of changes in Operating Conditions From Those Described in the Variance Application</u>

40 CFR 268 6(e)(1) and (2) require reporting of changes from conditions described in the variance application, including changes in the type of waste stream received,

operating practices, unit design and construction, or unusual and significant changes in the environment such as significant fluctuations in the water table or surface water flow Where such a change is planned, such as for an operating practice, the owner or operator must notify the Agency in writing at least 30 days in advance for approval Where the owner or operator discovers that there has been a significant and unplanned change from the conditions upon which the variance was granted, the owner or operator must notify the Agency within 10 days of discovery. EPA then will determine whether action is necessary, such action may include revocation of the variance or variance modifications

Detection of Migration of Hazardous Constituents

The Agency has promulgated at 40 CFR 268 6(f) notification requirements if migration is detected. If an owner or operator discovers migration from the unit after a variance has been granted, the owner or operator must immediately stop receipt of the restricted waste and notify EPA within 10 days of discovery EPA will then decide within 60 days whether the unit can continue to receive prohibited waste, or whether the variance will be terminated If the Agency determines that migration is occurring or has occurred from the unit (i e , that a release from the unit exceeds Agency-approved health-based or environmental-based exposure levels), the Agency shall revoke the variance This approach is based upon the belief that, with the exception of the air medium, once even a single incidence of migration has occurred, the "no migration" demonstration has failed. For the air medium the Agency holds a slightly different interpretation, however, based upon an annual average air concentration to demonstrate that "no migration" is occurring from the unit. EPA interprets migration to the air medium as exceeding the health-based level for a hazardous constituent on an annual average basis, not on a single event The Agency believes this approach is consistent with the approaches to long-term ambient air standards under the Clean Air Act, and that it is also protective, since health-based levels are based upon long-term exposure assumptions, and are not appropriate for use in an acute air exposure scenario. Furthermore, air concentrations are highly dependent upon dispersive and temporal factors, and therefore differ from the ground water, surface water, and soil media, where these factors are less significant Furthermore, the Agency will revoke a unit's "no migration" variance if, on the basis of any information, the Agency at any time determines that migration from the unit has occurred, or that such a variance is no longer protective of human health and the environment

Substantive requirements for variances for waste disposal in deep injection wells may differ slightly from those described above The reader should refer to the July 26, 1988 rule (53 FR 28118) for more detailed information on injection wells.

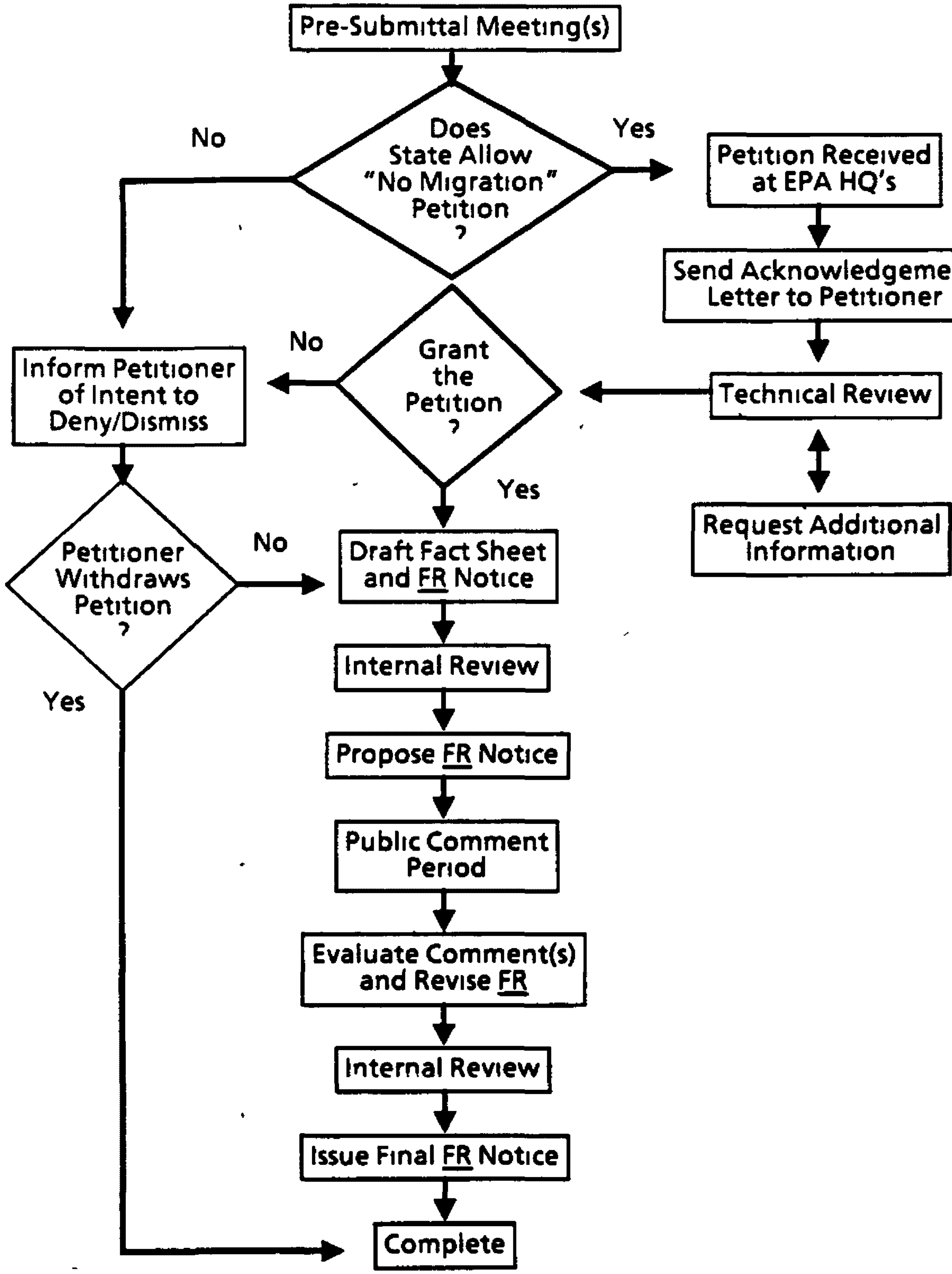
What is the Petitioning Procedure for "No Migration" Variances?

Outlined below is a step-by-step process for the submittal and review of "no migration" petitions, illustrated in the figure on the following page Until States have been authorized for the land disposal restrictions and "no migration" variances, EPA is requiring that applicants submit petitions to the EPA Administrator Petitioners should note that State programs are free to impose disposal prohibitions if such actions are more stringent or broader in scope than Federal programs (RCRA Section 3009 and 40 CFR 271 1(i)). Where States impose bans which contravene an EPA action, such as not allowing provisions for granting a "no migration" petition, the more stringent State standard shall apply and the petition will not be reviewed by EPA.

It should be noted that the petition submittal and review process discussed in this guidance manual does not apply to "No Migration" petitions for underground injection wells

Pre-Submittal

A very important component to the "no migration" process is the pre-submittal meeting between the petitioner and the EPA This meeting is critical in ensuring expeditious decisions on petitions. The purpose of the pre-submittal meeting is to provide the petitioner with an opportunity to identify the hazardous waste, hazardous constituents, and disposal unit(s) to be included in the petition. The EPA can provide some historical background on the review of similar petitions, including a tentative timeframe for the review process The Agency also recommends that petitioners submit a preliminary outline of their petition for Agency review.



"No Migration" Petition Review Process

Petition Submittal

As required by Sections 268 6(c) & (d) of the regulations, each petition must be submitted to the EPA Administrator and include the following statement signed by the petitioner or an authorized representative.

> I certify under penalty of law that I have personally examined and am familiar with the information submitted in this petition and all attached documents, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment

Six copies of the petition should be sent to

Chief, Assistance Branch
Office of Solid Waste
U S Environmental Protection Agency
401 M Street, S W (OS-343)
Washington, D C 20460

(When a State becomes authorized for the land disposal restrictions and "no migration" variances, petitions for units within that State should be sent to the State for review and determination)

Once the petition has been received by the EPA, a public docket will be established for the petition and a person from the Assistance Branch (the reviewer) will be assigned to the petition The reviewer will send a letter to the petitioner acknowledging receipt of the petition This letter may also contain a tentative timeframe for the review of the petition Copies of this letter will be distributed to the appropriate EPA Regional Office and State Agency

Petition Review

Petitions will be reviewed by EPA Headquarters with assistance from Regional and State personnel. The reviewers will perform an initial review of the petition Once this initial review is completed, EPA will decide if additional information is needed to make a decision on the petition. If additional information is needed, a letter requesting the information will be sent to the petitioner. Information to aid in the review may also be requested from the State contact The request letter to the petitioner will contain a deadline for the submittal of the additional information This deadline will be dependent on the type of information being requested Nevertheless, the deadline will not exceed a period of 180 days from the date of the request letter. Once the reviewers have obtained all of the necessary information for the review, a comprehensive, technical review will be performed As part of this review, the reviewers will work closely with the State contact and will normally perform a site visit

If the additional information is not received by the deadline, or a request for an extension of the deadline is not submitted, the reviewers may recommend that the petition be dismissed The Agency plans to dismiss incomplete petitions by letter. A dismissal letter will be sent to the petitioner and to the appropriate State and EPA regional contacts The effect of a dismissal is to remove the petition from the review process and close the petition file. The petitioner may at any time re-submit a complete petition

Decision to Grant or Deny

Once the technical review is complete, EPA will reach a tentative decision to grant or deny the petition If the tentative decision is to grant the petition, the Agency will publish a Federal Register notice describing its intent. If the tentative decision is to deny the petition, the petitioner will be informed by letter of the intent to deny. This letter will also offer the petitioner the opportunity to withdraw the petition If the petitioner declines to withdraw the petition, the Agency will publish a Federal Register notice describing its intent to deny the petition. At this point, with both petitions intended to deny and to grant, there will be opportunity for public comment. The final decision subsequently will be published in the Federal Register.

What Information Should be Included in a "No Migration" Petition?

"No migration" petitions will vary considerably. The petition content will be strongly influenced by the type of facility for which a variance is sought and the methods chosen to demonstrate that migration will not occur Certain types of units may have relatively simple information requirements because of the simple nature of their "no migration" demonstration (e g., some temporary storage units), other types of units for which complex demonstrations are made will necessarily require more complex characterization and detail. The petitioner must provide site-specific information and may, additionally, provide generic and national information for certain requirements The descriptions of petition content provided on the following pages are intended to illustrate the nature and complexity of the information that may be required

This manual should be used as a starting point for identifying the kind of information that will be required for each element of the petition In some cases, information identified in this manual may not be necessary; in other cases, additional information will be required Identification of the specific information needs for a given unit can best be accomplished in pre-petition conferences between the Agency and facility owners and operators

Discussions of each of the principal petition components listed can be found in the following pages (It should be noted, however, that the information components described below generally apply to long-term land disposal For temporary placement, some of the items might not be relevant) A detailed checklist of possible petition requirements is presented at the end of this manual

Often, much of the information required for a "no migration" petition will already have been submitted in the petitioner's Part B permit application Such information need not always be duplicated in the "no migration" petition, but in some cases simply may be summarized and referenced therein. However, the petitioner is encouraged to duplicate and include critical components of the petition in order to expedite its review and processing

Waste Descriptions

"No migration" variances are available only for the disposal of specific wastes at specific units. Variances are not available for broad categories of wastes; they are issued only for those wastes for which compliance with the "no migration" standard is demonstrated in the petition Proper management of wastes for as long as they remain hazardous requires that potential incompatibilities and waste transformation mechanisms be assessed

Hazardous and nonhazardous wastes may interact causing changes in their toxicity and/or mobility Therefore, it is important that the applicant individually characterize, to the extent possible, each waste to be placed in the unit, including wastes not subject to the land disposal ban

Waste descriptions should be properly documented and in compliance with appropriate quality control and quality assurance guidelines The following is a breakdown of the information that generally should be provided on each petitioned waste.

Waste Types and Sources --

Background information generally should be provided on each waste to be covered by the variance. Such information includes the applicable waste codes (EPA and industrial), the waste-generating processes, the hazardous constituents and their properties, the quantities of waste to be placed in the unit and the rates of placement, and handling and storage practices

Waste Characteristics --

Physical and chemical characterization is required for each petitioned waste and other wastes to be placed in the unit. The potential for leachate formation, waste solubilities, hazardous-constituent vapor pressures, and other factors that could affect waste mobility should also be assessed Analytical information should include results of testing for Appendix VIII constituents reasonably expected to be present in the waste Where release to groundwater is a concern, the petition should provide leachability study test results to determine the leachability of contaminants, simulation models of leachability and transport, and field leachate analyses, if available Acceptable procedures for waste sampling and analysis can be found in the EPA publication Test Methods for Evaluating Solid Waste

Waste Incompatibilities --

The codisposal of incompatible wastes can result in the generation of heat, the production of flammable and toxic gases, and the solubilization and mobilization of hazardous constituents. A comprehensive assessment of waste compatibilities would include all potential chemical interactions, reaction products, and product characteristics. The applicant should document, to the extent practicable, any waste incompatibilities and reaction products.

Waste Transformation Mechanisms --

To properly demonstrate that wastes can be contained in the unit, the applicant may be able to show that wastes change over time, resulting in nonhazardous degradation products In addition, it may be necessary to characterize the mechanisms by which the wastes change over time Waste transformations may alter waste mobility and/or toxicity and should be predicted to properly determine the resulting concentrations of hazardous constituents at the unit boundary In any case, reaction rates and products should generally be characterized and product characteristics for each transformation mechanism should be provided The petitioner may also be called upon to characterize combinations of transformation mechanisms An assessment of the stability of the waste matrix, matrix characteristics, and the effect of all transformation mechanisms on the matrix should be provided The mechanisms that generally should be accounted for in a "no migration" demonstration are as follows:

Biodegradation. The breakdown of a compound by microbial attack, may be very important for organic compounds. Degradation rates are dependent on environmental conditions (pH, salinity, dissolved oxygen, nutrients), the concentrations of waste and microbes, and the types of microbes.

Photodegradation. A chemical change in a compound resulting from absorption of ultraviolet light, must be considered where appropriate Tests to determine the photodegradation rates should control for pH, light wavelength, light intensity, competing reactions, temperature, and waste concentrations.

Hydrolysis. The degradation of a chemical compound upon reaction with water, may be a significant transformation mechanism for some wastes

Oxidation/reduction. The transfer of electrons between molecules, is a common degradation mechanism

Volatilization Although technically not a *transformation* mechanism, is the conversion of a solid or liquid material into a vapor state. It may represent a significant waste *transport* mechanism (i e , from one medium to another). Determination of environmental factors affecting volatilization rates (e g., temperature, pressure, vapor pressure, solubility) may also be required

The likelihood of these and other waste transformation mechanisms should be described in the petition The methods by which petitioners determine transformation rates, whether actual waste data or theoretical calculations, also should be thoroughly described The actual testing of waste transformation processes or the use of accepted procedures for transformation rate determination may be required

Facility Description

The petition should include a description of the hazardous-waste management facility where the waste will be disposed in sufficient detail to familiarize the reviewer with its overall operation The facility name, mailing address, and location should be provided, together with information on a point of contact for correspondence concerning the petition The nature of the facility's business should be identified and, for onsite facilities, the processes involved in the generation of hazardous wastes should be described Operators of facilities accepting waste from off-site should identify the types of industries serviced

Detailed design, layout, and operating plans should be provided for the unit covered by the petition. Unit descriptions should focus on waste isolation capabilities of the unit or environmental setting In many cases, the type of information and level of detail will be similar to those included in RCRA Part B permit applications. (Detailed guidance concerning Part B applications for land disposal units can be found in the EPA's 1984 Permit Applicants' Guidance Manual for Hazardous Waste Land Treatment, Storage and Disposal Facilities)

Although man-made barriers and engineered systems alone cannot be relied upon to provide the long-term "no migration" assurances required, they may play a role in the facility operation The exception is certain temporary storage facilities that may rely entirely upon engineered systems to isolate wastes For temporary land-based storage purposes only, the containment of hazardous waste within engineered barriers (and meeting Part 264 requirements) will be considered in making the "no migration" demonstration, provided that wastes are to be removed after a reasonably short storage period that may be conservatively projected to be well before the failure of the engineered barrier system. All barriers should be thoroughly described.

The unit boundaries, which will serve as the compliance point for the variance, should be defined and thoroughly described In the case where there is no engineered boundary above the waste to control air emissions, the downwind edge of the unit at a height of 1 5 meters will be the point of compliance for air emissions

Other aspects of facility design and operation may be considered in evaluating the petition, including·

Procedures employed to prevent hazards
Contingency plans
Personnel training plans
Closure plans
Post-closure plans

These elements of the facility description are also common to Part B applications. Any relevant Part B information should be summarized in the petition, or attached as necessary

Site Characterization

A thorough description of each facility's natural environmental setting is crucial to a "no migration" demonstration in any case where permanent disposal is contemplated. The site's climatology, meteorology, geology, and hydrology must be described in sufficient detail to permit assessment of the degree of waste isolation achievable. Environmental factors and long-term environmental changes that may impact the waste isolation potential of the unit should be addressed. Moreover, background ground water, surface water, soil, and air quality must be determined to properly assess any potential impacts of land disposal. The information that may be required is similar to the requirements for a Part B permit application and a RCRA Facility Investigation (RFI) (Detailed guidance concerning RFIs can be found in EPA's 1989 interim final RCRA Facility Investigation Guidance Manual)

Even so, because a "no migration" demonstration does not allow for consideration of fate and transport of hazardous constituents above acceptable levels outside the unit boundary, the focus of site characterization should be on the potential impacts of the site on the waste to be isolated in the unit For example, the potential impacts of wind, rainfall, and the fluctuation in the ground-water table on the unit and the waste within it should be addressed Nonetheless, while the demonstration cannot involve consideration of fate and transport of constituents outside the unit, locational and environmental factors that are external to the unit may have significant bearing on the probability of migration from the unit occurring. Therefore, information on particularly sensitive or vulnerable site characteristics may be useful in determining the degree of certainty required in a "no migration" demonstration

Geology --

A geologic description should include regional, local, and site information. A discussion of regional and local geology should include the following components and contain maps and other supporting documentation

Structure. Density, distribution, and orientation of faults, folds, and fractures

Subsurface Geology. Identification, lithologic descriptions, and thicknesses of all geologic formations underlying the region, available geophysical surveys, well logs, and boring logs

Geomorphology, Discussion of present surface features, processes that could affect surface features, and subsurface features that may be implied

Geologic Stability. Potential for earthquakes and degree of resulting ground motion, faulting, landslides, subsidence, creep, and other types of earth movement

The discussion of local geology should also include soils and topography Where relevant, the soils information should encompass soil types (Unified Soil Classification System), properties, thicknesses, and depths to bedrock In addition, similar site-specific geologic information should be provided, whenever possible

Ground-Water Hydrology --

The petition should include a comprehensive description of regional, local, and site ground-water hydrology Ground water is particularly vulnerable to contamination with hazardous constituents from land disposal units and, in many cases, can provide an avenue for waste constituent transport to surface waters and municipal and private wells as well as provide a subsurface migration pathway for gases. In some instances ground water may migrate into a unit, mobilizing contaminants out of the unit The following types of information, including maps and supporting documentation, may be required for a "no migration" petition

Identity and lateral extent of all aquifers, confining layers, and perched water tables

Characteristics of all necessary aquifers and confining layers, including thickness, porosity, permeability, hydraulic conductivity, and storage

Ground-water elevations and seasonal variations thereof

Existence of aquifer interconnections

Ground-water flow rates, directions, and recharge and discharge areas

Locations of all local municipal and private wells and surface water discharge areas. (For temporary storage in enclosed waste piles, and perhaps other cases where groundwater is of limited relevance, groundwater information may not be necessary, or the level of detail may be less.)

Surface-Water Hydrology --

A discussion of surface-water hydrology should include identification of all watersheds within the region that could potentially affect the facility. Maps of regional and facility drainage and the effects of facility run-on and run-off controls should be provided. Floodplain maps incorporating appropriate flood frequency data should also be provided It must be clearly demonstrated that waste isolation will not be adversely affected by floods with a reasonable probability of occurrence during the period in which the wastes are hazardous (e.g., 25-year floods, 100-year floods, etc)

Climatology and Meteorology --

Meteorological and climatological information should be sufficient to allow for the assessment of impacts of these factors on the disposal unit and site The climate and meteorology of the site can have significant impact on the rate of emissions to air, for example. The following types of information may be required

- Site wind roses
- Data on precipitation, temperature, and relative humidity data (seasonal maximums and minimums)
- Maps of severe storm tracks and statistics on storm occurrence
- Data on depth of seasonal freezing

Facilities relying in part on climatic factors to control waste migration (e.g , arid regions with no ground-water recharge) will be required to submit considerably more meterological and climatic information than facilities that are not significantly affected by climatic changes

Background Environmental Quality --

The RCRA regulations specifically require that "no migration" petitions contain analyses of background air, soil, and water quality. The analyses and levels of detail should be site-specific. Those petitioners with facilities in sensitive environments will be required to submit considerably more background data than other petitioners

Monitoring Plans

Monitoring of environmental media at land disposal sites is necessary to confirm that "no migration" of hazardous constituents beyond the unit boundary occurs (unless the Agency determines that monitoring of one or more media at a specific site is unnecessary or technically infeasible or impracticable) Accordingly, the Land Disposal Restrictions First Third Rule [53 FR 31189, August 17, 1988] amended 40 CFR 268 6 to require that "no migration" petitions include a plan for monitoring at the unit boundary, to include the following information·

Media to be monitored
Type of monitoring to be conducted at the unit
Location of the monitoring stations
Frequency of monitoring at each station
The specific hazardous constituents to be monitored
An implementation schedule for the monitoring program
Equipment to be used at the monitoring station
Sampling and analytical techniques to be employed
Data recording/reporting procedures

The petitioner should provide sufficient information to justify the design of the monitoring program and to demonstrate that monitoring stations will be located to detect migration from the unit at the earliest practicable time.

For existing units that are receiving waste prior to "no migration" petition submittal, monitoring data for ground water, surface water, soil, and air will be required as part of the petition. The Agency recognizes, however, that monitoring data may be difficult or impossible to collect, or may be nonexistent, for new units. In these cases (as well as for existing units), variance approval will be conditioned upon Agency review and approval of monitoring data, gathered at regular intevals subsequent to unit operation, which confirms "no migration". (Nevertheless, where any monitoring data are available for a new unit, as a result of field test plots, etc., such data may be required as part of a "no migration" petition).

In most cases, in addition to initial monitoring to demonstrate "no migration", detection monitoring to confirm "no migration" for each medium will be required at regular intervals (for example, semiannually for ground-water monitoring to coincide with Part 264 Subpart F monitoring). However, for the air medium EPA is taking a slightly different monitoring approach Except for those units where the Agency has determined that air monitoring is unnecessary because there is no realistic probability of migration to the air medium, petitioners generally should conduct a one-time, reasonable worst-case ambient monitoring program to confirm that modeling estimates are reasonably accurate for the unit in question (Monitoring under reasonable worst-case conditions is proposed, because it would facilitate detection of hazardous constituents, which may be at low concentrations near detection limits) Subsequent to granting of the variance, however, rather than performing regular ambient monitoring during the operation of the unit, the owner or operator should regularly sample the waste stream entering the unit to confirm that the modeled annual quantity of a hazardous constituent is not exceeded The Agency believes this approach will be appropriate because ambient air monitoring performed at the unit boundary may involve too many uncertainties and too much variability to be reliable in detecting migration. More information on air modeling and monitoring for the "no migration" demonstration is available in the Appendix to this guidance document (Where a unit is covered or contained, and monitoring is at a specific point of release, however, routine monitoring may be appropriate.)

Monitoring immediately at the unit boundary may be difficult in certain locations or under unusual physical conditions at the site Under such circumstances, the petitioner should propose a monitoring plan to be conducted as near as possible to the unit boundary without compromising the integrity of the unit. One such case may be hazardous waste repositories in geologic formations that are so extensive that installation of monitoring wells around the formation itself may not allow detection of migration at the earliest time, and installation of monitoring wells in the formation may damage the integrity of the formation. Monitoring of the *repository itself (e.g., pressure monitoring of fluids between well casings in solution-*mined caverns, or leachate sumps and pumps in room-and-pillar mines) may be suitable in this case After repository closure, however, such monitoring may no longer be feasible In certain situations, the Agency may determine that conventional monitoring of one more media at the unit boundary is technically infeasible or impractical In most cases of technical infeasibility or impracticality, however, the Agency still will require some type of monitoring or modified monitoring as near as possible to the unit boundary without compromising the integrity of the unit.

In other cases, monitoring of all environmental media at a particular facility may be unnecessary. In certain limited cases the Agency may determine, based upon waste- and site- specific characteristics, that monitoring of one or more media is unnecessary at an individual site, because migration to that medium (those media) clearly is not a realistic concern An example of this might be monitoring of air outside a totally enclosed treatment facility In such a case, petitioners should include information that clearly demonstrates why monitoring of any medium is unnecessary. The Agency may then determine on a site-specific basis to waive monitoring requirements for one or more media Petitioners who believe that one of these situations applies to their units should include in their petitions information that clearly demonstrates why monitoring of any medium is unnecessary or technically infeasible

In addition to monitoring at the unit boundary, the petition in some cases should also include a plan for monitoring the wastes in the unit to detect any changes in waste composition which could affect the potential for migration of hazardous constituents over time. Such monitoring might include periodic testing of the waste in the units or leachate collection systems in surface impoundments, landfills, and room-and-pillar mines.

A petitioner may be able to incorporate all or part of a monitoring plan designed to comply with 40 CFR 264 or 265 Subpart F requirements into the "no migration" monitoring plan. For example, a petitioner may be able to use Subpart F monitoring wells if they will detect migration at the earliest practicable time, and may only have to modify the frequency or timing of monitoring. Nevertheless, the petitioner should be aware that "no migration" monitoring is different from Subpart F monitoring in that it is to be performed immediately at, or as close as possible to, the unit boundary. (See the Land Disposal Restrictions First Third Rule promulgated on August 17, 1988 (53 FR 31138)) Subpart F ground-water monitoring, on the other hand, does not necessarily occur at the <u>unit</u> boundary, but may instead occur at the edge of the waste management area. Furthermore, although Subpart F detection monitoring for indicator parameters may be helpful to demonstrate "no migration", "no migration" monitoring should be for a set of constituents determined based on a unit-specific analysis of the waste While indicator parameters may still be suitable for "no migration" monitoring purposes, they may differ from those of Subpart F monitoring.

Waste Mobility Modeling

Accurate and representative modeling of waste constituent mobility may be required for the environment within the unit including unit liners and engineered barriers. The Agency also may determine in certain limited situations that modeling of a particular medium is unnecessary or infeasible (e g , air modeling for a covered waste pile) However, where an engineered control such as a cover exists which greatly reduces the likelihood of migration to the air medium, but for which modeling is infeasible, the Agency may require the petitioner to assess the performance of the engineered system in lieu of modeling. Presented below is a brief overview of information requirements for modeling as well as considerations relevant to the choice of a representative model

Several types of models may be used to predict waste mobility within the confines of the unit for which a variance is sought Although hazardous constituents must not exceed human health-based levels beyond the engineered boundary of the unit, waste migration within the unit will be acceptable Models may be developed for predicting leachate and gas generation rates, barrier integrity over time, and many other factors that can affect waste mobility All such models and the assumptions underlying them must be thoroughly explained, and descriptions of the calculations and codes employed must be provided. Model assumptions and input data should be conservative and tend toward overestimating rather than underestimating migration Models, input data, and relevant documentation should be available to EPA upon request and without restriction.

Modeling of waste and leachate migration in the unsaturated zone may be required for some units (e.g., the treatment zone of a land treatment unit). Waste constituent transport within that zone depends on site geology, soils, and climatology, as well as the physical and chemical characteristics of the waste and leachate The factors affecting flow at or near the land surface are precipitation, run-off/run-on, evaporation, and transpiration.

Physical properties of the site soils that affect flow in the unit and the unsaturated zone that should be described in the petition include.

Water content
Pressure potential
Permeability
Degree of water saturation
Bulk density
Particle density
Water capacity
Hydraulic conductivity
Water diffusivity

The waste or leachate in the unsaturated zone can be affected by various chemical processes, including ion exchange, adsorption, precipitation, dissolution, and complex formation Those processes appropriate to the waste and its leachates should be considered Moreover, certain properties of the soil can be affected by the waste or leachate its hydraulic conductivity can be changed; its permeability can be increased by the removal of organic matter or a change in adsorptive properties; and others of its properties can be altered by the dewatering of clays or a change in pore size. Flow patterns within the soil can also be altered by changes in pore size due to the dissolution and precipitation of chemical species. The impact of these factors should be taken into account in the model.

The potential for air emission of hazardous constituents from the waste surface into the atmosphere must be addressed. Emission rates are influenced by environmental as well as chemical and physical factors The principal environmental factors influencing air emissions are temperature, soil characteristics (e.g., pH, moisture, grain size), and precipitation. The waste or leachate properties that should generally be modeled include vapor pressure, solubility, chemical activity, partitioning behavior of the solute (waste) between the atmosphere and water (Henry's Law), diffusivity, absorption, and release rate. (In some cases, such as covered or closed units, actual data on emission rates may be more appropriate than modeling)

Limitations of any air emission release rate and dispersion models should be documented. The applicant should combine the use of models with ambient air and emission monitoring to characterize conditions at the unit to the greatest extent possible. Any models used should be verified at the site (For more information on the "no migration" demonstration methodology air, see the Appendix)

Appropriate models should be chosen for each of the waste mobility cases discussed (i e , unsaturated zone, air, etc.). The choice depends on the objectives of the study and on the sensitivity of the model to various chemical and physical processes. The model chosen should be sensitive to all of the significant processes and, of the models considered, should be the most sensitive to those processes of greatest importance.

Other concerns in choosing a model are how well it represents the field situation, whether it is appropriate for the available data, and whether it can be confirmed for accuracy by comparison to actual measurements The most sophisticated models may be inappropriate for the available data

The petitioner should provide the following quality assurance and quality control information for every model used

Model Confirmation and Calibration. Comparing the results of analytical and numerical models or matching field data to the model results is critical to model confirmation Models should be calibrated at the site.

Justification of assumptions. Proper justification of all assumptions should be provided. Reasonably conservative assumptions should be chosen

Sensitivity tests. An assessment of the influence of changes in the magnitude of model parameters should be provided Models should show greatest sensitivity to the most influential processes.

Model accuracy assessment. It should be demonstrated that: (1) the model reasonably represents the actual physical system, (2) there are no computational errors in the computer code, and (3) there is a high degree of correlation between the model and measured data

The EPA discourages the use of proprietary models, since the models selected will have to be closely scrutinized to determine their reasonableness and accuracy. They also will be subject to public comment The Agency will give most weight to data developed under appropriate QA/QC procedures, as described in the facility QA/QC plan, in the petition review

Assessment of Environmental Impacts

In a "no migration" demonstration the petitioner must show that hazardous constituents do not exceed human health-based levels at the edge of the disposal unit If lower levels must be met to protect the environment, then those levels will be required For example, lower levels may be needed where there is potential impact to a sensitive environment (e g , an adjacent wetland) or an endangered species even if human health- based levels are met The petition should identify such environments or species for which there exists the reasonable probability of impacts from the unit for which a variance is sought The assessment of environmental impacts does not mean that migration of hazardous constituents will be measured (or allowed) beyond the boundary of the unit. Such an assessment should be undertaken merely to determine if human health-based levels measured at the unit boundary are sufficient to protect any sensitive environmental receptors.

Environmental assessments should identify any factor which may reasonably be assumed to require stricter contaminant levels. This will involve defining the terrestrial and aquatic species that may be exposed to contaminants and the exposure pathways through which the species may be sensitive (e.g., inhalation, direct contact). Where exposure is possible, acute and chronic toxicity and bioaccumulation factors should be provided for each constituent with respect to the species involved Effects of transported and transformed air pollutants (e.g., ambient ozone or photochemical oxidants) on agricultural crops, forests, or materials should be considered by the applicant. Field studies and biomonitoring may be performed in the absence of data, or available data for chemical analogs may be substituted.

Environmental considerations may include but are not limited to evaluation of:

Species diversity and abundance potentially affected by migration from the unit

Bioaccumulation potential in plants and animals

Fishery and habitat impacts

Endangered species of flora and fauna potentially affected by migration from the unit

Biological community structure alteration potential

It is important to note that, for many chemicals, exposure levels deemed safe for humans often have adverse effects upon terrestrial and aquatic life In addition, toxicants present at low levels in the environment may bioaccumulate, presenting significant health risks to man and animals higher in the food chain.

Prediction of Infrequent Events

Under 40 CFR 268 6(b)(5) an analysis must be performed to identify and quantify any aspects of the demonstration that contribute significantly to uncertainty

The petitioner must identify and evaluate the impacts of predictable future events that could contribute to or result in inadequate waste isolation Natural phenomena that might require consideration include.

Earthquakes and resulting ground motion
Floods and droughts
Severe storm events
Climatic fluctuations
Geologic activity

The potential for such natural events during the period in which the wastes remain hazardous should be determined Potential impacts and consequences of events with a reasonable probability of occurring during that period should then be estimated with respect to the facility's ability to isolate wastes from the environment. In addition, likely human-induced events which may affect the isolation capability of the unit, such as disturbance of the hydrologic regime and future land uses, should generally be considered.

Analyses of predictable events should take into consideration both the disposal unit and the surrounding environment For example, ground motion resulting from an earthquake may cause the breaching of a unit, the fracturing of surrounding rocks, and surges in the ground-water level Previously unconsidered avenues for contaminant migration may be created by the earthquake. Impacts of other geological activity such as sinkhole formation in areas of karst terrane or slope failure in areas of landslide susceptibility also should considered In analyzing the potential consequences of predictable phenomena, probable worst-case scenarios should be used to ensure that any errors occur on the side of safety

Quality Assurance and Control

Under 40 CFR 268 6(b)(4) a QA/QC plan that addresses all aspects of the petition demonstration must be included in the petition submittal and approved by the Agency Quality goals and methods to assure that these goals are achieved should be included for each of the following aspects of the petition demonstration

Waste and environmental monitoring, sampling, and analysis activities

Field measurements of the facility setting, such as geophysical exploration, ground-water monitoring, weather observations, and topographic mapping

Validation of computations, codes, models, and methods used in calculating critical facility parameters

Control of construction activities to ensure compliance with design specifications, where relevant to the "no migration" demonstration.

Evaluation of the integrity of construction materials, where relevant to the "no migration" demonstration

The QA/QC plan generally should identify goals for each of the following quality indicators and describe how they will be achieved:

Data representativeness. The degree to which data accurately and precisely represent a characteristic of a population, a parameter, variations at a sampling point, or environmental conditions

Data accuracy. The degree to which data agree with an accepted reference or true value The measurement of accuracy exposes any bias in a system or method.

Data precision. A measure of the mutual agreement between comparable data gathered or developed under similar conditions Precision is best expressed in terms of a standard deviation

Data completeness. A measure of the amount of valid data obtained against the amount that was expected

EPA will give most weight to data developed under appropriate QA/QC procedures, as described in the facility QA/QC plan, in the petition review.

CHECKLIST OF INFORMATION NEEDS

The following checklist is a comprehensive, but not all-inclusive, list of information needs Individual petitions may require more or less information than that presented below The level of detail required will depend on site-specific factors

Facility Description

- ☐ Name of facility
- ☐ Address of facility
- ☐ Name of owner/operator
- ☐ Anticipated period of operation
- ☐ Status of RCRA permit application
- ☐ Location map
- ☐ Detailed site plan
- ☐ Aerial surveys
- ☐ Advantages/disadvantages of location
- ☐ Evaluation of storage/disposal unit
  - ☐ Design objective
  - ☐ Design criteria
  - ☐ Design performance projection
  - ☐ Materials specifications
  - ☐ Detailed drawings and specifications
  - ☐ Documentation of unit construction
  - ☐ Documentation of unit operation
- ☐ Closure plans
- ☐ Post-closure plans
- ☐ Cover design
- ☐ Design QA/QC demonstration (testing & inspection)
- ☐ Facility operation QA/QC demonstration

Waste Characteristics

- ☐ Waste type by name
- ☐ Processes that produced the waste
- ☐ Hazardous properties
- ☐ Physical characteristics
- ☐ Chemical characteristics
- ☐ Biological properties
- ☐ Constituents and percentages of constituents
- ☐ Analytical methods and results
- ☐ Projection of waste volume to be disposed
- ☐ Quantity of banned waste being disposed
- ☐ Frequency of disposal
- ☐ Period of time waste has been and will be disposed
- ☐ Handling procedures
- ☐ Waste treatment before, during and after disposal
- ☐ Liquid phase mobility information
- ☐ Gas/particulate mobility
- ☐ Solid phase mobility
- ☐ Dust generation potential
- ☐ Gas-liquid phase interactions
- ☐ Persistence/degradation potential in unit and environment
- ☐ QA/QC demonstration

Waste Transformation and Immobilization

- ☐ Estimation of quantity and quality of leachate formation
- ☐ Waste/waste compatibility, interaction, reaction products
- ☐ Waste/liner compatibility
- ☐ Assessment of biodegradation potential
- ☐ Assessment of oxidation/reduction potential
- ☐ Assessment of immobilization due to insolubility
- ☐ Assessment of photodegradation potential
- ☐ Assessment of immobilization due to hydrolysis
- ☐ Assessment of immobilization due to adsorptivity

Site Characterization

- ☐ Surficial geology and soils (regional and local)
  - ☐ Topography
  - ☐ Soil types
  - ☐ Soil properties
  - ☐ Depth to bedrock
- ☐ Bedrock geology (regional and local)
  - ☐ Stratigraphy and lithology
  - ☐ Seismic activity of area
  - ☐ Assessment of ground motion potential and degree

- ☐ Geologic cross sections
  - ☐ Degree of bedrock faulting and fracturing
  - ☐ Rock characterization
- ☐ Ground-water hydrology (regional and local)
  - ☐ Water table map
  - ☐ Seasonal variations in the water table
  - ☐ Identification of all aquifers and aquitards
  - ☐ Characterization of all aquifers
  - ☐ Vertical and horizontal hydraulic conductivity
  - ☐ Aquifer interconnection
  - ☐ Description of ground water monitoring program
  - ☐ Monitoring QA/QC documentation
- ☐ Surface water hydrology
  - ☐ Location of all watersheds
  - ☐ Map of drainage patterns
  - ☐ Map of floodplain
  - ☐ Flood analysis
- ☐ Meteorology/climatology
  - ☐ Wind rose
  - ☐ Precipitation records
  - ☐ Temperature records
  - ☐ Relative humidity records
  - ☐ Maps of storm tracks

Monitoring Plan

- ☐ Media to be monitored
- ☐ Type of monitoring to be conducted at the unit
- ☐ Location of monitoring stations
- ☐ Frequency of monitoring at each station
- ☐ Specific hazardous constituents to be monitored
- ☐ Implementation schedule for the monitoring program
- ☐ Equipment used at the monitoring stations
- ☐ Sampling and analytical techniques employed
- ☐ Data recording/reporting procedures

Waste Mobility

- ☐ Unsaturated zone soils
  - ☐ Soil sampling
  - ☐ Soil testing
- ☐ Unsaturated zone physical properties
  - ☐ Volumetric water content
  - ☐ Degree of water saturation
  - ☐ Bulk density
  - ☐ Pressure potential
  - ☐ Relative permeability
  - ☐ Unsaturated hydraulic conductivity
  - ☐ Water capacity
  - ☐ Water diffusivity
- ☐ Leachate characteristics affecting mobility
  - ☐ Leachate characterization
  - ☐ Leachate interactions
- ☐ Secondary leachate evaluation
- ☐ Evaluation of transport mechanisms
- ☐ Evaluation of fate of contaminants in unsaturated zone
- ☐ Vapor concentration of constituents at the source
- ☐ Vapor pressure of constituents
- ☐ Solubility data for constituents
- ☐ Activity coefficient
- ☐ Henry's Law constant
- ☐ Background measurements for air
- ☐ Assessment of volatilization potential

Modeling Evaluation

- ☐ Model accounts for all transport mechanisms
- ☐ Model appropriate for petitioned waste
- ☐ Data input accurate and verified
- ☐ Model tested under field conditions
- ☐ Model is accurate over long time periods
- ☐ Limitations of model
- ☐ Model inputs adequately documented
- ☐ Model outputs appropriate and reasonable

Assessment of Environmental Risk

- ☐ Identification of all exposure pathways and routes
- ☐ Identification of all potential receptors
  - ☐ Wildlife
  - ☐ Vegetation
  - ☐ Identification of sensitive or endangered species
- ☐ Assessment of bioaccumulation through the foodchain

Uncertainty Analysis

- ☐ Natural Events
  - ☐ Climatic fluctuations
  - ☐ Glaciation
  - ☐ Stream erosion

- ☐ Magmatic activity
- ☐ Epeirogenic displacement
- ☐ Orogenic diastrophism
- ☐ Diagenesis
- ☐ Static fracturing
- ☐ Dissolution
- ☐ Sedimentation
- ☐ Flooding
- ☐ Undetected features (i e faults, lava tubes)
- ☐ Meteorites
- ☐ Fires
- ☐ Hurricanes
- ☐ Tornadoes
- ☐ Earthquakes
- ☐ Ground motion

☐ Waste/facility-induced events

- ☐ Thermal effects
- ☐ Chemical effects
- ☐ Mechanical effects
- ☐ Modification of hydrologic regime

☐ Human-induced events

- ☐ Improper design or operation
- ☐ Past intrusions
- ☐ Future intrusions
- ☐ Intentional intrusion
- ☐ Perturbation of ground-water system
- ☐ Biosphere alterations

Where Can I Obtain Additional Information Concerning "No Migration" Variances?

Additional information on "no migration" variances is available from EPA Headquarters in Washington, D C Facilities considering submitting a petition are strongly encouraged to meet with the Agency before preparing the petition to assess the exact nature of the information required in the "no migration" demonstration and the level of detail appropriate for the petition Questions concerning petitions and requests for petition meetings should be directed to

U S Environmental Protection Agency
Permits and State Programs Division
401 M Street, S W
Washington, D C 20460
Telephone 202/382-4782

Questions concerning these and other RCRA requirements can also be directed to the RCRA/Superfund Hotline at 800/424-9346 or, in the Washington, D.C. metropolitan area, 202/382-3000. The Hotline can also provide assistance in obtaining copies of Federal regulations and other relevant guidance documents.

The following is a list of selected documents which may be of value to potential petitioners.

Permit Applicants' Guidance Manual for the General Facility Standards 1983. EPA SW-968

Permit Applicants' Guidance Manual for Hazardous Waste Land Treatment, Storage, and Disposal Facilities. 1984 EPA 530 SW- 84-004

Hydrologic Simulation at Waste Disposal Sites 1982. EPA SW-868.

Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods Third Edition, 1986 EPA SW-846.

A Method for Determining the Compatibility of Hazardous Wastes. EPA 600/2-80-076.

A Guide for Estimating the Incompatibility of Selected Hazardous Waste Based on Binary Chemical Mixtures 1986 ASTM P-168

Soil Properties, Classification, and Hydraulic Conductivity Testing 1984. EPA SW-925

Criteria for Identifying Areas of Vulnerable Hydrogeology Under the Resource Conservation and Recovery Act. 1986 NTIS 86-224946

RCRA Facility Investigation Guidance Manual, Interim Final EPA 530/SW-89-031, February, 1989

Solid Waste Leaching Procedure 1984 EPA SW-924

Waste Analysis Plan Guidance Manual 1984 GPO 055-000-00244-4

Construction Quality Assurance for Hazardous Waste Land Disposal Facilities, Draft. 1985. EPA/530 SW-85-021

RCRA Groundwater Monitoring Technical Enforcement Guidance Document, 1986.

Surface Impoundment Clean Closure Guidance Manual, Interim Final October, 1987

Superfund Public Health Evaluation Manual. EPA/540-1-86-060.

Guidelines for Carcinogenic Risk Assessment. 51 FR 33992-34003.

Guidelines for the Health Risk Assessment of Chemical Mixtures. 51 FR 34014-34025.

Integrated Risk Information System (IRIS) Chemical Files. EPA/600/8-86/032b

APPENDIX

AIR PATHWAY ASSESSMENT METHODOLOGY

"NO MIGRATION" VARIANCES TO THE HAZARDOUS WASTE LAND DISPOSAL PROHIBITIONS: A GUIDANCE MANUAL FOR PETITIONERS

Prepared for

U.S. Environmental Protection Agency
Office of Solid Waste
Washington, DC

JULY 1992

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1.0 INTRODUCTION

The Environmental Protection Agency (EPA) promulgated a final rulemaking (51 FR 40572) that established the overall framework for the land disposal restrictions as mandated by the Hazardous and Solid Waste Amendments (HSWA) of 1984 A major requirement of HSWA is that all hazardous wastes must meet treatment standards based on performance of best demonstrated available technology before placement into the land Otherwise, the owner/operator is prohibited from land disposal of the waste Sections 3004(d), (e), and (g) also provides an opportunity for generators, owners, and operators to either individually or collectively petition for a variance from the prohibition against land disposal of hazardous wastes not meeting Agency standards In order to receive a variance, a petitioner must successfully demonstrate that there will be "no migration" of hazardous constituents from the disposal unit or injection zone for as long as the waste remains hazardous [3004(d)(1)]

A "no-migration" demonstration methodology applicable to air releases has been developed This methodology has been based on consideration of the emission and atmospheric dispersion potential of gaseous and particulate air contaminants from land disposal units. Typical hazardous waste disposal units such as land treatment, surface impoundments, and landfills have the potential for air contaminant emissions even with the application of control technology Local wind conditions will result in the transport of these air contaminants beyond the unit boundary Therefore, the air pathway assessment methodology presented in Section 2, which accounts for these emission/dispersion mechanisms, is recommended for "no-migration" demonstrations Example applications of this methodology are presented in Section 3

Regulations currently are being developed by EPA under Section 3004(n) of HSWA to control air emissions from hazardous waste treatment, storage, and disposal facilities. In addition, the National Emission Standards for Hazardous Air Pollutants (NESHAP) applicable to benzene were promulgated in March 1990. The Occupational Safety and Health Administration (OSHA) has promulgated air contaminant standards which address short-term exposures Compliance with 3004(n) and certification of compliance with NESHAP and OSHA requirements are necessary prerequisites for approval of a "no-migration" petition.

- 3004(n) - Requires air standards for land treatment, landfill, and waste pile units when obtaining a "no-migration" variance These regulations will be proposed with the revisions to Section 268.6. Once regulations implementing Section 3004(n) are promulgated, petitioners will need to demonstrate volatile organic concentrations in the waste of less than or equal to 500 ppmw If this is not met, pretreatment or physical controls to limit emissions will be required

- Benzene NESHAP - 40 CFR Part 61 sub-part FF was promulgated March 7, 1990, 55 FR 45 It requires certain facilities that manage >10 Mg/year of total annual benzene in the waste to control certain waste streams, normally ones with >10 ppmw benzene in waste Facilities subject to the benzene NESHAP control requirements must treat the benzene in the waste to below 10 ppmw prior to land disposal in an open unit

- OSHA - 29 CFR Part 1910 was promulgated June 7, 1988, 53 FR 109. It requires facilities to meet concentration limits for 8-hour time-weighted averages (TWA), and short term exposure limits (STELS), which generally are 15-minute time-weighted average exposures

2.0 AIR PATHWAY ASSESSMENT METHODOLOGY

2.1 Overview

The intent of a "no-migration" petition is to demonstrate that there will be no transport of constituents at hazardous concentrations from the disposal unit. For air pathway assessments, "no-migration" is defined as constituent-specific (gaseous and particulate) air concentrations which are protective of human health and the environment This approach involves the application of standard emission and dispersion models to estimate air concentrations at or beyond the point of compliance for comparison to available inhalation health criteria. The point of compliance is the outermost extent of the berm that contains the LTU. Concentrations at or beyond the point of compliance must to be shown to be less than all applicable health criteria to demonstrate "no-migration"

A height of 1 5m should be used for "no-migration" air pathway assessments to evaluate air concentrations relative to health criteria Although dispersion models can be applied to a ground-level measurement height, this would not be appropriate for "no-migration" because of the need to compare ambient air quality monitoring and dispersion modeling Monitoring at a height less than 1.5m is not appropriate for a land treatment unit because surface effects would pose a major complication for collecting representative air quality samples For example, particulate samples with inlet heights significantly less than the inhalation height of 1 5m would have the potential to collect non-suspendable particulates from the surface This could bias the measured data set, and adversely affect long-term comparisons of modeled and measured concentrations The 1 5m height is a compromise, which is unlikely to show significantly lower concentrations than surface concentrations because the composite LTU area source is generally large relative to the difference in height of 0 to 1 5m at the LTU boundary[1]

[1] **Only during stable conditions is there likely to be strong enough vertical gradients to potentially show significant differences in concentration within the range of 0 to 1.5m above ground level.**

A combination of modeling and monitoring approaches can be used to estimate the maximum air concentration at 1 5m at or beyond the point of compliance An overview of the recommended air pathway assessment methodology for "no-migration" demonstrations is illustrated in Figure 2-1 This methodology consists of the following major components:

- Conduct an emission rate/dispersion modeling assessment prior to submittal of a "no-migration" petition.

- Conduct a worst-case air quality monitoring assessment and optional emission rate monitoring prior to submittal of a "no-migration" petition

- Scale-up modeled concentrations within a pollutant class if measured data show that modeling underestimates the pollutant class

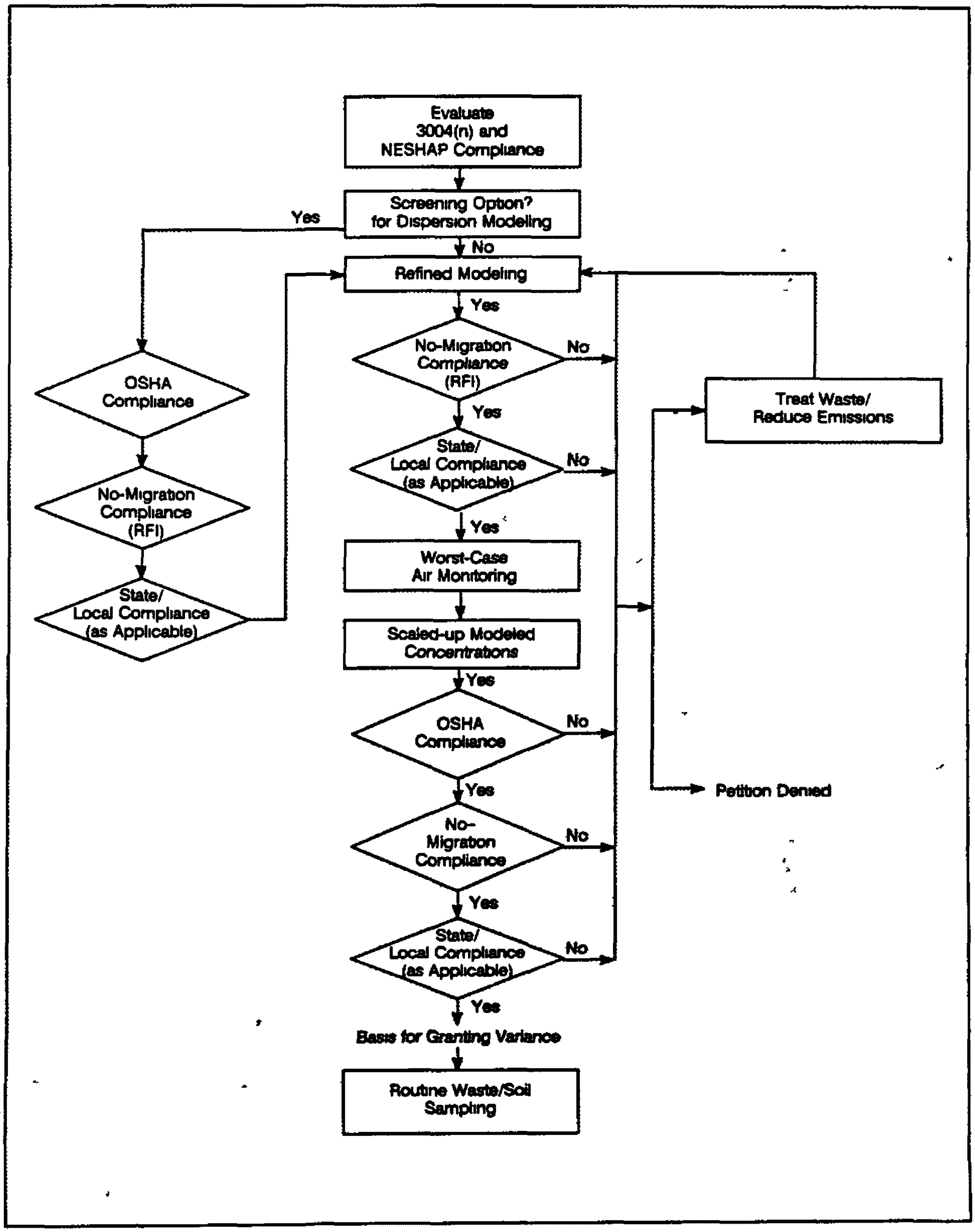
- Conduct a routine waste and soil sampling after a "no-migration" variance has been granted

A waste-based analysis is needed to evaluate compliance with section 3004(n) and the benzene NESHAP Dispersion modeling is the basis to evaluate compliance with the RFI Health Criteria (EPA, May 1989a). A dispersion modeling assessment initially should be conducted to characterize the air emission potential for the disposal unit and to estimate maximum air concentrations at the unit boundary The primary modeling approach, which must be done for all sources and Skinner List pollutants, is to use refined emission rate and dispersion models An alternative (optional) approach involves the application of conservative screening models The screening approach is generally useful to obtain preliminary conservative modeling results. But the refined modeling approach will still be required as the primary basis for evaluation of a "no-migration" petition. If modeling results indicate compliance, then a monitoring assessment should be conducted Non-compliance results indicate that waste treatment and/or additional measures to reduce emissions would be needed. Based on these control measures, a revised modeling assessment should be conducted If waste treatment/ control measures are not adequate for compliance, the "no-migration" petition will be denied The recommended methodology for the conduct of modeling assessments is presented in Section 2 2

A monitoring assessment also should be conducted (e.g , this may involve a demonstration plot for a new land treatment unit) to evaluate modeling estimates, and the results should be submitted with the "no-migration" petition. All pollutants with ratios of modeled concentrations divided by applicable health criteria greater than 0.10 for any health criteria should be included in the monitoring program unless there is not a

Figure 2-1

AIR PATHWAY ASSESSMENT METHODOLOGY FOR "NO-MIGRATION PETITION" DEMONSTRATION



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validated method suitable for use in the ambient air The emission and air monitoring program should be conducted during a period representative of worst-case emission/ dispersion conditions. Worst-case conditions, considering waste application rates, emission conditions, and meteorological conditions, provide the best potential to obtain conclusive monitoring results because of the higher concentrations expected relative to analytical detection limits

Measured air quality concentrations are then compared with matched modeled concentrations. If modeled concentrations are less than measured values based on selected indicative pollutants, the modeled concentrations are scaled up to the magnitude of the measured values A scale-up factor is determined separately for each pollutant class (volatile organics, semi-volatile organics, and metals) Comparisons between scaled-up concentrations and all applicable health criteria must be made for all pollutants and applicable averaging periods Compliance based on this evaluation will be a prerequisite for granting a "no-migration" variance, while non-compliance will constitute a basis for petition denial The recommended methodologies for the conduct of monitoring assessments for "no-migration" demonstrations are presented in Section 2 3

In existing units, air modeling and monitoring data for appropriate constituents must be submitted as part of the "no-migration" petition for units currently managing hazardous wastes. Petitions will be considered incomplete if these data are not submitted The only exemption to this requirement is for petitions submitted prior to January 1, 1990. These petitions will be considered complete for "initial review" purposes if they lack only modeling and monitoring data for particulates This exception was necessary to allow those early petitioners reasonable time to implement the additional requirements of the "Air Pathway Assessment Methodology" Particulate modeling and monitoring data, however, must still be submitted to EPA before a "no-migration" determination can be made.

Subsequent routine waste and soil sampling and analyses will be required to determine compliance with modeling assumptions and results used for the "no-migration" petition. The modeling analyses should establish a Mg/year application limit and constituent concentration limits, neither of which should be exceeded. The recommended methodologies for the conduct of routine sampling assessments after a "no-migration" variance has been granted are presented in Section 2 4

2.2 Modeling Methodology

The air pathway assessment modeling methodology for "no-migration" demonstrations involves applying emission rate and dispersion models These modeling results are used to estimate the maximum air concentrations at the unit boundary for comparison to health-based criteria The methodology consists of five steps as follows (see Figure 2-2)

- Step 1 - Obtain Source Characterization Information. This information (e.g , unit size, waste quantity, etc) is needed to define the emission potential of a disposal unit. The specific source data needed will be a function of the input requirements of the emission and dispersion models selected

- Step 2 - Select Release Constituents Unit and waste- specific information should be used to identify potential release constituents for modeling purposes

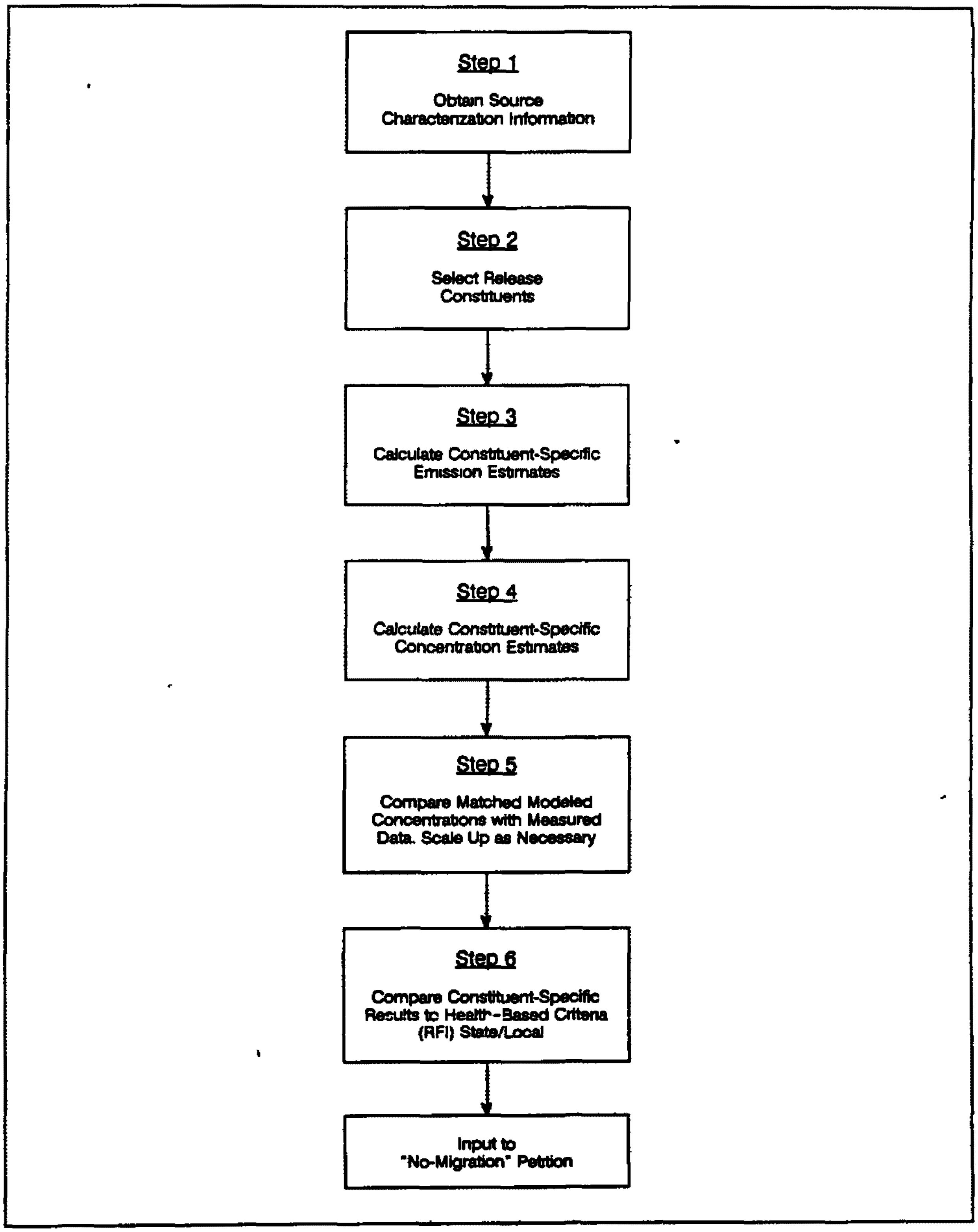
- Step 3 - Calculate Emission Estimates: Unit-specific emission models should be used based on source conditions identified in Step 1 for constituents identified in
Step 2. These modeling results will provide constituent-specific emission rate estimates, which are input to Step 4.

- Step 4 - Calculate Concentration Estimates Emission rates from Step 3 should be used to calculate concentration estimates at and beyond the unit boundary Standard dispersion models (see Section 2.2.2) should be used to obtain these concentration estimates

- Step 5 - Compare Modeled Concentrations with Matched Measured Data: The measured and modeled data are matched in space and time. Average concentrations measured across the monitoring program are compared with corresponding modeled data for indicative pollutants after subtracting background concentrations from the measured data Modeled concentrations should be scaled-up as necessary Modeled concentrations are never reduced on this basis.

Figure 2-2

MODELING METHODOLOGY OVERVIEW



- Step 6 - Compare Concentration Results to Health-Based Criteria (RFI and State and Local Criteria) Concentration results from Step 5 should be compared with constituent specific, health-based criteria presented in the interim final RCRA Facility Investigation (RFI) Guidance (U.S.EPA, May 1989a) Chronic exposures for carcinogens and toxicants should be evaluated by comparison of the estimated maximum annual (1-year) concentration directly to the annual average concentrations (based on RFI health criteria and assuming a 70- year exposure) Therefore, the health criteria concentrations should not be exceeded during any calendar year. Furthermore, credit should not be taken for reduced 70-year average concentrations if the unit will not be operational for the full 70-year period Interpretation of the ambient concentration estimates should account for the uncertainties associated with the source/waste characterization data, as well as modeling inaccuracies

Hard copies of modeling input and output files and supporting calculations should be submitted with the "no-migration" petition Submittal of modeling files on floppy disk is recommended to help facilitate review of the air pathway assessment by the U.S. EPA Wind direction (wind rose) plots also should be submitted with the petition for each modeling period

Recommended emission rate methods and dispersion modeling methods as they apply to "no-migration" demonstrations are presented in Section 2 2 1 and 2.2.2, respectively.

2.2.1 Emission Rate Modeling

All air emissions sources (both direct and indirect) within the unit boundary should be evaluated in the petition to demonstrate compliance with the "no-migration" criteria for the air pathway at the point of compliance (based on modeling and monitoring) Emissions sources outside of the unit boundary are excluded from the "no-migration" evaluation, although it might be desirable to account for such background levels so that air emissions attributable to the unit alone may be evaluated The only exceptions are surface impoundment emissions if the impoundment(s) is covered in the "no-migration" demonstration These emissions would be included in the "no-migration" demonstration

Air emission models can be used to estimate constituent-specific emission rates based on waste/unit input data for many types of waste management units (An emission rate is defined as the source release rate for the air pathway in terms of mass per unit time) The models applicable to land disposal units are based on theoretical considerations and have been evaluated against pilot-scale and field test results. Often these models are empirically correlated. However, because the models attempt to predict complex physical and chemical phenomena, they should be used carefully. These models are generally considered accurate within an order of magnitude (assuming representative input data) for short-term emission rate estimates. Accuracies for long-term estimates are more favorable and are also limited by mass balance considerations (i.e , the emission rate cannot exceed the waste input to the disposal unit)

The potential variability of the waste and unit input data should be accounted for in the modeling assessment Therefore, a sensitivity analysis of this variability relevant to emission rate estimates should be conducted to determine the level of confidence associated with the emission modeling results

Emission rate estimation methods for gaseous emissions should be based primarily on CHEMDAT7 (or alternatively LAND7 (U S EPA, 1990)), which are computer models applicable to land treatment units Emission factors should be used to estimate fugitive emissions of particulate matter

<u>Gaseous Emissions</u>

The modeling methodology for "no-migration" demonstrations to estimate gaseous emissions is based on the application of CHEMDAT7 air emission models developed by EPA's Office of Air Quality Planning and Standards (U.S. EPA, March 1989) and is available from NTIS. These models are applicable to volatile as well as semi-volatile constituents that enter the air pathway via volatilization CHEMDAT7 includes air emission rate models for the following land disposal units

- Land treatment
  - Oil film surface
  - Land treatment soil
- Disposal impoundment
- Landfills
  - Open landfills
  - Closed landfills

Comprehensive technical information regarding these CHEMDAT7 models is presented in the <u>Hazardous Waste Treatment, Storage and Disposal Facilities (TSDF) Air Emission Models</u> (U.S. EPA, March 1989) This reference also presents air emission rate models for many other sources

For some applications, Step 4 - Calculate Concentration Estimates, will not warrant the use of emission models because it can be assumed that all of the volatile wastes handled will eventually be emitted to the air. This assumption is generally appropriate for highly volatile organic compounds placed in a disposal unit like a surface impoundment In these cases, mass balance calculations can be used since the air emission rate can be assumed to be equivalent to the disposal rate, and an emission rate model may not be required. This assumption is valid because of the long-term residence time of wastes in the disposal units. In open units like surface impoundments, a substantial portion of the volatile constituents will frequently be released to the atmosphere within several days But the use of the mass balance approach is only applicable if waste transformation and degradation processes do not produce significant quantities of the constituents being evaluated

For more complex situations (e.g , land treatment units and landfills), air emission models can be used to obtain a more refined release rate If subsurface injection is the application method, the depth of injection should be considered in the analysis of peak emission rates Whenever subsurface injection is not the application method, the petitioner should consider using the oil film model, or the landfill model for limited seepage depth, not the full depth of tilling, when estimating maximum emission rates Inappropriate characterization of the depth of initial application can be a major oversight that leads to underestimating concentrations

To calculate the oil loading rate and the concentration of constituents in the oil, the following equations apply

$$L = oil\ loading = [(W)x(O_r)] \ / \ [(A)x(D)] = grams\ oil/cm^3 \quad (Eq.\ 2\text{-}1)$$

where.

- W = total mass of waste applied (g)
- O_r = grams of oil per gram of waste
- A = area of plot (cm^2)
- D = tilling depth (cm)

C_i = concentration of pollutant in oil, not waste

C_i = [(ppmw pollutant in waste) / (O_r)] x 10^{-6}

Fugitive Particulate Matter

Trace metal and semi-volatile constituents of fugitive particulate emissions are of concern for "no-migration" demonstrations Emission factors should be used to estimate these fugitive particulate air emissions Emission rate estimates should be based on standard methodologies developed by the U.S. EPA in the following documents:

- Hazardous Waste TSDF - Fugitive Particulate Matter Air Emissions Guidance Document, (EPA-450/3-89-019), U.S. EPA, March 1989
- Control of Open Fugitive Dust Sources, U.S EPA, September 1988a.
- Compilation of Air Pollutant Emission Factors (AP-42), U.S. EPA, 1985, Supplement B, September 1988b, and Supplement C, 1990)

Emission estimates should be representative of inhalable particles (i e , particles 10 microns or less in diameter) Soil concentration estimates (representative of inhalable size particles) from the surface of the unit should be used as modeling input to determine constituent-specific emission rates These soil concentration estimates should be used to define the upper limit for unit operating conditions and, therefore, should account for the potential accumulations of the constituents being evaluated In other words, trace metal analysis generally must consider worst-case annual impacts on soil metal concentrations expected during the last year of operation Guidance on developing particulate emission estimates is provided in Hazardous Waste TSDF - Fugitive Particulate Matter Air Emissions Guidance Document (U S EPA, March 1989).

Potential fugitive particulate emissions due to mechanical disturbances, wind erosion, and fugitive gaseous emissions from the application process, waste handling/transfer, and waste storage within the LTU all should be quantitatively evaluated and presented in the "no-migration" demonstration Particulate and gaseous emissions should be estimated from tank loading, unloading, vacuum truck loading/unloading, vehicular-induced fugitive dust, pumps, valves, flanges, etc , for all releases within the LTU The potential for reduced fugitive particulate emissions as a function of moisture or oil and grease content of exposed soil surfaces should be based on Figures 2-3 or 2-4, respectively. However, the applicant must commit to maintain these soil conditions on a long-term basis in order to obtain credit for these mitigative control conditions

Control performance should be estimated in the "no-migration" petition. It should be confirmed that no sources are inappropriately dismissed because the petitioner assumed 100 percent efficiency for controls, e g watering plots/roads

Routine (weekly) soil moisture and/or oil and grease content sampling from the unit and background conditions is recommended to confirm initial emission modeling/control assumptions. It should also include daily observations and documentation of visible dust emissions (especially during unit disturbance periods and high wind speed events) Appropriate soil sampling and analysis methods for this application are presented in the following references

- Hazardous Waste TSDF-Fugitive Particulate Matter Air Emissions Document, (Appendix D - Sampling and Analysis Procedures) U S. EPA, March 1989 (and subsequent versions as available)

- RCRA Facility Investigation Guidance, Section 7 - Waste and Unit Characterization, and Section 9 - Soil, U S EPA, May 1989a.

- Test Methods for Evaluating Solid Waste, U S EPA, November 1986.

Figure 2-3

WATERING CONTROL EFFECTIVENESS FOR UNPAVED TRAVEL SURFACES (U.S. EPA, SEPTEMBER 1988a)

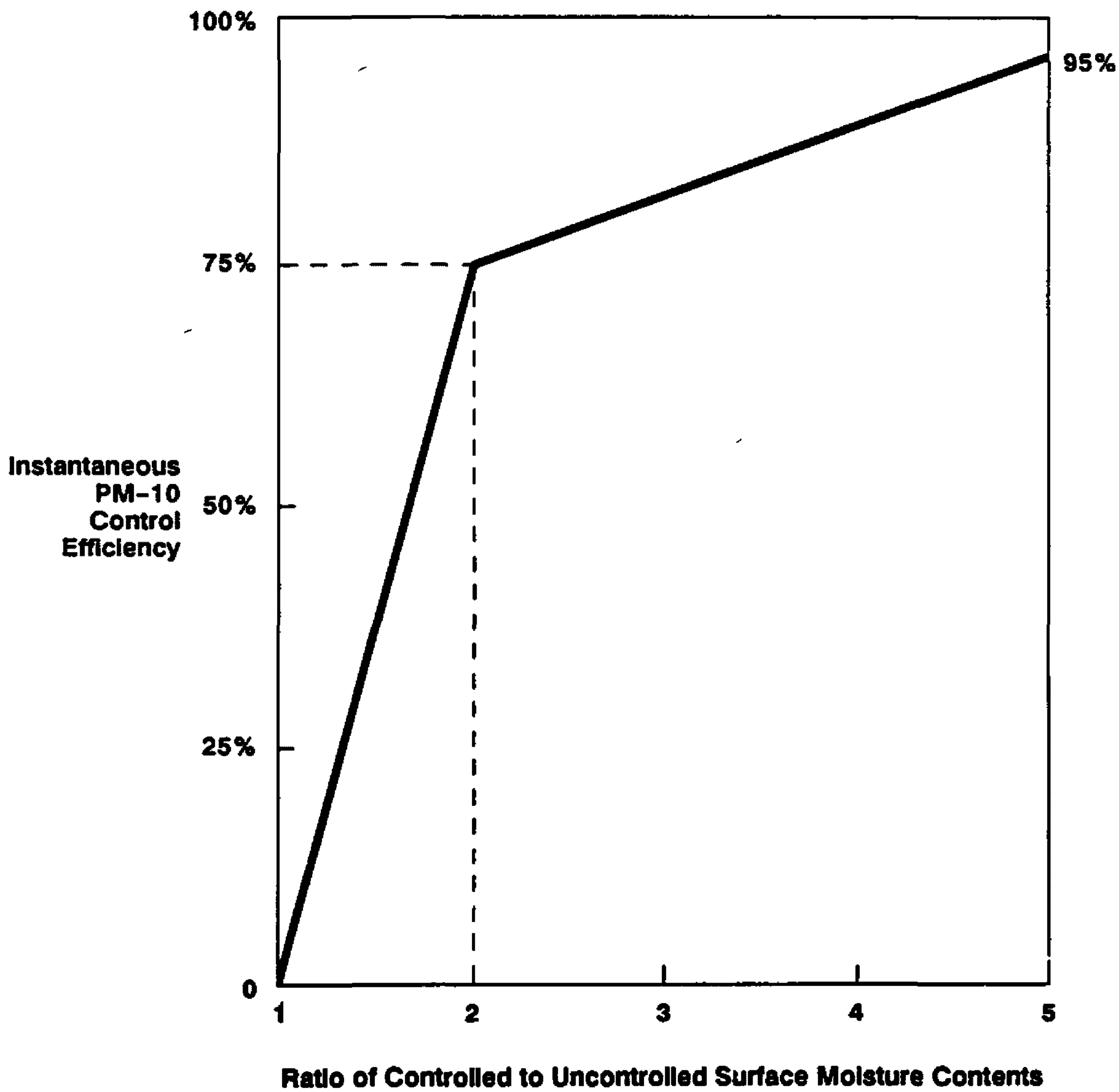


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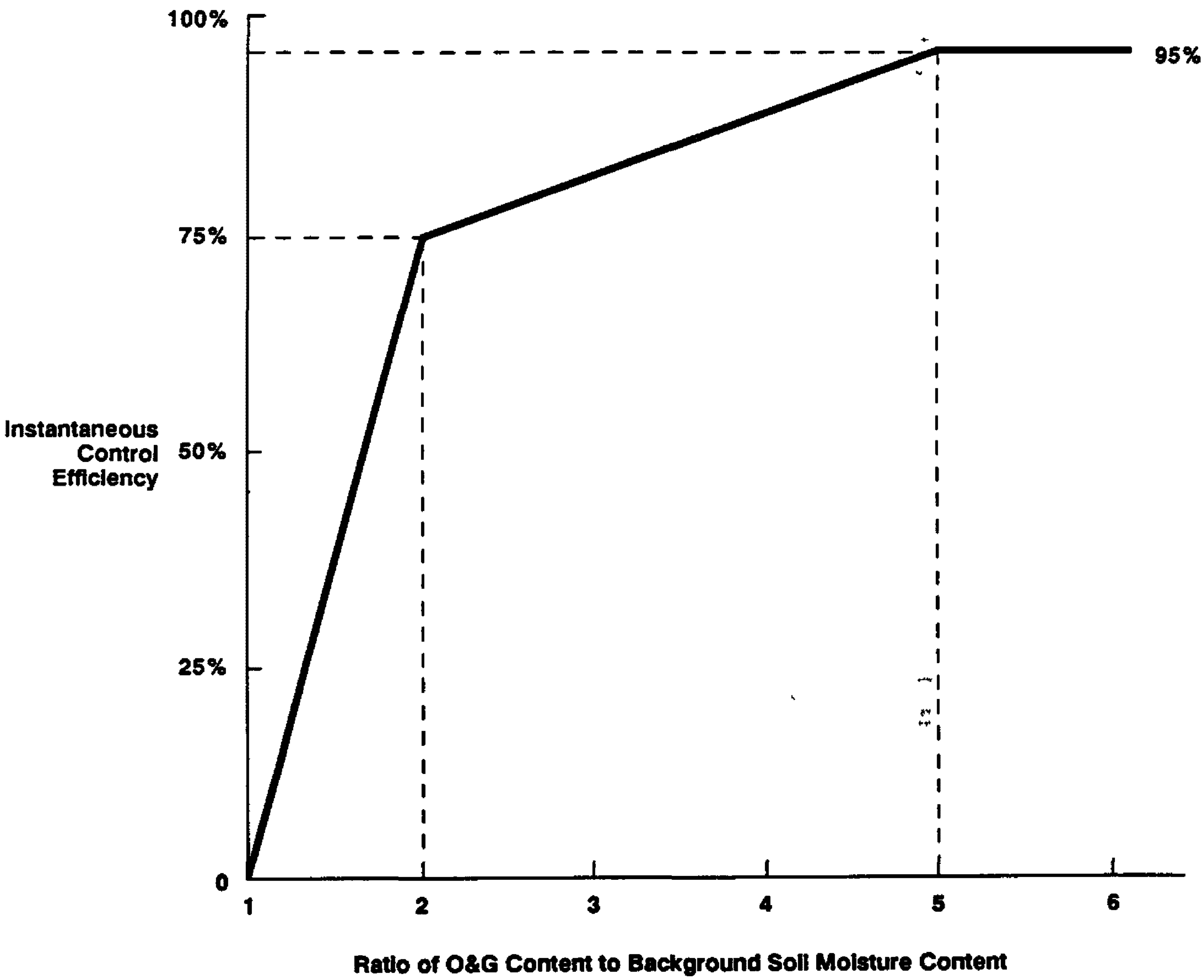
Figure 2-4

PROCEDURE FOR ESTIMATING CONTROL EFFICIENCY WITH OIL AND GREASE (O&G) CONTENT AND MOISTURE CONTENT MEASUREMENTS (U.S. EPA, MARCH 1989)



S12074-6

Vehicle travel from the land treatment unit to other locations of the facility could result in the "trackout" of contaminated soil This potential can be reduced by proper management of soil moisture conditions (in general, muddy soil conditions are not conducive to effective land treatment operations) Trackout can also be reduced by use of vehicles which are committed exclusively to the land treatment unit and by the use of routine washing of vehicles before they leave the unit "No-migration" demonstrations should address unit-specific preventive controls for potential trackout of contaminated soil and should estimate trackout rates

Wind erosion potential can be reduced by the revegetation of fallow areas and use of berms or shelter belts around the perimeter of the unit "No-migration" demonstrations should take appropriate credit for preventive wind erosion and soil erosion controls. Soil and wind erosion rates for "no-migration" demonstrations should include emission rate estimates with and without preventative emission controls

2.2.2 Dispersion Modeling

Emission rate values from Step 3 should be used as modeling input to calculate concentration estimates at or beyond the point of compliance. Two alternative types of models (i.e , flux models and dispersion models) are candidates for this application.

Flux models can be used to evaluate concentrations at and in the vicinity of an area source (Most disposal units such as land treatment areas, surface impoundments, and landfills can be classified as area sources) Although these models can be technically sophisticated, they generally lack extensive validation

Standard dispersion models used by EPA for regulatory applications are based on the assumption that the downwind concentration of air contaminants can be characterized by a statistical (Gaussian) distribution Validation efforts have confirmed the performance of this class of models Atmospheric dispersion models are typically accurate on a long-term basis within a factor of two to three for flat terrain sites (inaccuracy can be a factor of 10 or more in complex terrains) However, validation studies have been quite limited in regard to receptors near an area source boundary. However, dispersion model predictions for such situations are still considered more dependable than the use of flux models which have little, if any, validation

The use of the Industrial Source Complex (ISC) model is recommended as the preferred model for "no-migration" demonstrations The ISCLT version of the model can be used to calculate long-term concentrations for exposure periods ranging from 24 hours to annual average estimates. The ISCST model is generally used to estimate concentrations for averaging periods of 24-hours or less Selection of the ISCLT versus ISCST version of the model should be based on matching the averaging time for dispersion modeling with the specific exposure period for the applicable health criteria, including annual averages. The model can be used for both flat and rolling terrain, and for urban or rural conditions Petitioners that use urban dispersion coefficients need to provide documentation to support the use of this option, since the rural treatment will generally show higher concentrations. The ISC model software is available from NTIS and the user's guide is presented in Industrial Source Complex (ISC) Model User's Guide. (U S. EPA, December 1987b) Additional guidance on dispersion model selection and application is available in the Guideline on Air Quality Models (Revised). U.S. EPA, July 1986)

Meteorological data (i e., wind and atmospheric stability summaries) are necessary dispersion modeling input. Data from a representative National Weather Service station can be used as available but must be justified in terms of terrain, land/water interface, and other relevant factors It is preferable to evaluate five years of meteorological data and base "no-migration" estimates on the one-year period associated with the highest predicted concentration, as opposed to a five-year composite model run Alternatively, onsite meteorological data can be used If less than five years of meteorological data are available (as is frequently the case for on-site data) the available data should be compared to long-term offsite data to evaluate the representativeness of the data selected for modeling to estimate air concentrations during the worst-case year Guidance on the conduct of meteorological programs is presented in On-Site Meteorological Program Guidance for Regulatory Modeling Applications (U S EPA, 1987)

Land treatment units can be seasonal operations, especially for northern sites The modeling analyses should account for the seasonal variations in emission rates when there are substantial differences in application rates on a seasonal basis Since wastes are generally applied during the daytime, there is a diurnal factor, which also can be addressed Facilities where a waste stream(s) is applied once or several times a year need special consideration There is a major complication: (1) annual average concentrations could be heavily weighted by the specific conditions during the day of application Petitioners that model extreme emission rates will need to estimate annual average concentrations for a range of potential meteorological conditions that could occur during the day(s) of applications If restrictive meteorological conditions could result in exceedance of chronic health criteria, the maximum daily application rates may need to be reduced or conditions for application restricted.

Two alternative dispersion modeling approaches are available for "no-migration" demonstrations, as illustrated in Figure 2-5 The primary (required) approach involves the direct application of the ISC dispersion model based on site-specific and unit-specific input data. The alternative (optional) screening approach involves the application of modeling results available for a limited set of source and meteorological conditions This screening approach can be used to obtain preliminary, conservative modeling estimates Based on these results, the applicant may decide whether to consider waste treatment or proceed to refined modeling. The "no-migration" demonstrations, however, must be based on ISC. Following is a description of each of these approaches.

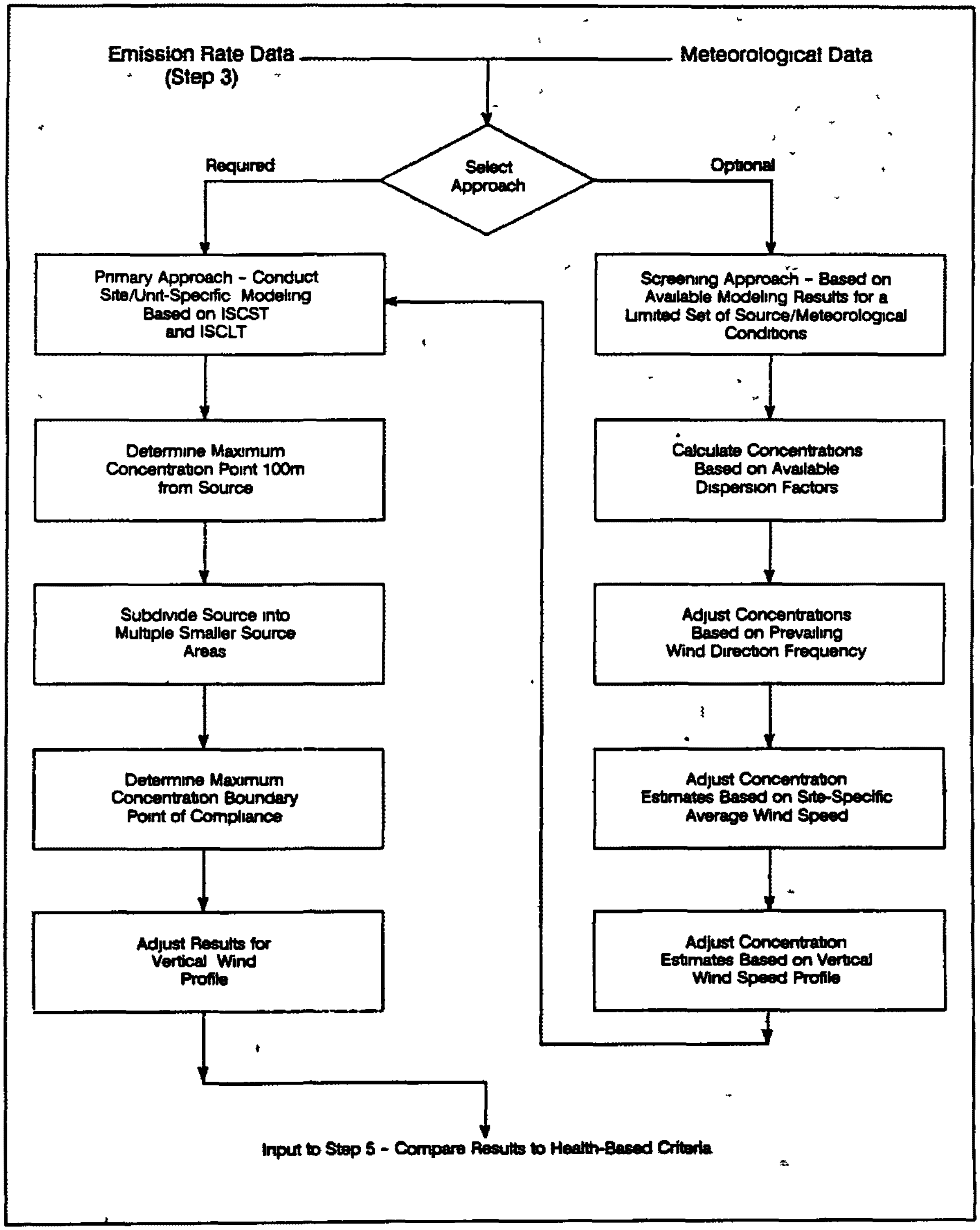
Primary Approach

The conduct of a dispersion modeling study based on site/unit-specific model input data is the required approach for "no-migration" demonstrations The air modeling analyses should be conducted separately for each land treatment unit to account for variations in unit size, configuration, and waste/operating conditions, however, modeled concentrations should consider contributions from all units at each modeled receptor. This refined modeling approach involves the direct use of the ISC dispersion model to provide estimates of concentrations The following tasks are required, as indicated in Figure 2-5:

- Determine the point of maximum concentration up to 100m beyond (outside) the point of compliance,
- Subdivide the source area into multiple smaller source areas,
- Determine the maximum concentration at or beyond the point of compliance (generally the maximum concentration will be at the unit, boundary), and
- Adjust modeling results, as necessary, to account for the vertical wind profile.

Figure 2-5

STEP 4 – CALCULATE CONCENTRATION ESTIMATES



S12074-3

Dispersion modeling estimates should be obtained that are representative of each land treatment unit A specialized modeling approach is generally needed for standard dispersion models, such as ISC, in order to obtain concentration estimates near the boundary of a large area source. This approach consists of the following tasks, assuming a ground-level area source.

- Determine the point of maximum concentration up to 100m outside the point of compliance using standard dispersion modeling methods. Concentration estimates should be obtained based on receptors placed in each of 16 sectors of 22.5 degrees each (a finer resolution is acceptable) in order to select the point of maximum concentration. A polar coordinate system should not be used These results will provide the basis to identify the sector associated with the maximum concentration.

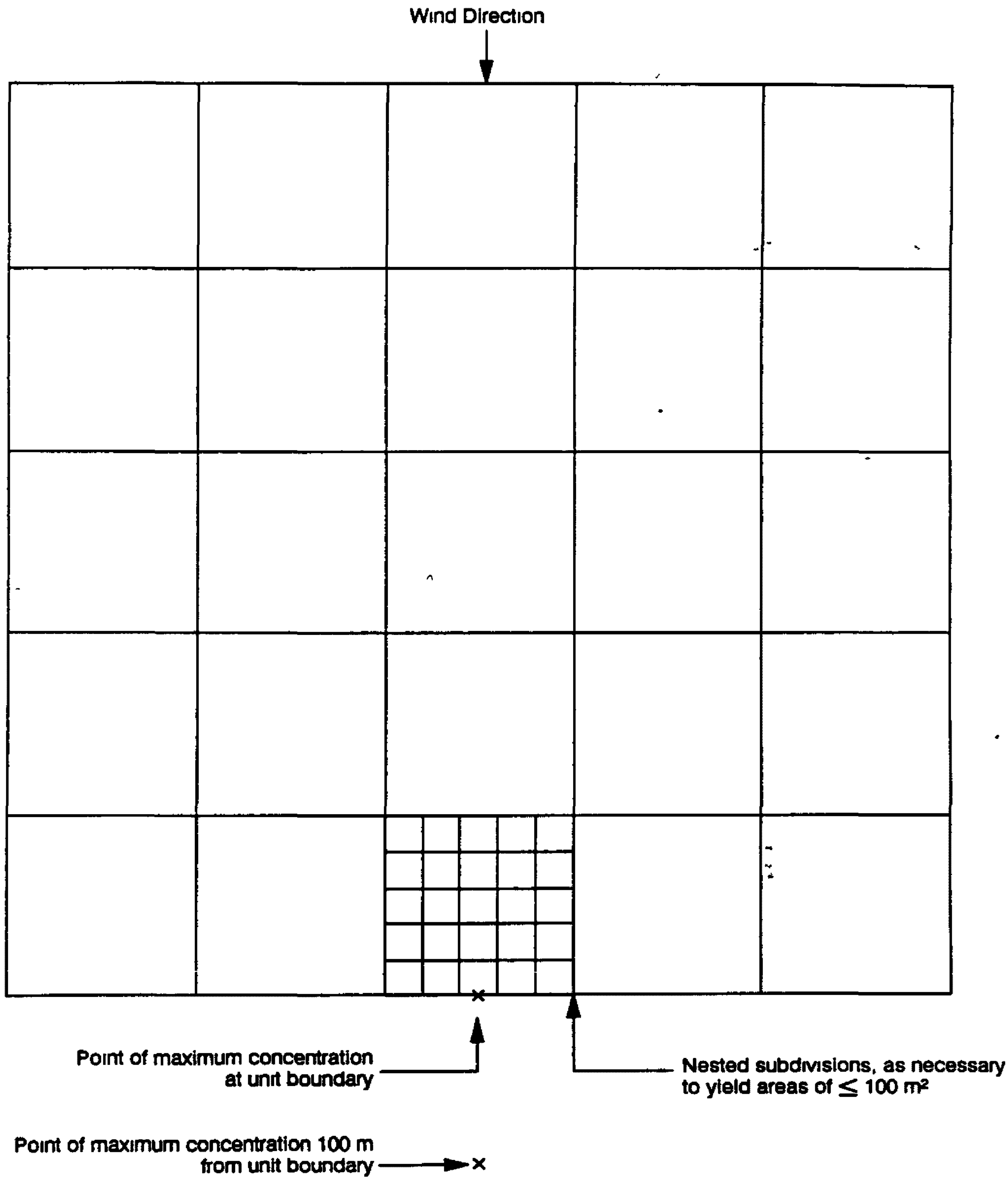
- Refine the area source grid to provide enhanced resolution near the area of maximum concentrations The goal is to confirm that the size of each area source is smaller than the distance from each area source to the closest model receptor (See Figure 2-6) Computational restraints of ISC require that area sources must be represented as a square or multiple squares. (The ISC user's guide should be consulted for the approach to use for irregularly shaped area sources) For "no-migration" demonstrations, it is recommended that the land disposal area should be represented initially by at least 25 squares of equal area

- Using the refined area sources, estimate the concentrations from the point of compliance out to at least 100m Contributions from all sources should be included (For modeling purposes, a downwind distance of approximately 1m from the point of compliance can be used for the closest receptors, as necessary) In most cases, the maximum concentrations and the point of compliance are at the LTU boundary, but not always Periods with minimal dispersion (stable conditions) can act to restrict plume growth to the extent that maximum concentrations at the reference height of 1 5m above ground level occur past the LTU boundary For this reason, the dispersion modeling approach requires modeling out to 100m past the site boundary

- Concentration estimates for "no-migration" demonstrations should be representative of the 1 5m inhalation height Meteorological data available for modeling studies often are based on a 10m tower height. Air concentrations are inversely proportional to wind speed. Near the surface, the mean wind speed has been found to increase in proportion to the logarithm of the height Therefore, wind speed values or modeling results should be adjusted, as necessary, to account for the vertical wind profile.

Figure 2-6

EXAMPLE SUBDIVISION OF AREA SOURCE



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Many standard dispersion models, such as ISC, extrapolate input wind data to a height of 10m for ground level sources. However, 1.5m winds are more representative for this application Example wind profile adjustment factors for "no-migration" demonstrations are presented in Table 2-1 based on the logarithmic wind profile law (U S EPA, 1974).

TABLE 2-1

EXAMPLE ADJUSTMENT FACTORS TO ACCOUNT FOR THE VERTICAL WIND SPEED PROFILE

Wind Speed Measurement Height X (m)	Wind Speed Adjustment Factor [Ratio of Wind Speed (1 5m) to Wind Speed (Height X)]	Concentration Adjustment Factor (CAF) [Ratio of Concentration (1.5m) to Concentration (Height X)]
20 0	0 7	1 5
15.0	0.7	1.4
10.0	0 7	1 4
5.0	0.8	1.2
2 0	0 9	1 1
1.5	1.0	1.0

-Assuming neutral stability and uniform roughness

Screening Approach

Screening dispersion modeling is an optional approach to obtain preliminary, conservative estimates of air concentrations The screening approach involves the manual calculation of concentration estimates based on adjusting dispersion modeling results available for a limited set of source/meteorological conditions Since these results may be less representative than those based on the refined modeling approach, conservative assumptions should be used. The following tasks are required for the screening modeling, as indicated in Figure 2-5

- Calculate concentration estimates at the unit boundary based on available dispersion factors;

- Assume an invariant wind direction,
- Adjust concentration estimates to account for the site-specific average wind speed,
- Adjust concentration estimates to account for the vertical wind profile; and
- Apply a safety factor to account for input data and modeling uncertainties.

This process can be summarized by the following equation:

$$C = ER \times DF \times UCF \times (WDF/100) \times (10/WS) \times CAF \times SF \qquad \text{(Eq 2-2)}$$

where

C	=	annual average concentration at unit boundary ($\mu g/m^3$);
ER	=	emission rate (10^6 g/yr = Mg/yr),
DF	=	dispersion factor for appropriate source area (sec/m^3),
UCF	=	unit conversion factor ($3\ 17 \times 10^4$),
WDF	=	frequency of occurrence of the prevailing wind direction (assumed to be invariant for screening application, i.e , WDF = 100 percent);
WS	=	average wind speed 1 5m above ground (mph),
CAF	=	concentration adjustment factor to account for the vertical wind profile (dimensionless), and
SF	=	Safety factor of 10 0 (to account for input and modeling uncertainties)

The product of ER times DF times UCF yields an initial concentration estimate The emission rate estimates from Step 3 should be used as ER values Dispersion factor (DF) values can be obtained from Table 2-2 as a function of source area. These DF values are based on ISCLT dispersion equations for a receptor on the downwind unit edge assuming a square area source configuration (with no subdivisions of the area), neutral stability, 10 mph winds at a measurement height of 10m and an invariant wind direction (i e , the receptor point for calculation purposes is directly downwind of the source 100 percent of the time).

This initial concentration estimate should be adjusted (using the parameters WS and CAF) to account for site-specific wind conditions Representative National Weather Service or onsite meteorological data should be used as the basis for these adjustments.

The modeling results presented in Table 2-2 are based on a 10 mph wind speed The average wind speed (WS) at the site should, therefore, be used to adjust these modeling results Similarly, a concentration adjustment factor (CAF) should be used to account for the vertical wind speed profile. Values of CAF are presented in Table 2-1 for a range of wind measurement heights to facilitate scaling concentration modeling results to represent a 1 5m inhalation exposure

An example application of this approach is illustrated in Section 3

2.3 Air Monitoring Methodology

For most "no-migration" variances, a monitoring program must be conducted to confirm that modeled concentrations conservatively represent LTU impacts, i.e. modeled concentrations should overestimate, not underestimate, actual concentrations (see Figure 2-7) The main objective of the ambient air quality monitoring program is to confirm that the modeling analysis is conservative, not to calibrate the model to site conditions. The monitoring program for the air pathway involves air quality monitoring (and optional emissions monitoring) conducted prior to the submission of the "no-migration" petition. (This may involve monitoring demonstration plots for new land treatment units.) The applicant is encouraged to submit a detailed monitoring plan prior to the execution of the field program to facilitate the completion of "no-migration" The air pathway assessment requirements are also applicable to petitions that include "no-migration" demonstrations for multiple units at the facility

Separate air monitoring programs for each unit are generally necessary. However, there is an exception to this requirement If the petition can demonstrate that a representative monitoring program can apply to other units having similar characteristics such as waste/soil, meteorological, topographic, air flow, and operating conditions, then only one representative program would be necessary

Prior to implementing an air monitoring program, a sensitivity analysis should be done that considers ranges in meteorological conditions and emissions for volatiles, semi-volatiles, and metals as a function of seasonal and operational factors.

TABLE 2-2

EXAMPLE UNIT BOUNDARY DISPERSION FACTOR VALUES

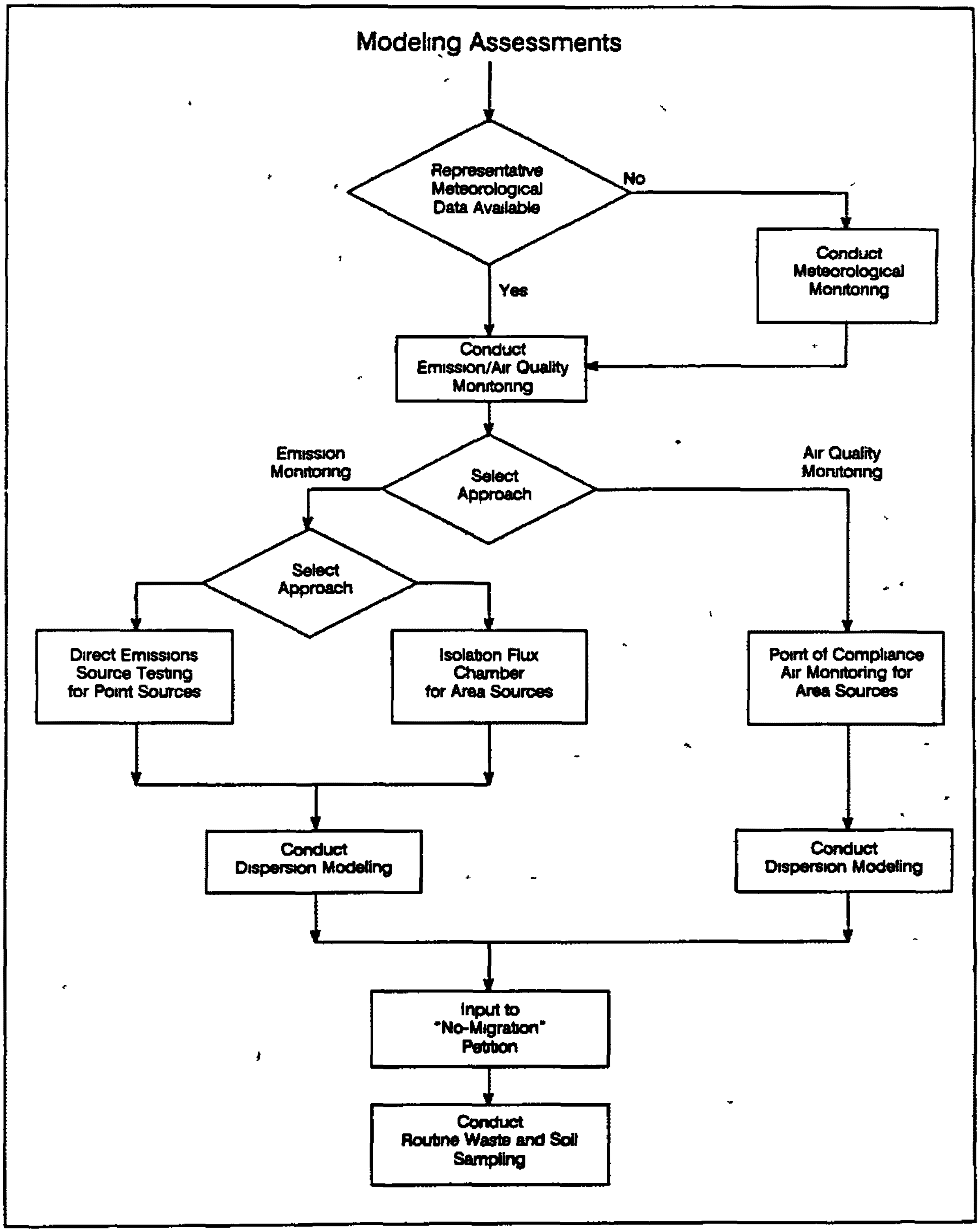
Unit Area (Hectares)	Dispersion Factors 1/ (sec/m^3)
0 01	3.9x10^{-3}
0 04	2 6x10^{-3}
0 25	8 9x10^{-4}
1 00	2 8x10^{-4}
4 00	7 9x10^{-5}
25 00	1 5x10^{-5}
100 00	4.3x10^{-6}
400 00	1 4x10^{-6}

1/ Based on ISCLT results with the following assumptions

- Ground-level area source (square configuration).
- Average wind speed of 10 mph at a measurement height of 10m (dispersion factors do not account for the expected lower wind speeds at 1 5m exposure height
- Invariant wind direction
- Dispersion factors are the maximum value at the unit boundary.

Figure 2-7

MONITORING METHODOLOGY - OVERVIEW



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These results, therefore, provide the basis for selection of the target season, preferred wind and temperature conditions, as well as optimal operating conditions (i e conditions to obtain worst-case concentrations) for conduct of the air monitoring program. Each pollutant class needs to be considered separately Criteria should be established based on sensitivity analyses to select specific periods that represent worst case conditions for each pollutant class Conditions that may be difficult to monitor or model and are not conducive to worst-case air concentrations (e g , snow cover, frozen ground or precipitation conditions at LTUs) do not support viable monitoring periods.

2.3.1 Monitoring Approaches

There are two major areas of uncertainty in modeling air quality emission rates and transport/dispersion Two monitoring strategies can be used to assess uncertainty in these areas: ambient air quality monitoring and emission flux monitoring. Ambient air quality monitoring is required in this methodology because it evaluates the overall adequacy of the modeled ambient concentrations, i e , the endpoint of analysis Ambient monitoring, therefore, can be used to evaluate the combined adequacy of emissions and dispersion/ transport

Emission Monitoring - Emission flux monitoring and direct emission sampling are suggested as options to enhance the comparison of modeled (an appropriate dispersion modeling methodology was presented in Section 2 2) and measured air quality data Direct emission sampling should be used for point sources (e g , vents at covered waste piles) Source testing via emission flux measurements can isolate the emission term To be effective, this option requires detailed planning and interpretation.

An isolation flux chamber may be used for gas-phase area source emission measurements (e g., land treatment areas). Multiple sampling locations are required to adequately characterize the spatial and temporal variability of emission conditions over an area source The spatial and temporal coverage recommended in U S EPA, February 1986, however, is not directly suited to the highly variable nature of emissions from land treatment, which are often characterized by high emission rates immediately after waste application, and then rapid decrease in emissions Alternative emission rate monitoring approaches may need to be considered for waste spreading operations. The petitioner needs to propose a sampling strategy that adapts this method to effectively estimate average emission rates within the LTU for the 24-hour periods of the monitoring program The spatial and temporal resolution in the emission flux monitoring needs to be sufficiently compatible with key emission terms in the dispersion modeling analysis in order to support model performance evaluation

The petitioner also should describe in the monitoring plan how the emission flux data will be interpreted to evaluate the performance of emission and dispersion modeling. A significant limitation of emission flux monitoring is that these techniques cannot be applied during spreading and tilling operations, which are conditions when peak concentrations often occur. Further guidance on the application of isolation flux chambers and the quality control procedures to be followed are provided in Measurement of Gaseous Emission Rates from Land Surfaces Using an Emission Isolation Flux Chamber: User's Guide. (U.S. EPA, February 1986)

A concept similar to flux monitoring is using a portable wind tunnel deployed in the field to estimate potential particulate emission rates due to wind erosion. But, either way, emission rate monitoring still requires the use of dispersion modeling to estimate air concentrations. However, emission rate monitoring in conjunction with air monitoring at the unit boundary may provide an enhanced basis to interpret modeling results In most cases, the preferred approach would be to conduct a representative ambient air quality monitoring program.

Ambient Monitoring - Air monitoring at the area of maximum concentration at or beyond point of compliance is the preferred approach for confirming modeled concentrations. This facilitates the direct comparison of measured and modeled air concentrations at or beyond the point of compliance However, for air modeling and monitoring purposes, EPA on a site-specific basis, may choose to modify the definition of the outer edge of the unit boundary where there is an inordinate distance separating the outer most point of waste placement and the outer edge of perimeter dikes or berms In other words, buffer zones will not be allowed to expand the unit boundary and the resultant point of compliance

The sampling approach for inhalable particulates, which is generally applicable to many trace metal constituent analyses, is well documented in the PM-10 regulations (40 CFR Part 50 - Appendix J and 40 CFR Part 58 - Appendix E) This approach is based on the use of a high-volume sampler. However, the potential for sample loss due to volatilization should be evaluated on a constituent-specific basis The inlet height for this sampler should be 1.5m above the ground surface. Analytical methods for trace metals in particulate samples generally include the application of Atomic Absorption, Inductively-Coupled Argon Plasmography, and Graphite Furnace Atomic Absorption. Additional information concerning the sampling and analysis of airborne trace metals is summarized in the following document

> "Toxic Trace Elements Associated With Airborne Particulate Matter A Review". (Schroeder, et.al., 1987).

Volatile organics are generally measured using EPA Method TO-14 (canister sampling and GC/MS analysis). Semi-volatiles are generally measured using EPA Method TO-13, i e PUF sampler. The EPA Compendium of Methods (U S EPA, April 1984, U.S EPA, September 1986; U.S EPA, June 1988) should be consulted for specific monitoring recommendations

2.3.2 Meteorological Monitoring

Representative meteorological data (preferably onsite) will be necessary to interpret air monitoring results and needs to be justified. Precipitation data that are representative of the site should be provided for seven days before air monitoring is conducted and for the duration of the ambient air quality monitoring program. After a precipitation event, air monitoring should not be conducted for at least 48 hours unless justified on a site-specific basis. The following documentation should be shown in the petition for onsite field programs

- Representative hourly averages are needed for wind speed, wind direction, stability, and ambient temperature,
- Calibration procedures need to be shown,
- The representativeness of meteorological data collected during the air quality field program need to be compared to long-term averages using offsite data sources, and
- The method used to estimate stability needs to be described

Recommendations on the conduct of meteorological programs are presented in On-Site Meteorological Program Guidance for Regulatory Modeling Applications (U S EPA, 1987)

Representative (preferably onsite) meteorological data also should be available as dispersion modeling input to calculate concentration estimates based on emission rate monitoring results

2.3.3 Pollutants to be Measured

Petitions do not have to include air monitoring data for those constituents that are modeled to have concentrations that are ten times less than the applicable health criteria. With the exception of benzene, the Agency intends to exclude constituents which are considered insignificant for the "no-migration" demonstration This exclusion does not apply to benzene because it is considered a critical constituent of "no-migration" demonstrations for the land application of refinery wastes The exclusion of benzene from the ambient air quality monitoring program will be considered on a case-by-case basis

Monitoring results for at least one indicator constituent for volatile organics, semi-volatiles and trace metals, should be used to confirm modeling results Monitoring results that are below the analytical detection limit for an indicator constituent should be considered as acceptable if appropriate standard sampling and analytical methods are properly used Long-term modeling results should not be adjusted for these situations.

2.3.4 Site Selection

The selection of appropriate monitoring locations is critical to ensure the measurement of maximum concentrations. There should be upwind (at least 1) and downwind (at least 2) coverage, and the monitoring program duration must be adequate to facilitate comparison of monitoring and modeling results for at least five days, with 24-hour sample duration for each. Additional recommendations for the conduct of air monitoring programs for gas phase and particulate constituents are presented in the interim final RCRA Facility Investigation Guidance (U.S EPA, May 1989a)

2.3.5 Sampling Duration

Monitoring should be conducted during a minimum of five sampling days of 24 hours each, which include worst-case emission/dispersion conditions Worst-case conditions provide the best potential to obtain conclusive monitoring results because of the higher concentrations expected relative to analytical detection limits The five days selected for monitoring do not have to be a sequential five-day block This approach provides greater flexibility for a petitioner to obtain air monitoring data during actual worst-case air concentration conditions. Petitioners have the option to use more than five monitoring days to compare monitoring versus modeling results for a larger data set The petitioner also can develop alternative approaches to use monitoring data to confirm modeling estimates in order to demonstrate "no-migration". If an alternative approach is used, the burden of proof is on the petitioner to present a comprehensive technical defense of the approach selected

2.3.6 Monitoring Requirements for New Units

The same submittal requirements discussed for existing units are applicable to new units. However, for new units, an air monitoring plan can be submitted in lieu of monitoring data "No-migration" variances for these new units will be granted on a conditional basis and subsequent performances of one-time monitoring program must confirm the modeling results presented in the petition to demonstrate "no-migration". The air monitoring program must be implemented within one year of initiation of new unit operations. The air monitoring program for new LTUs can be done concurrent with the land treatment demonstration If this option is selected, the LTD monitoring data must be submitted with the "no-migration" petition

2.3.7 Documentation of Field Programs

The description of Chain of Custody Procedures needs to indicate how samples are handled, stored, and transported. Furthermore, a detailed air quality monitoring program is of little value unless site conditions during the monitoring program are clearly described. The following is needed to adequately interpret the measured data set

- A site map is needed showing the locations of all active areas during each day of the field program (where waste is applied, stored, and transferred, etc);

- All activities should be shown for each day of the monitoring program, including application, disking, tilling, storage, vehicular-induced dust along access roads, etc. Activities should be described as a function of time and day;

- Waste application amounts and waste constituents, including physical characteristics, and soil characterization need to be described specific to the field test period, and

- Surface meteorological data (onsite or representative offsite data) needs to be submitted for a seven-day period preceding each monitoring day, and for the full monitoring period (wind speed/wind direction, precipitation, stability, relative humidity or dew point temperature).

2.3.8 Pretreatment Issues

Petitioners for LTUs that receive (or will receive) waste pretreated to lower volatile organic concentrations must adhere to the same submittal requirements (including providing air monitoring data) as discussed. Facilities that pretreat waste may have relatively low ambient concentrations associated with these waste streams This could lead to difficulty in quantifying ambient concentrations during an air quality monitoring program. It is especially important for these facilities that the following be considered in the monitoring program:

- Care should be taken to select sampling days that are conducive to high constituent concentrations, in order to improve the detectability in the ambient air of the constituents of the pretreated waste streams;

- The preferred approach is to follow routine operating procedures as closely as possible during the air monitoring program. The petitioner would have the option, however, to apply waste streams (that are routinely pretreated) without any treatment for the monitoring test periods, as necessary, to improve detectability in the ambient air. As part of this approach, credit for pretreatment to lower volatile organic constituent waste concentrations would need to be taken as an input parameter to support the "no-migration" demonstration. If this option is used, it would be essential for the differences in physical characteristics and pollutant concentrations in the treated and untreated waste to be clearly documented This would ensure that the credit for pretreatment is accurately computed, and

- Emission flux monitoring may be helpful to confirm emission rates for cases where ambient concentrations are below detection limits.

The option to apply untreated wastes and to scale modeling for documented treatment efficiency also would apply to facilities that currently apply untreated waste, but plan to treat waste in the future There would be no need to delay the implementation of an ambient air quality field program until treated wastes are routinely applied In all cases, however, routine waste stream sampling must be sufficient to demonstrate consistent and acceptable pretreatment efficiency

2.3.9 Presenting Monitoring Results

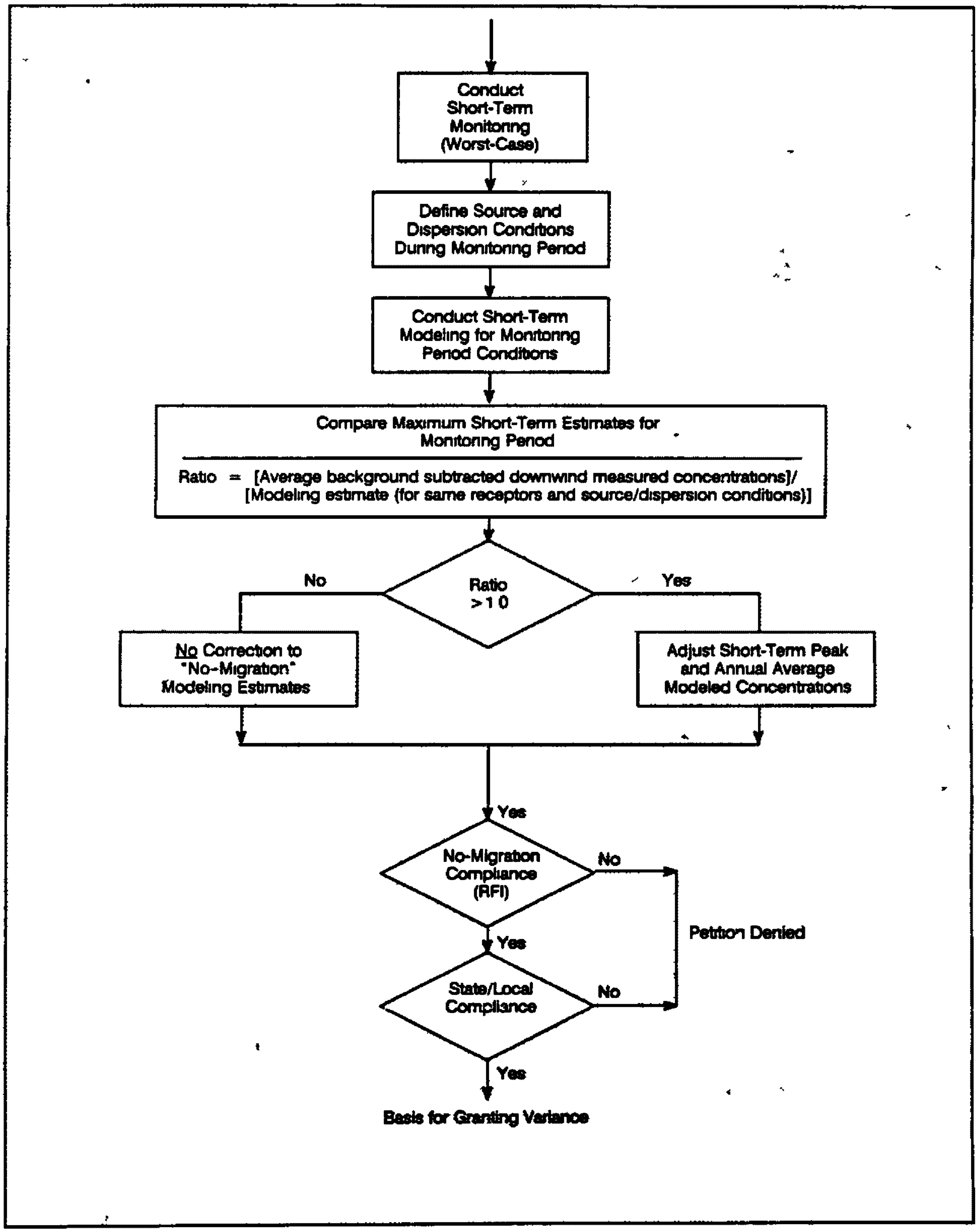
Monitoring results and quality control data should be submitted with the "no-migration" petition. For each sampling medium, a minimum of five sampling days of 24-hours each should be evaluated which include worst-case emission/dispersion events. Worst-case emission/dispersion events for particulate emissions may not necessarily coincide with worst-case conditions for gaseous emissions For example, worst-case LTU conditions for volatile organic constituent emissions will generally occur during the summer months (especially hot and dry conditions) at the time of application and spreading of the waste For this example the monitoring period should include at least one day of waste application/ spreading It would be preferable to monitor during several of these waste application/spreading events But the monitoring period should not include 24-hour samples beyond the fourth day after the last waste incorporation For particulate emissions, worst-case LTU conditions generally will occur during tilling operations subsequent to initial waste incorporation, and during dry and high wind-speed conditions which are conducive to wind erosion The monitoring period for particulates should include five days each with a high potential for particulate emissions.

2.3.10 Use of Measured Data

The use of monitoring data for "no-migration" demonstrations is summarized in Figure 2-8. The emissions and air monitoring data representative of worst-case, short-term conditions should be used to evaluate the accuracy of the modeling estimates developed to support the "no-migration" petition This should be accomplished by comparing short-term modeling and monitoring results for the same source and dispersion conditions that occurred during the monitoring period. This comparison should be the basis for developing a scale-up factor to adjust, as necessary, previous modeling estimates used to demonstrate "no-migration" compliance. Short-term versions of the emission and dispersion models should be used, as available, for these comparisons.

Figure 2-8

UTILIZATION OF MEASURED DATA FOR "NO-MIGRATION" DEMONSTRATIONS



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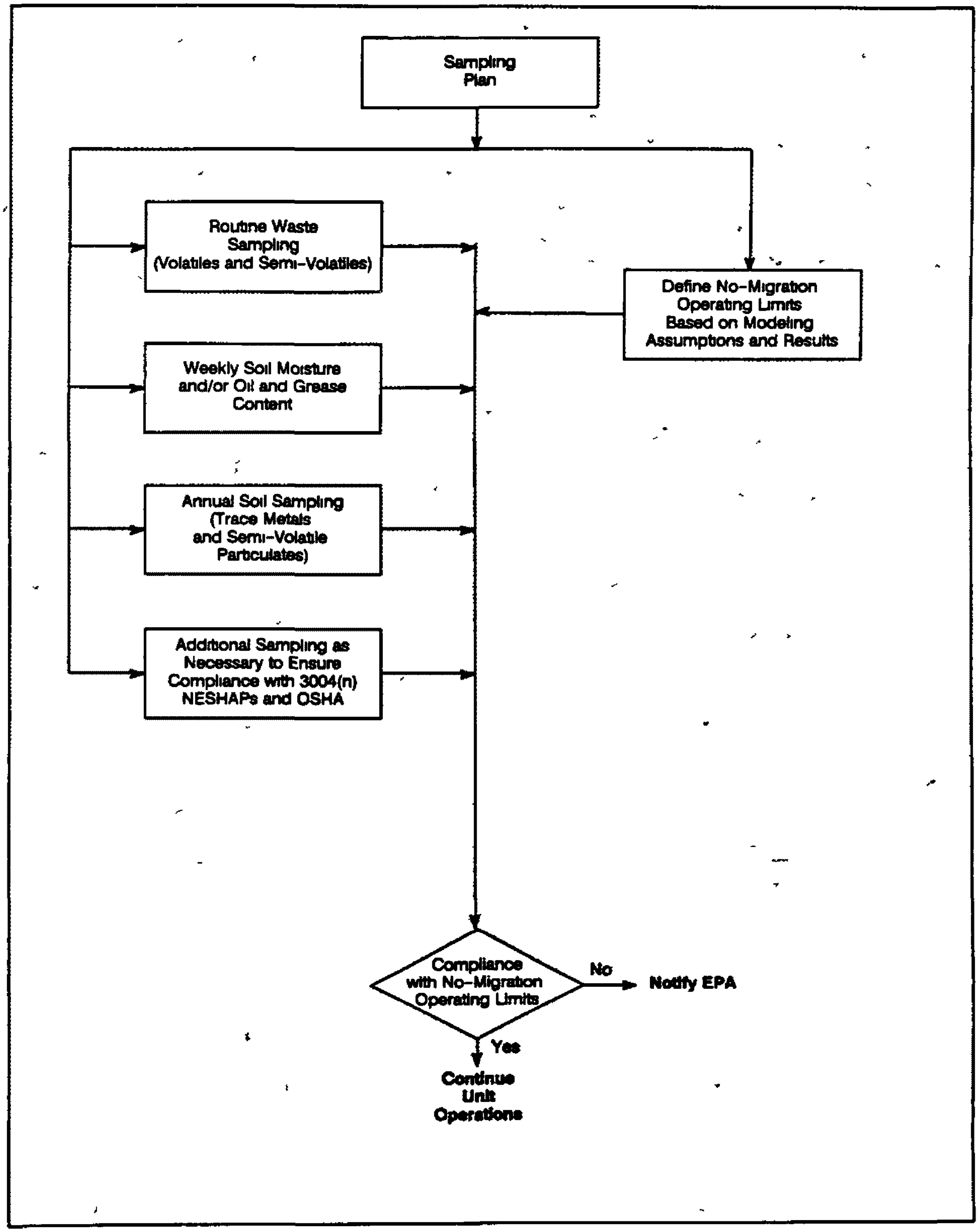
A ratio of the maximum monitoring estimates divided by the modeling estimates (which correspond to the same maximum monitoring locations and source/dispersion conditions) should be computed Constituent-specific ratios should be determined as feasible. Comparisons should be made for both emission rate monitoring (as available) and air monitoring results. If the average ratio, based on indicative pollutants in a class, is greater than 1, the maximum "no-migration" modeling estimates should be multiplied by the ratio to account for modeling under-predictions This would apply to either the emission flux or ambient air quality data The computed scale-up factors apply to all pollutants and averaging periods in the applicable pollutant class If the ratio is less than or equal to 1, the maximum "no-migration" results should not be adjusted. The revised modeling estimates should be evaluated for compliance with the "no-migration" criteria It should be noted that although worst-case monitoring conditions are used, exceedance of health based criteria during monitoring is not grounds for denial.

2.4 Routine Waste and Soil Sampling

Ambient air monitoring generally needs to be performed only once (i e. prior to submittal of the "no-migration" petition) to confirm air modeling results. Routine compliance monitoring for the air medium will typically consist of waste stream and soil sampling during operation of the unit to confirm that the constituent concentrations specified as operating limits in the petition are not being exceeded A plan for routine waste and soil sampling should be submitted with each "no-migration" petition. This plan should be implemented to determine on a continuing basis, compliance with "no-migration" conditions presented in the petition. A summary of this routine sampling process is presented in Figure 2-9.

Figure 2-9

ROUTINE WASTE AND SOIL SAMPLING PROGRAM



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The sampling plan should define specific "no-migration" operating limits. These operating limits should be based on the modeling analyses (assumptions and results) presented in the petition and should ensure compliance with all "no-migration" requirements and applicable 3004(n). These operating limits should include, at a minimum, the following factors

- Concentrations in zone of incorporation,
- Annual throughput quantity by volatile and semi-volatile constituents to ensure compliance with chronic health criteria for gaseous emissions;
- Weekly soil surface moisture and/or oil and grease content to ensure implementation of fugitive dust emission mitigative controls as assumed in the "no-migration" petition,
- Annual soil sampling (based on composite results for the zone of incorporation) to determine compliance with upper limit concentration assumptions for particulate trace metals and semi-volatiles;
- Daily documentation of visible dust emissions;
- Waste concentration limits, and
- Additional criteria as necessary to ensure compliance with 3004(n).

The comparison of modeled emissions and concentrations data should be used to establish peak short-term and average application rates. Peak and annual average application rates need to be presented based on limits set from the air quality analysis used for the "no-migration" demonstration

Appropriate sampling procedures are presented in the following references:

- Hazardous Waste TSDF - Fugitive Particulate Matter Air Emissions Document, (Appendix D - Sampling and Analysis Procedures), U.S. EPA, March 1989 (and subsequent versions as available),
- RCRA Facility Investigation Guidance, (Section 7 - Waste and Unit Characterization and Section 9 - Soil), U S EPA, May 1989a; and
- Test Methods for Evaluating Solid Waste, U S EPA, November 1986.

The unit owner/operator should notify EPA on a timely basis of non-compliance with "no-migration" operating limits

3.0 EXAMPLE APPLICATIONS

The following case studies have been selected to demonstrate the recommended air pathway assessment methodology for "no-migration" demonstrations These case studies present example modeling results and do not represent the example content of a "no-migration" petition for the air pathway (which should contain a much more detailed documentation of the analyses) Although not discussed in these examples, each case study would require the conduct of a monitoring program to evaluate modeling results (and to adjust for modeling under-prediction, as necessary) Routine waste and soil sampling during unit operations would also be necessary to assure compliance with "no-migration" criteria Two examples, a gas phase and particle phase example are presented in the following sections

3.1 Gas Phase Emissions - Example Assessment

The case study involves a "no-migration" petition for an existing land treatment unit and includes an example application of the six-step air pathway assessment process The following is a synopsis of the modeling assessment for the new unit.

Step 1 - Obtain Source Characterization Information

The following input information describes the proposed land treatment unit:

- Land area = 2.5 hectares (6 2 acres),
- Annual waste throughput = 1,800 Mg,
- Oil content of waste = 10 percent by weight;
- Silt content = 10 percent,
- Subsurface injection depth = 5 cm,
- Tilling depth = 20 cm,
- Soil air porosity = 0 5,
- Soil total porosity = 0 61,
- Average molecular weight = 282 g/g mol;
- Waste is applied 12 times per year (150 Mg/application) and tilled within 1 hour of application,

- Annual average wind speed = 10 mph, and
- Average Waste Constituents

Pollutant	**ppm**
Benzene	200
Toluene	750
Ethylbenzene	1500
Xylene	600

Step 2 - Select Release Constituents

Each of the four pollutants were covered by applicable health criteria Since the oil content is 10 percent of the waste, the constituent concentration in the oil is calculated as follows:

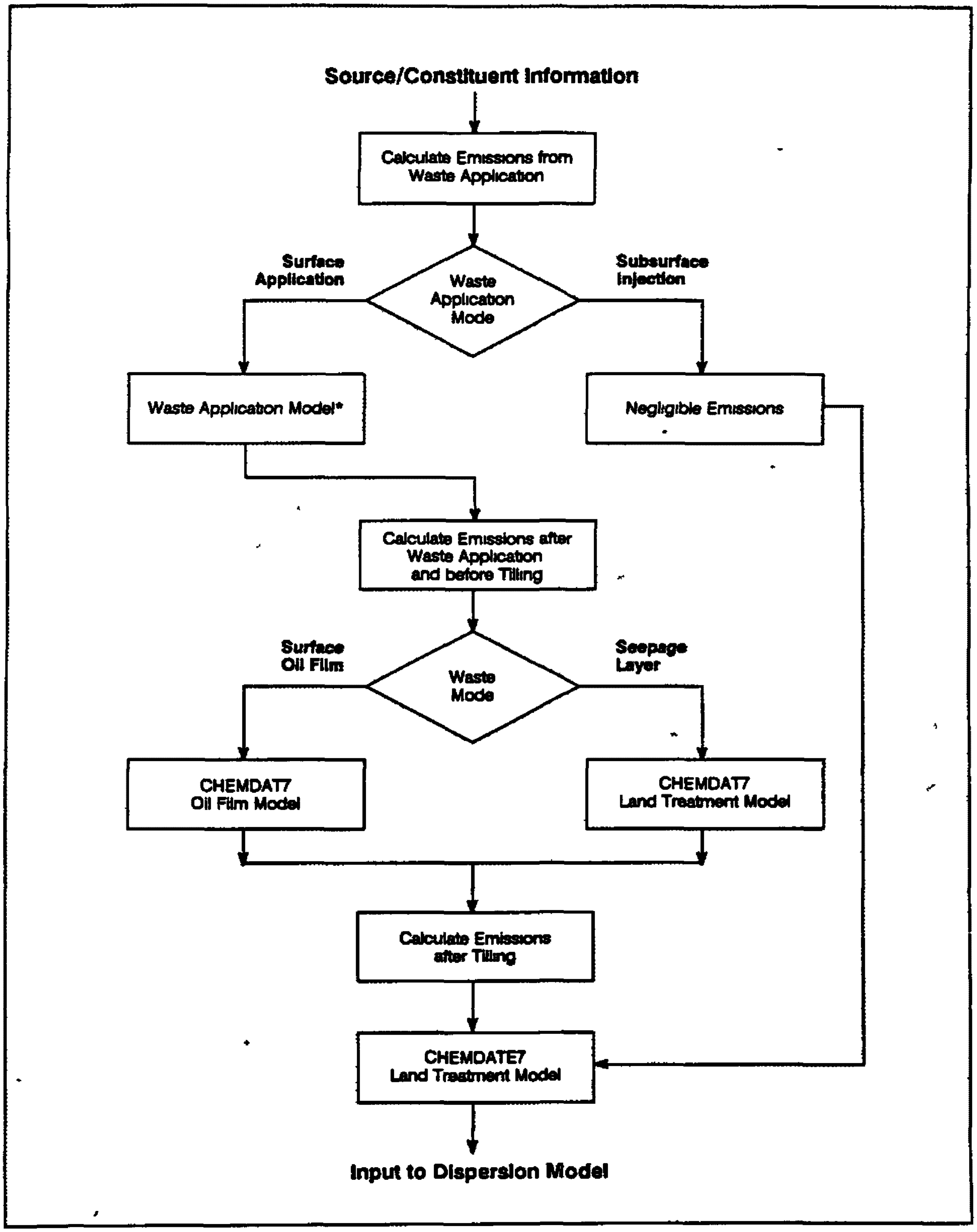
Pollutant	**Concentration in waste (ppm)**	**Concentration in oil (ppm)**
Benzene	200	2,000
Toluene	750	7,500
Ethylbenzene	1500	15,000
Xylene	600	6,000

Step 3 - Calculate Emission Estimates

The emission rate modeling process for land treatment units is summarized in Figure 3-1. Air emissions can occur during three stages (i e , during waste application, after waste application prior to tilling, and after tilling) The appropriate emission rate models are also a function of the type of waste application (i e., surface application or subsurface injection) as well as the fate of the oil for surface application operations prior to waste incorporation into the soil (i e , formation of a surface oil film, oil seepage through a layer of the soil, or the waste is immediately tilled into the soil). For this case study, it has been assumed that the unit will use subsurface injection (thus the emission rates during application are negligible) and tilling occurs immediately after injection Modeling results based on CHEMDAT7 for untreated waste are summarized below for the applicable pollutants For the annual estimates, the full 20 cm tilling depth was used

Figure 3-1

GASEOUS EMISSION RATE MODELING – LAND TREATMENT UNITS



* Equations presented in Hazardous Waste Treatment, Storage, and Disposal Facilities-Air Emissions Models (U S EPA December 1987)

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Pollutant	Annual Emission Rate (Mg/yr)
Benzene	[illegible]25
Toluene	[illegible]66
Ethylbenzene	1.931
Xylene	0.346

These results indicated that waste pretreatment was necessary in order to reduce the volatile organic constituent content necessary to comply with the RFI criteria for benzene. The revised emission rates based on 99 9 percent efficient treatment are as follows:

Pollutant	Annual Emission Rate (mg/yr)
Benzene	3.3×10^{-4}
Toluene	$6 7 \times 10^{-4}$
Ethylbenzene	1.9×10^{-3}
Xylene	3.5×10^{-4}

Step 4 - Calculate Concentration Estimates

The screening dispersion modeling approach was selected for this case study Actual petitions would also need to show the refined modeling analysis. Representative wind speed data were available from the National Weather Service The average wind speed is 10 mph (at a measurement height of 10m)

A maximum concentration representative of chronic exposure at the unit boundary was estimated as follows.

$$C = ER \times DF \times UCF \times (WDF/100) \times (10/WS) \times CAF \times SF \qquad (Eq. 3\text{-}1)$$

where:

- C = Annual average benzene concentration at the point of compliance ($\mu g/m^3$);
- ER = benzene annual average emission rate (computed to be $3 3 \times 10^{-4}$ Mg/yr after waste treatment),
- DF = dispersion factor for source area of 2 5 hectares based on Table 2-2 (interpolated value of 1.2×10^{-4} sec/m^3);
- UCF = unit conversion factor ($3 17 \times 10^{4}$),

WDF = frequency of occurrence of the wind direction (100 percent);

WS = annual average measured wind speed (10 mph),

SF = safety factor of 10.0; and

CAF = concentration adjustment factor from Table 2-1 to account for the lower wind speeds at the 1.5m receptor height compared to 10m wind measurement height (1.4)

Therefore

C = (0 00033) x (1 2x10^{-4}) x (3 17x10^{4}) x 100/100 x 10/10 x 1 4 x 10
= 0 02 $\mu g/m^3$ benzene,

C = (0 00067) x (1 2x10^{-4}) x (3 17x10^{4}) x 100/100 x 10/10 x 1.4 x 10
= 0 04 $\mu g/m^3$ toluene,

C = (0 00193) x (1.2x10^{-4}) x (3 17x10^{4}) x 100/100 x 10/10 x 1 4 x 10
= 0.10 $\mu g/m^3$ ethyl benzene, and

C = (0 00035) x (1 2x10^{-4}) x (3 17x10^{4}) x 100/100 x 10/10 x 1 4 x 10
= 0.02 $\mu g/m^3$ xylene.

CONCENTRATIONS $\mu g/m^3$

POLLUTANT	ANNUAL AVERAGE
Benzene	0 02
Toluene	0 04
Ethyl benzene	0 10
Xylene	0 02

Step 5 - Compare Matched Modeled Concentrations with Measure Data

This step would have been included had there been measured data provided in this example

Step 6 - Compare Concentration ($\mu g/m^3$) Results to Health-Based Criteria

POLLUTANT	RFI CRITERIA		
	CARCINOGENS	SYSTEMIC TOXICANTS	AVE. MODELED CONCENTRATION
Benzene	0 12	-	0.02
Toluene	-	-	0.04
Ethyl benzene	-	-	0 10
Xylene	-	-	0.02

For this example, pretreatment resulted in all criteria being met. If the criteria had not been met, either the magnitude of waste would need to be reduced during each application, or conditions for application be restricted to meet all applicable criteria based on this pretreatment efficiency.

[Note that in the No Migration proposed rule published in August 1992, EPA proposes that it will not routinely consider additive effects for either carcinogens or systemic toxicants, within a single medium or across two or more media. The Agency is soliciting comments on this approach. An earlier draft of this Air Pathway Assessment Methodology provided one approach to addressing possible additive effects of hazardous constituents within the air medium However, in this draft EPA has deleted consideration of possible additivity to be consistent with the Agency's current policy as proposed in the rule EPA nonetheless welcomes comments on the issue of additivity in decisions on individual no migration petitions and will give those comments careful consideration]

3.2 Fugitive Particulate Matter - Example Assessment

Fugitive particulate matter emissions were also characterized for the land treatment unit described in the example presented in Section 3 1. The following additional data are needed

Average Waste Constituents

Pollutant	ppm
Arsenic	3
Chromium	300
Cadmium	5

For the purpose of this example, assume that the preceding pollutant concentrations apply to all soil within the LTU.

Potential sources of particulate emissions from land treatment units include the following (see Figure 3-2)

- Waste application operations,
- Waste incorporation and cultivation operations,
- Wind erosion of exposed surface areas, and
- Track-out from vehicles

For this example, we will further assume that the petition shows that an efficient wash station is in place near the boundary of the LTU In this example, emission estimates are shown only for incorporation/cultivation operations, and vehicular travel on the LTU. Actual petitions would need to estimate emissions from waste application, incorporation/cultivation, wind erosion, and trackout, and then sum the predicted incremental impacts

The emission factors for incorporation and cultivation is as follows:

$$e = k(4.80)(s)^{0.6} \ lb/acre \qquad (Eq.\ 3\text{-}2)$$

where:

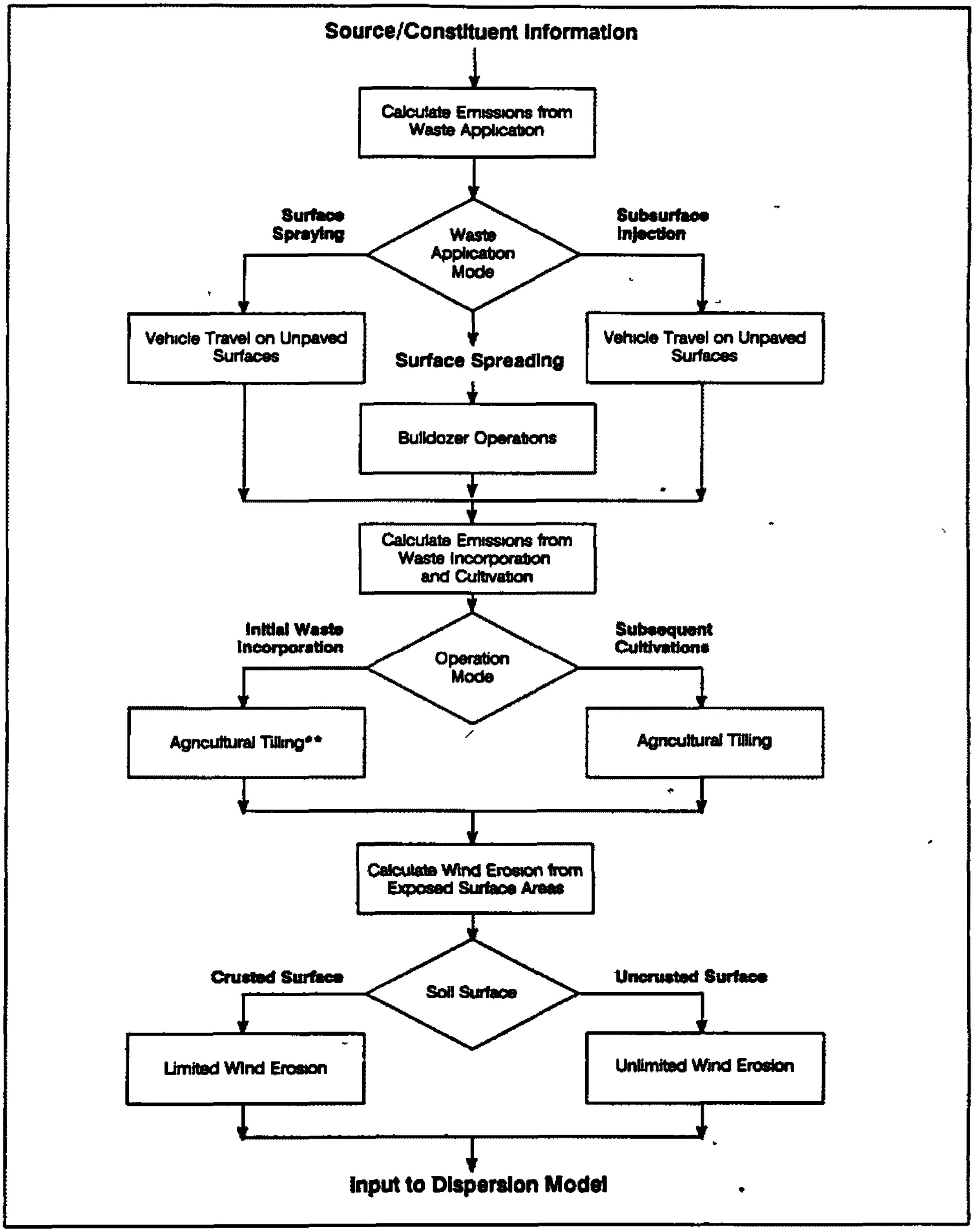
e = PM_{10} emission factor in lbs/yr;

k = particle size multiplier = 0 21 for PM_{10}, and

s = silt content of the disturbed surface material (%) = 10.

Figure 3-2

PARTICULATE EMISSION RATE MODELING – LAND TREATMENT UNITS*



* Emission factors are presented in Control of Open Fugitive Dust Sources (U S EPA, September 1988) Equipment track-out of particulates should also be evaluated

** Emissions generally negligible

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Further assume that application takes 1 hour and cultivation/tilling takes 1 hour per application Thus.

$$e = (0\ 21)(4.8)(10)^{0.6} = (4\ 01\ \text{lbs/acres})(6\ 2\ \text{acres}) = 24\ 9\ \text{lbs/yr}$$

The following additional data are needed when using the equation for delivery vehicle travel within the LTU:

$$e = 2\ 1\left(\frac{s}{12}\right)\left(\frac{S}{30}\right)\left(\frac{W}{3}\right)^{0\ 7}\left(\frac{w}{4}\right)^{0\ 5}\left(\frac{365 - p}{365}\right)\ lb/VMT \qquad (Eq\ \ 3\text{-}3)$$

where

e = PM_{10} emission factor in lbs/acre,

s = *silt content of road surface material, % = 10;*

S = mean vehicle speed, mi/hr = 5,

W = mean vehicle weight, ton = 8,

w = mean number of wheels (dimensionless) = 10,

p = number of days with precipitation greater than or equal to 0.01,

For this example, the term (365 - p/365) is dropped out because of the assumption that there was no application occurring during wet conditions.

VMT = vehicle miles traveled, the annual source extent = 100

For PM_{10}:

$$e = 2.1(10/12)(5/30)(8/3)^{0\ 7}(10/4)^{0\ 5}(100\ \text{miles}) = 91.6\ \text{lbs}$$

To calculate the arsenic emissions associated with the waste application, multiply the concentration of arsenic in the soil, i.e., 3 ppm, by the results of the two equations and sum as follows:

$E_{As} = (3/10^6)(24.9) + (3/10^6)(91.6) = 3.5x10^{-4}$ lbs of arsenic

$E_{Cr} = (300/10^6)(24.9) + (300/10^6)(91.6) = 3.5x10^{-2}$ lbs of chromium

$E_{Cd} = (5/10^6)(24.9) + (5/10^6)(91.6) = 5.8x10^{-4}$ lbs of cadmium

Assuming the ratio of oil and grease content/background soil moisture = 4, the control efficiency is estimated to be 85% based on Figure 2-4 Therefore, multiply total emissions by 0.15:

$E_{As} \times 0.15 = 5.2 \times 10^{-5}$ lbs/yr $= 2.4 \times 10^{-8}$ Mg/yr

$E_{Cr} \times 0.15 = 5.2 \times 10^{-3}$ lbs/yr $= 2.4 \times 10^{-6}$ Mg/yr

$E_{Cd} \times 0.15 = 8.7 \times 10^{-5}$ lbs/yr $= 4.0 \times 10^{-8}$ Mg/yr

Using Equation 3-1, the concentrations for these metals are estimated as follows:

$C = (2.4x10^{-8}) \times (1.2x10^{-4}) \times (3.17x10^{4}) \times 100/100 \times 10/10 \times 1.4 \times 10$

$= 1.3x10^{-6}\ \mu g/m^3$ arsenic

$C = (2.4x10^{-6}) \times (1.2x10^{-4}) \times (3.17x10^{4}) \times 100/100 \times 10/10 \times 1.4 \times 10$

$= 1.3x10^{-4}\ \mu g/m^3$ chromium

$C = (4.0x10^{-8}) \times (1.2x10^{-4}) \times (3.17x10^{4}) \times 100/100 \times 10/10 \times 1.4 \times 10$

$= 2.1x10^{-6}\ \mu g/m^3$ cadmium

Compare Concentration ($\mu g/m^3$) Results to Health-Based Criteria

METAL	RFI CRITERIA		
	CARCINOGEN TOXICANTS	SYSTEMIC	AVE MODELED CONCENTRATION
Arsenic	2.3×10^{-4}	-	1.3×10^{-6}
Chromium	4.5×10^{-4}	-	1.3×10^{-4}
Cadmium	8.5×10^{-5}	-	2.1×10^{-6}

In this example, chromium is approaching the RFI criteria for cancer On this basis, the routine sampling plan would need to confirm the assumed control efficiency of 85%

[Note that in the No Migration proposed rule published in August 1992, EPA proposes that it will not routinely consider additive effects for either carcinogens or systemic toxicants, within a single medium or across two or more media The Agency is soliciting comments on this approach An earlier draft of this Air Pathway Assessment Methodology provided one approach to addressing possible additive effects of hazardous constituents within the air medium However, in this draft EPA has deleted consideration of possible additivity to be consistent with the Agency's current policy as proposed in the rule EPA nonetheless welcomes comments on the issue of additivity in decisions on individual no migration petitions and will give those comments careful consideration.]

4.0 REFERENCES

Davis, C, et.al December 1987. "A Review of Sampling Methods for Polyaromatic Hydrocarbons in Air" The International Journal of the Air Pollution Control and Hazardous Waste Management, Vol 37, No. 12, Pittsburgh, PA , 15230.

Schroeder, W , et al , November 1987 "Toxic Trace Elements Associated with Airborne Particulate Matter· A Review" The International Journal of the Air Pollution Control and Hazardous Waste Management, Vol. 37, No 11, Pittsburgh, PA , 15230.

U.S EPA 1990. Supplement C Compilation of Air Pollutant Emission Factors, (AP-42). Office of Air Quality Planning and Standards Research Triangle Park, NC.

U.S EPA. July, 1990 User's Guide for land Treatment Compound Property Processor and Air Emissions Estimator (LAND7) U S Environmental Protection Agency, Chemical and Petroleum Branch, OAQPS, Research Triangle Park, NC

U.S EPA. May 1989a. RCRA Facility Investigation Guidance, (interim final) EPA-530/SW-89-031 Office of Solid Waste Washington, D C 20460.

U.S EPA May 1989b Air Release Screening Assessment Methodology, Office of Solid Waste Washington, D C 20460

U.S. EPA March 1989 Hazardous Waste TSDF - Fugitive Particulate Matter Air Emissions Guidance Document (Review Draft) EPA-450/3-89-019. Office of Air Quality Planning and Standards Research Triangle Park NC

U S EPA. September 1988a Control of Open Fugitive Dust Sources, EPA 450/3-88-008. Office of Air Quality Planning and Standards Research Triangle Park, NC 27711.

U S EPA September 1988b Supplement B Compilation of Air Pollutant Emission Factors, (AP-42). PB89-128631 Office of Air Quality Planning and Standards Research Triangle Park, NC.

U S EPA June 1988. Second Supplement to Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air Office of Research and Development, Research Triangle Park, NC.

U.S. EPA. 1987 On-Site Meteorological Program Guidance for Regulatory Modeling Applications. EPA-450/4-87-013 Office of Air Quality Planning and Standards. Research Triangle Park, NC 27711.

U S EPA. December 1987a. Hazardous Waste Treatment Storage and Disposal Facilities (TSDF) Air Emission Models) EPA-450/3-87- 026 Office of Air Quality Planning and Standards Research Triangle Park, NC 27711.

U.S. EPA. December 1987b Industrial Source Complex (ISC) Model User's Guide-Second Edition. EPA-450/4-88-002a and b Office of Air Quality Planning and Standards Research Triangle Park, NC 27711

U S EPA November 1986 Test Methods for Evaluating Solid Waste (SW-846), Office of Solid Waste, Washington, DC 20460

U S EPA September 1986 First Supplement to Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. EPA-600/4-87-006 Office of Research and Development Research Triangle Park, NC

U S EPA February 1986 Measurement of Gaseous Emission Rates from Land Surfaces Using an Emission Isolation Flux Chamber User's Guide EPA/600/8-86/008. NTIS PB 86-223161 Environmental Monitoring Systems Laboratory. Las Vegas, NV 89114

U S. EPA July 1986 Guideline on Air Quality Models (Revised). EPA-450/2-78 027R. NTIS PB 86-245248 Office of Air Quality Planning and Standards Research Triangle Park, NC 27711.

U S EPA. September 1985 Compilation of Air Pollutant Emission Factors, (AP-42) Office of Air Quality Planning and Standards Research Triangle Park, NC.

U.S EPA. April 1984 Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air EPA-600/4-84-041. Office of Research and Development Research Triangle Park, NC.

U S EPA 1974 Development of Emission Factors for Fugitive Dust Sources Office of Air Quality Planning and Standards Research Triangle Park, NC 27711