ADDRESSING JUSTIFIABLE NIMBY: A PRESCRIPTION FOR MSW MANAGEMENT

Published as: Lee, G. F. and Jones-Lee, A., "Addressing Justifiable NIMBY: A Prescription for MSW Management," Environmental Management Review, Government Institutes, Rockville, MD, No. 31, First Quarter, pp 115-138 (1994).

G. Fred Lee, Ph.D.
President
Anne Jones-Lee, Ph.D.
Vice-President
G. Fred Lee & Associates
El Macero, California

Dr. G. Fred Lee is president and Dr. Anne Jones-Lee is vice-president of G. Fred Lee & Associates, an environmental consulting firm located in El Macero, California.

Drs. Lee and Jones-Lee have worked together as a team since the mid-1970's. They have high degrees of expertise and many years' experience in aquatic chemistry, aquatic toxicology/biology, public health, and environmental engineering and sciences. Their areas of specialization include evaluating the water quality and public significance of chemical contaminants in water (surface freshwater, groundwater, coastal marine water), soils, sediments, and wastes, and Superfund site investigation and remediation.

Dr. Lee has conducted over $5 million in research on various aspects of water quality and solid and hazardous waste management. He has published more than 550 papers and reports on his work, and has served as an advisor to numerous governmental agencies and industries in the U.S. and other countries on water supply, water quality, water and wastewater treatment, water pollution control, and solid and hazardous waste management.

For 30 years Dr. Lee held university graduate-level teaching and research positions at the Universities of Wisconsin and Texas, Colorado State University, and New Jersey Institute of Technology. He retired from university teaching as a Distinguished Professor of Civil and Environmental Engineering in July 1989.

Dr. Jones-Lee held university faculty professions at several universities for an 11-year period; most recently she was Associate Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology.

Dr. Lee holds a Ph.D. degree form Harvard University in environmental engineering and environmental sciences and a Master of Science in public health degree from the University of North Carolina. He obtained a Bachelor's degree from San Jose State University. Dr. Lee is a registered professional engineer in Texas and a Diplomate in the American Academy of Environmental Engineers. He is also Chief AAEE examiner for the Sacramento area of the state.

Dr. Jones-Lee holds a Ph.D. from the University of Texas at Dallas in environmental sciences with emphasis in aquatic chemistry and aquatic toxicology. She earned her Bachelor of Science degree in biology from Southern Methodist University.

Addressing Justifiable NIMBY: A Prescription for MSW Management

G. Fred Lee, Ph.D., P.E., D.E.E., President
Anne Jones-Lee, Ph.D. Vice President
G. Fred Lee & Associates
El Macero, CA
https://www.gfredlee.com

Municipal solid wastes (MSW) are principally generated in urban areas yet they are typically disposed of by landfilling in rural areas. On October 9, 1991, the US EPA adopted Subtitle D landfill regulations that specify as a minimum a single composite lined and covered landfill that is designed to try to keep leachate (garbage juice) that will be generated when moisture enters the solid wastes from polluting groundwaters in the vicinity of the landfill. The adoption of this approach represents a significantly different approach for managing municipal solid waste than has been followed in the past with the classical unlined sanitary landfills. In this approach, an attempt is made to create a "dry tomb" for waste isolation from the environment.

The US EPA stated in the October 9, 1991 Federal Register, which sets forth the Subtitle D regulations, that one of the benefits of these regulations is that they should make the siting of new landfills more readily achievable. The Preamble to these regulations states under "Other Benefits,"

> *"First, EPA believes that the promulgation of federal municipal solid waste landfill criteria will increase public confidence that landfills are designed to protect human health and the environment. EPA believes that this increased confidence will reduce opposition to landfills and make the siting of new landfills less difficult."*

The Subtitle D regulations, in which the "dry tomb" landfilling approach is adopted, only address groundwater quality protection for a short period of time compared to the time that the waste will represent a threat to groundwater quality; at best, the liners system specified in these regulations will only postpone groundwater pollution, it will not prevent it (See Lee and Jones, 1991a). Therefore, contrary to the US EPA statements about the benefits of the new regulations, they will not in any significant way, and should not, affect public opposition to a proposed landfill in their vicinity. If anyone believes otherwise, they should do informal polls among residential areas in typical suburbia, US to inquire as to whether the residents of the area would object to having a US EPA-approved "dry tomb" landfill sited within their area.

The US EPA, in adopting these regulations took a very short term approach that was designed to try to meet the immediate solid waste capacity crisis that exists in many parts of the US. Unfortunately, the proposed regulations do not address the

long term consequences of the "dry tomb" landfilling approach to groundwater quality of inevitable pollution by landfill leachate. As discussed by Lee and Jones (1993) and Lee and Jones-Lee (1993f), the "dry tomb" landfill approach is a flawed technology if there is interest in protection of groundwater quality for those landfills sited at locations where landfill leachate can be transported via groundwaters to areas where the groundwaters are used for domestic water supply purposes.

The flawed technology of the "dry tomb" landfilling approach was recognized by the US EPA which, in 1988, as part of the then proposed Subtitle D regulations, stated,

> *"First, even the best liner and leachate collection system will ultimately fail due to natural deterioration, and recent improvements in MSWLF (municipal solid waste landfill) containment technologies suggest that releases may be delayed by many decades at some landfills."* (US EPA Solid Waste Disposal Criteria, August 30, 1988) (US EPA, 1988a)
>
> * * *
>
> *"Once the unit is closed, the bottom layer of the landfill will deteriorate over time and, consequently, will not prevent leachate transport out of the unit."* (US EPA Criteria for Municipal Solid Waste Landfills) (US EPA, 1988b)

Since the publication of those statements, a number of individuals and groups have reviewed the actual and expected performance of the liners and covers typically used in "dry tomb" landfills today. As discussed by Lee and Jones (1993), it is appropriate to conclude from the literature and the properties of compacted soil-clay liners and plastic sheeting used in FML liners that these materials will not provide protection of groundwater quality for as long as municipal solid wastes represent a threat to it. There is no technical justification for the US EPA to now assert that the "dry tomb" landfilling approach advocated in the October 9, 1991 Federal Register will be protective of groundwater quality. The US EPA's adoption of this approach appears to be motivated by political expediency, where the short term economic interests of those who own property or reside outside of the influence of the landfills (the primary solid waste generators) took precedence over the interests of those who could be adversely affected by a "dry tomb" landfill. Obviously, such short term approaches will do little to justifiably address the NIMBY (not in my backyard) concerns about siting a landfill in their area.

Flaws in "Dry Tomb" Landfilling Approach for Protection of Groundwater Quality

A review of the actual and expected performance of compacted soil-clay and plastic sheeting (flexible membrane liners (FMLs)) used today to cover and line "dry tomb" landfills shows that, at best, the "dry tomb" approach for municipal solid waste management only postpones groundwater pollution, since the liners either have finite

permeabilities (for soil-clay liners) or have holes in them at the time that they are put into service for FMLs and their liner performance will deteriorate over time, eventually becoming essentially nonfunctional in preventing leachate migration to groundwater. Municipal solid waste components will be a threat to groundwater quality forever. As discussed by Jones-Lee and Lee (1993), municipal solid wastes contain a wide variety of inorganic (salts and heavy metals), nondegradable organic and degradable organic residues that will be present in the landfill forever, i.e., as long as it exists, and will be leachable-dissolve on contact with water, creating a leachate of which small amounts have the potential of polluting large amounts of groundwater, rendering it unusable for domestic water supply use. Upon examination of the characteristics of municipal solid waste leachates and the physical, chemical and biological processes that can take place within municipal solid waste landfills, it is obvious that such landfills will be a threat to groundwater quality forever. Therefore, in order for the "dry tomb" landfill approach to be protective of groundwater quality, the landfill cover and liners must work perfectly forever. In the case of the liners, since they are often buried under hundreds of feet of garbage, there is no possibility of inspection or repair of them. It is therefore obvious that the "dry tomb" landfilling approach is a flawed technology that will not protect groundwater quality.

Groundwater Quality Protection Performance Standards

Typically, federal and state landfill regulations have explicitly stated performance standards that require the protection of groundwater quality for as long as the solid waste components represent a threat. For example, the US EPA claims in the October 9, 1991 Federal Register,

> *"These Subtitle D Criteria establish minimum national performance standards necessary to ensure that 'no reasonable probability of adverse effects on health or the environment' will result from solid waste disposal facilities or practices."*

While there are no time limitations set forth on this level of performance for Subtitle D landfills, it is reasonable to expect that this performance should be achieved for as long as the wastes represent a threat. However, the US EPA in its economic analysis associated with Subtitle D landfills assumes that 30 years of post-closure care of the landfill is all that is needed to protect public health and groundwater quality. The cost of the 30 year post-closure care used by the US EPA to estimate the cost of implementation of new regulations represents an infinitesimally small part of the true costs of post-closure care for "dry tomb" landfills if groundwater quality protection is to be achieved at most locations where such landfills will be sited. Basically, what the US EPA has done with these regulations is to pass the burden of post-closure care and the consequences of liner system failure to achieve fail-safe post-closure care on to future generations, thereby enabling this generation to experience cheaper than real cost garbage disposal.

The state of California regulations governing the landfilling of municipal solid wastes are set forth in the Water Resources Control Board's Chapter 15. These regulations establish three types of landfills. Class I covers those wastes that are classified as "hazardous" under US EPA RCRA (Resource Conservation Recovery Act) and California Department of Health Services Title 22 regulations. Class II landfills typically take municipal solid wastes and special-designated wastes. Class II landfills have as a performance standard no leakage of waste components to the underlying geologic material, i.e., the liners, if used, must prevent leachate migration through them. Class III landfills are used for municipal solid wastes. The performance standard for these landfills is that the waste components shall not impair the use of groundwaters for domestic or other purposes. While the federal regulations set forth in RCRA focus on the so-called hazardous chemicals, such as the Priority Pollutants, the California regulations consider all potential impacts of contaminants on beneficial uses of water, whether the chemical is classified as hazardous or not. Adverse impacts include aesthetic quality - tastes and odors - and economic impacts, such as shortening hot water heater usable life due to scale formation associated with high hardness waters. Chapter 15 regulations explicitly state that the performance standards shall be achieved for as long as the wastes represent a threat to groundwater quality.

The US EPA Subtitle D regulations, as well as many state regulations governing "dry tomb" landfills, specify a minimum liner and cover system design that is to be used in implementing the regulations. It is frequently asserted by landfill applicants and consultants working on their behalf that such a specified minimum liner system design represents the equivalent of the groundwater protection performance standard set forth in the regulations. While some regulations, such as the US EPA Subtitle D regulations, are nebulous on this point, others, such as California's Chapter 15, are explicit in mandating that engineered systems of liners that may be used at geologically unsuitable sites, i.e., where groundwater pollution is possible, must achieve the groundwater protection performance standard set forth in the regulations. The liner systems specified as the minimum that might be suitable at some site are not considered to be applicable at all sites in achieving the groundwater quality protection standard.

Unfortunately however, some regulatory boards/agencies allow the permitting of "dry tomb" landfills that use liner systems with materials that will obviously not meet the groundwater quality protection performance standards set forth in the regulations. Even double composite liners of the type being used today will obviously not achieve this level of performance. This approach then tends to give some unjustified credibility to misinterpreting the regulations, where what is obviously an inadequately engineered liner system cannot provide true groundwater quality protection for as long as the wastes represent a threat as specified in the regulations. So long as these highly inappropriate approaches exist, "dry tomb" landfills will continue to be used where the public will justifiably oppose their siting in their area

based on the fact that the engineered liner-cover system will not achieve the groundwater protection performance standards of the regulations.

Adverse Impacts of "Dry Tomb" Landfills on Adjacent/Nearby Property Owners/Users

While the US EPA has stated that one of the benefits of these regulations will be reduced opposition to siting landfills, in fact, the agency has made a very serious error in asserting that there will be less opposition because of the adoption of these regulations. As discussed by Lee and Jones-Lee (1993b,e), there is a wide variety of justifiable reasons for opposing landfills in the vicinity of a property, residence or workplace. These include,

- public health, economic and aesthetic aspects of groundwater and surface water quality
- methane and VOC migration - public health hazards, explosions and toxicity to plants
- illegal roadside dumping and litter near landfill
- truck traffic
- noise
- dust and wind-blown litter
- odors
- vectors, insects, rodents, birds
- condemnation of adjacent property for future land uses
- decrease in property values
- impaired view

Many of the problems associated with landfills listed above, are related to problems during the active life of the landfill. As discussed by Lee and Jones-Lee (1993e), such problems can be addressed if an adequate land buffer exists between the landfill site and adjacent property owners' lands. Typically, very limited land buffer areas are provided for at landfills, with the result that those who own or use lands next to a landfill find that their use and enjoyment of these lands is impaired because of it. Rather than having a few hundred yard-wide land buffer around the landfill, any proposed landfill should have at least a mile or more of land between the

active sites of the landfill and adjacent property owners' lands. It may be possible in some terrains to have smaller land buffers than one mile. Even with a one mile land buffer, there will still be adverse impacts of a landfill on adjacent property owners/users through truck traffic, illegal dumping, etc. It is felt that anyone owning property within two miles of a proposed landfill should be given the option of selling their property at at least the fair market value to the landfill company/agency should they choose to do so. The value of the land should be based on its value prior to the proposal to develop a landfill in that area, and should reflect possible increased value that could occur over the next 10 years or so due to development of the area.

One of the most significant consequences of the adoption of the "dry tomb" approach for managing municipal solid waste is that it perpetuates the garbage crisis that exists in the US, rather than meaningfully addressing this crisis so that the public who reside or otherwise use lands near a proposed landfill would be assured that the landfill would not represent a significant threat to their public health, groundwater resources, environmental quality or social and economic welfare. The public will justifiably continue to vigorously oppose "dry tomb" landfills that are to be sited in their vicinity. Discussed in a subsequent section of this paper is an approach that, if adopted, could enable "dry tomb" landfills to be used for temporary storage of solid wastes in which there would likely be a significant reduction in the public's justifiable opposition to a "dry tomb" landfill being sited in their vicinity.

Groundwater Monitoring and Remediation

The minimum one mile land buffer around the landfill would also provide a significantly improved ability to monitor groundwater in order to detect groundwater pollution by municipal landfill leachate before pollution under adjacent properties occurs. The situation that exists today, where the point of compliance for the groundwater monitoring program is at or near the down groundwater gradient edge of the landfill, as is the case in California, or is within no more than 150 meters (~ yards) from the edge of the landfill, as required by US EPA Subtitle D regulations, where monitoring wells are spaced hundreds to a thousand or so feet apart does not provide for the development of groundwater monitoring programs with a high degree of reliability detecting groundwater pollution before significant pollution has occurred. Lee and Jones-Lee (1993d) have discussed the problems with the currently used groundwater monitoring programs for "dry tomb" landfills. They point out, as did Cherry (1990) previously, that the typical groundwater monitoring program that is being used for lined landfills, in which vertical monitoring wells are sampled quarterly or so, have a low probability of detecting leachate contaminated groundwater when it first reaches the point of compliance for the landfill. Instead of a single row of monitoring wells at the point of compliance, multiple rows spaced at increasing distances of staggered monitoring wells, coupled with horizontal monitoring wells would provide a much greater probability of detecting leachate pollution of groundwater than is typically being achieved today. Typically, the traditional land

buffer area around the landfill deposition site is inadequate to provide for the development of an appropriate groundwater monitoring program. Increasing this land buffer to about a mile or so between the active site and the adjacent property owners' lands would provide the space to develop groundwater monitoring programs to significantly enhance the detection of groundwater pollution before trespass of leachate occurs into groundwaters under adjacent properties.

Those who advocate the permitting of a proposed "dry tomb" landfill frequently assert that once the groundwater monitoring program has detected landfill liner system failure, groundwater remediation programs can be initiated to clean up the groundwater, implying, but usually not specifically stating, that the part of the groundwater aquifer that has been contaminated by municipal landfill leachate can be used again for domestic water supply purposes. It is widely recognized in the professional community by those knowledgeable in this topic area that there is no clean up of the contaminated groundwaters and that part of the aquifer that has been contaminated by municipal landfill leachate so that it could again be considered safe for use for domestic purposes. Jones-Lee and Lee (1993) discuss that municipal landfill leachate contains a large amount of uncharacterized-unidentified organic constituents (non-conventional pollutants) that could represent a significant public health and environmental threat to groundwater resources. Even if all of the drinking water MCLs (maximum contaminant levels) are met in groundwaters extracted from an aquifer that has been previously polluted by municipal landfill leachate, it should never be assumed that the water is safe to consume.

The US EPA has developed drinking water MCLs for a small number of the many tens of thousands of chemicals that are present in municipal solid wastes that could be a threat to groundwater quality. The groundwater monitoring programs that are typically used to evaluate groundwater safety at best only measure a hundred or so of the chemicals of potential concern in municipal landfill leachate contaminated groundwaters. It is therefore prudent public health policy to abandon any part of an aquifer that has been contaminated by municipal landfill leachate for domestic water supply use. The US EPA (1988a and 1991) has concluded that groundwater wells that are pumping water that is contaminated by leachate have to be abandoned. There is no plausible clean up of the groundwaters intercepted by such wells.

Economic Compensation for Non-controllable Adverse Impacts of Landfills

Lee and Jones (1993b) have suggested that a significant economic incentive be provided to all individuals who are potentially adversely impacted by a proposed or existing landfill. In addition to providing public health, groundwater quality and environmental protection far in excess of what will be achievable under the US EPA Subtitle D regulations, the owners/residents within a two to three mile radius of the landfill should be provided with an annual payment of sufficient magnitude to compensate them for the uncontrollable problems associated with the landfill, such

as truck traffic, noise, infrequent odors and the potential of groundwater pollution. Such payments would not constitute a license to pollute. This approach would only be allowed if the owner/operator of the landfill, whether public or private, took extraordinary steps to minimized the adverse impacts of the landfill during its active life and post-closure care period. It is suggested that $5,000 per year per household be considered as appropriate compensation that would be paid by those who generate the wastes that are placed at the landfill but do not want the landfill in their backyard. Such payments would significantly contribute to isolating landfills from high population areas. The cost to the typical waste generator might equal a few cents per person per day, and in many instances it would be less than one cent per person per day. It is important, as discussed by Lee and Jones (1993b), that in adopting this approach essentially fail-safe groundwater quality protection be achieved for as long as the wastes represent a threat where at least a double composite liner system is constructed and when leachate migrates through the upper liner sufficiently to represent a potential worst case scenario threat to groundwater quality that there are sufficient funds available in a dedicated trust fund generated from disposal fees to exhume the wastes, properly treat them and manage the residues from such treatment so that they will not be a threat to future generations' groundwater resources. As discussed by Lee and Jones (1990a), it is now possible under certain conditions to exhume-mine MSW landfills to remove waste in order to prevent groundwater pollution.

Funding for Independent Third-Party Monitoring

It is suggested that, in addition to providing financial compensation for the adverse impacts of locating a landfill in a particular area on the residents and property owners of the area, a fund also should be developed from disposal fees that could be used by the residents/property owners in the area of the landfill, i.e., within two to three miles, to independently monitor the landfill operations to ensure that, during the active life and especially during the post-closure care period *ad infinitum*, the cover of the landfill will be maintained, leachate will be removed to the extent possible, i.e., until the liners fail to provide an effective barrier to leachate migration to groundwater, and appropriate groundwater monitoring will be conducted. While assurance that post-closure care activities will be carried out is typically the responsibility of the state regulatory agency, there are few state agencies that are adequately funded to carry out the responsibilities assigned them by the legislature. Further, unfortunately, there are examples of regulatory agencies being subject to political and/or other pressures, which cause the public to justifiably question how well a regulatory agency can and will protect their interests. By establishing a garbage fee based funding of independent third-party monitoring of landfill activities, it would be possible to significantly improve the performance of the landfill company/agency in carrying out the required post-closure care activities to in fact cause the public who could be adversely affected by the landfill to feel that the siting of a landfill at a particular location would not represent a significant threat to their public health, groundwater resources, environment, economic and other welfare.

It is suggested that the funding for the third-party monitoring be typically set at $50,000 - $100,000 per year. Some landfill sites may require greater levels of funding. Those doing the monitoring would report and be responsible to the public who own, reside or use lands in the vicinity of the landfill where adverse impacts of the landfill could, under the very worst case plausible scenario, occur. This funding would be required for as long as the landfill exists and should be set up in a dedicated trust fund generated from disposal fees.

Permitting of Landfills

While urban dwellers who generate the wastes are willing to dispose of their wastes in someone else's backyard, they object to paying for the true long term costs of waste disposal to provide for public health, groundwater quality, environmental protection and economic and social welfare for as long as the wastes represent a threat to those in the vicinity of the landfill. Instead of complaining about a few cents to a few tens of cents per person per day increase in their garbage bill, those who contribute garbage to landfills sited outside of their sphere of influence on them should be advocating spending all necessary funds to ensure that those who own property, reside or use the areas within this potential sphere of influence of the landfill interests are protected. Rather than calling those who oppose landfills in their neighborhood NIMBYs, and either stating or implying that their opposition to a proposed landfill that would accept their wastes is unjustified, those generating the wastes should do everything possible to ensure that those who accept waste management/disposal in their area's interests are fully protected, even to the point of providing overprotection beyond that needed for plausible worst case scenario problems.

The current approach creates a situation where rural residents who live, work or own land near a proposed landfill justifiably object to the siting of landfills in their area. While those who object are characterized as NIMBYs, there are few, if any, urban dwellers who would not also vigorously oppose the siting of a landfill of the types being developed and operated today in their neighborhood. The problems of municipal solid waste management would be quickly solved if each neighborhood had to manage its own waste in its area where problems in management would affect those who generate the waste. If every white middle class suburban American community had a landfill sited in the middle of it, where the residents would be within the sphere of influence of the landfill, the current problems of managing municipal solid wastes would soon be resolved. Under these conditions, efforts would be taken immediately and adequate funds would be found to ensure that those who generate the wastes that are placed in landfills that could affect them are not adversely affected by the siting of the landfill in their area.

The typical situation that exists today is that garbage companies/agencies select a rural area as a possible site for a potential landfill and then initiate the permitting process for the site. If the site is near an organized/wealthy/politically important group, the opposition efforts are often successful, since the opposition has the funds and/or political power needed to effectively oppose the landfill. If, however, the site for the proposed landfill is in an area where the potentially affected population has limited political power and/or has limited funds to oppose the proposed landfill, the landfill is frequently sited in the area. Landfill companies/agencies have essentially unlimited funds to hire consultants who will develop reports and testify that a proposed landfill will be "protective" without ever stating the limitations that are assumed and apply to the statement. It is well known in the landfill consulting field that failure to make such statements would mean that the consultants would not obtain future projects. This situation is an important professional ethics issue that has been recently discussed by Lee and Jones-Lee (1993c). Unfortunately there are few knowledgeable consultants who will develop reports and testify on the real expected performance of the liners that are being used today in "dry tomb" landfills. Typically, such consultants state that such liner systems will be "protective" and/or meet the minimum engineered liner design system prescriptive standards apparently allowed by the applicable regulations for some landfill sites - however they do not state in an unequivocal manner that the "dry tomb" landfill will protect groundwater quality for as long as the waste will represent a threat to groundwater quality, i.e., that the groundwater quality protection standards of the regulations will be achieved by the proposed design. This means that at many landfill permitting hearings the boards/agencies frequently are not provided with full disclosure on the deficiency of the landfill liner design.

Normally today, proposed landfills have to have an environmental assessment/statement/report prepared on them which is supposed to set forth the potential adverse impacts of the proposed landfill on the public and the environment. The authors have reviewed many such reports and have consistently found that they do not properly present the potential adverse impacts of the proposed landfill on those who own property, reside and/or use areas in the vicinity of the landfill. This is especially true for "dry tomb" landfills. While EIRs/EISs-assessments are supposed to be independent, unbiased reviews of a particular situation, it is rare that such reviews properly address the issues so that the regulatory agencies/boards can make a decision on a particular project with full knowledge of the adverse impacts of the project on those who are potentially impacted by the project. Unfortunately, those firms that prepare such reports, either because of lack of knowledge or because of economic considerations, do not reliably discuss the ability of various impact mitigation approaches to protect the interests of those who could be adversely affected by the project/landfill. An EIR/EIS-assessment firm knows that if they make a full disclosure on a particular project, they will not likely receive future projects of that type. This arises out of the situation where the proponents of the project either directly or indirectly control the funding-selection of the firms who undertake such work.

The problems of inadequate/incomplete/unreliable disclosure of proposed "dry tomb" landfills to provide groundwater quality protection for as long as the wastes represent a threat have become so numerous and prevailing that the authors have developed guidance on the kinds of questions that should be asked of landfill applicants as part of permitting the landfill. Lee and Jones (1991c) suggest that every landfill applicant, whether public or private, must address as part of permitting the landfill plausible worst case scenarios for adverse impact development on those who are within the sphere of influence of the proposed landfill during its active life and post-closure period. Rather than, as typically done today, accepting an overly optimistic assessment of how liner and cover systems will be able to protect groundwater quality for as long as the wastes represent a threat to it, the landfill applicant should be required to define all plausible possible modes of failure of the liner system that could lead to groundwater pollution by landfill leachate.

After reliably evaluating the worst case plausible possible modes of failure of the landfill to protect public health, groundwater resources, environmental quality and economic and social welfare of those who could be adversely affected by the landfill, the landfill applicant/proponent should then be required to define in a reliable manner the consequences of such failure-impacts and how the applicant will prevent such failure-problems from occurring for as long as the wastes represent a threat, i.e., forever. The applicant should also be required to reliably define the magnitude of the funding and its sources that will be needed to address plausible problems that could occur at the proposed landfill. This type of full disclosure, if properly conducted and presented, would be a significant step in the direction of reducing the magnitude of justifiable NIMBY that is occurring today on proposed "dry tomb" landfills. It would also bring out for public review the flawed technology of the "dry tomb" landfilling approach, and likely cause the public to conclude that alternative approaches for managing municipal solid waste should be adopted.

By far the greatest problem with many of the "dry tomb" landfills that have been approved or that could be approved under current federal and state regulations is the inadequate funding of post-closure care. This issue has been recently reviewed by Lee and Jones-Lee (1992, 1993a). As they point out, a number of groups or individuals have independently concluded that the current approach to funding post-closure care for "dry tomb" landfills provides little assurance that the funds will be available when needed to address problems that will occur associated with the ultimate failure of the liner-cover system to prevent leachate migration to the nearby groundwaters, rendering them unusable for domestic and many other purposes. The 30 year post-closure care funding period typically mandated in federal and state regulations represents a small and typically insignificant part of the time that post-closure care will be needed. Unless the landfill design, construction and operation is extremely poorly done, it will likely be beyond 30 years before the significant problems start to develop.

The issue of adequate post-closure care funding is applicable to all types of landfills, including hazardous waste landfills currently being permitted under RCRA. The US Congress General Accounting Office reviewed this topic (GAO, 1990) and concluded that the current approaches for providing financial assurance for landfills under RCRA is inadequate to address problems that will likely occur in most landfills. Hickman (1992) has recently raised questions about the long term ability of many of the financial instruments used to provide post-closure care funding for landfills. He recommends that a dedicated trust fund be developed for this purpose. As discussed above, this trust fund should be of sufficient magnitude to ensure that funds are readily available to immediately address the virtually inevitable problems that will occur at many "dry tomb" landfills.

As discussed by Lee and Jones (1993) the state of California Water Resources Control Board has adopted a revised Article 5 of Chapter 15, which as one of its provisions requires post-closure care funding of sufficient magnitude to adequately address groundwater contamination when the liner systems that are being used fail to prevent it. Such approaches should become standard practice in which trust funds of sufficient magnitude are developed from waste disposal fees to immediately curtail further spread of groundwater pollution and the initiation of remediation of contaminated groundwaters to the extent possible. The authors feel that the magnitude of the funding should be sufficient to exhume and treat the wastes should it become impossible to prevent further groundwater pollution by a particular landfill.

The March/April 1992 issue of EPA Journal presents a series of articles on the fact that the poor and the minorities tend to face greater environmental hazards than the majority of the US population. The socially disadvantaged because of race and poverty are significantly disadvantaged in opposing "dry tomb" landfills in their area. In order to effectively obtain a fair hearing on a proposed landfill, those who are potentially adversely impacted by the landfill must be able to hire attorneys and consultants who can effectively represent the concerned citizens' issues. Based on the experience of the authors, it is rare that effective representation of the issues can be achieved for less than $100,000 in attorney and consultant fees. Often, the cost of effectively addressing the potential problems of a proposed landfill will cost on the order of a quarter of a million dollars. Even if the issues can be addressed, no assurance can be provided that such expenditures will result in anything other than delaying of the operation of the landfill. Unfortunately, factors other than technical merit play dominant roles in the siting and permitting of some landfills.

There is growing sentiment in the US that those who generate the waste should keep it in their area. At this time the geographical definition of area is typically at the state and county level. There are few counties that do not have areas where the opposition to a landfill is from relatively poor rural dwellers or minority dominated

communities. The residents of such areas do not have the financial resources available to effectively express and have heard their concerns about the proposed landfill. William Reilly, former administrator of the US EPA (Reilly, 1992), in the EPA Journal in an article entitled, "Environmental Equity: EPA's Position," discusses the issues of environmental equality. He states,

> *"At its core, environmental equity means fairness. It speaks to the impartiality that should guide the application of laws designed to protect the health of human beings and the productivity of ecological systems on which all human activity, economic activity included, depends. It is emerging as an issue because studies are showing that certain groups of americans may disproportionately suffer the burdens of pollution."*

Reilly's statement on these issues has direct and significant applicability to the permitting of "dry tomb" landfills since, as discussed above, it is indeed rare if ever that such landfills are placed in areas where they would adversely impact white middle class suburbanites who generate a large part of the wastes.

The public who are potentially adversely affected by a proposed landfill in their vicinity should be given adequate funding to enable them to effectively express their concerns on the proposed landfill through the permitting process and the courts, if necessary, in order to obtain judicial relief from inappropriately sited landfills as well as those that do not properly protect their interests. About the only groups that have sufficient funds available to effectively address the concerns of a proposed landfill are organized urban communities and water utilities. An increasing number of domestic water utilities are becoming involved in opposing proposed landfills because of the long term threat that these landfills represent to groundwater quality. Lee and Jones (1991b) have developed guidance designed to assist water utilities in evaluating the potential threat that existing and/or proposed landfills represent to domestic water supply water quality. As the flawed technology of "dry tomb" landfills becomes more fully recognized and appreciated, it is expected that water utilities will play an even greater role in opposing improperly sited, designed, constructed, operated and closed landfills in their groundwater supply watershed.

The authors have repeatedly observed situations where landfills have been imposed on poor rural residents by regulatory agencies with little regard to the adverse impacts of the landfill on the people within the sphere of influence of the landfill. The current system of siting landfills and their review is grossly unfair to the public who are potentially adversely affected by the landfill because of the large amounts of funds necessary to effectively express the concerns of those who are potentially adversely affected by the landfill in the permitting systems normally used today.

Today's society should stop siting landfills at sites where the economically disadvantaged cannot effectively express their concerns. It is proposed that an

approach similar to that used in CERCLA Superfund site review, where funds are provided to the local concerned citizens by the US EPA and ultimately by the responsible parties for the site to hire attorneys and consultants to represent their interests at site review. Those who are potentially adversely affected by a proposed landfill should be given adequate funding by the landfill proponents to enable full public review of the issues. It is suggested that, as a first phase funding level, $100,000 be made available to support concerned citizens' expression of concerns on the potential problems of the proposed landfill to their health and welfare. Additional funding will likely become necessary if inadequate attention is given by the regulatory agencies to the appropriate concerns of those who could be adversely affected by the proposed landfill.

Landfill companies/agencies have adopted the tactic of negotiating the permitting of a landfill in which the initial proposal for the design of the landfill will typically be the minimum necessary based on past experience at other sites to just get by the local regulatory agency's current interpretation of the requirements for landfill siting and design. Often, if they are successful, then the company/agency has, through this approach, saved some funds in landfill construction. If, however, significant opposition is met, then the regulatory agency staff and representatives of the landfill company/agency will add components to the landfill design that are alleged to be more than the minimum necessary to meet the interpretations of the regulations with respect to the prescriptive design requirements. It is further often stated that the improved design will now provide for groundwater quality protection. The authors have seen several situations in which a series of steps of this type are taken in order to gain regulatory agency approval of a proposed landfill. Basically, this leads to a negotiated permit which at best lengthens the time that the landfill will exist before groundwater pollution occurs. So long as "dry tomb" landfills are permitted, using liners of the types allowed today, with their associated post-closure care funding and groundwater monitoring systems, there is no doubt that, ultimately, the so-called improved design landfill will also pollute groundwater.

Alternatives to "Dry Tomb" Landfills

The negotiated landfill permit process is not significantly different from what has been occurring in the US EPA's development of regulations governing the landfilling of wastes since the implementation of RCRA in the mid 1970s. While it has been obvious for many years and well-documented in the literature since the early 1960s that sanitary landfills were polluting groundwater with landfill leachate, it was not until the mid 1970s that any significant efforts were made to address this pollution. The US EPA, as part of implementing RCRA for hazardous waste sites (Subtitle C) first adopted clay lined disposal areas for solid waste management. While it was obvious from the beginning that this approach would not work to prevent groundwater pollution because of the finite permeability of clays, it was not until the early 1980s, when it was acknowledged that pure organic solvents of various types

could cause compacted clays to shrink and crack, leading to widespread liner failure, that the US EPA officially recognized that clay lined landfills would not protect groundwater quality. Actually, it was found in the mid 1970s by the senior author and his graduate students that, while pure organic solvents could cause clay liner failure, organic solvents with water present in them, which would typically be the case, do not cause this problem.

In an attempt to try to address the issue of pure solvent effects on clay liners, which was never a real issue since there is no disposal of pure solvents in landfills, the US EPA in the early 1980s abandoned clay liners in favor of plastic sheeting-flexible membrane liners for landfills. It was soon found, however, that it was impossible to construct and maintain this sheeting so that it did not have significant holes in it when the liner was put into service that could allow appreciable transport of leachate through the FML. Finally, in 1984 Congress, as part of re-authorization of RCRA, forced the US EPA to require that hazardous waste be treated-immobilized-detoxified before land burial of the treatment residues. Further, the US EPA has concluded that even the treated hazardous waste residues have to be buried in double composite lined landfills.

The US EPA is now resurrecting a technology that has been found to be flawed for management of hazardous waste because of liner leakage and has adopted this approach for municipal solid waste in their October 9, 1991 Federal Register, in which the US EPA formally adopted the "dry tomb" landfilling approach, where untreated municipal solid wastes are placed in "dry tomb" landfills. This approach obviously will not protect groundwater quality from landfill leachate using the materials that are used today to line and cover landfills.

There can be little doubt that the approach that was finally adopted by Congress/the US EPA for managing hazardous waste involving treatment of the waste prior to land burial will have to be adopted for municipal solid waste if protection of groundwater quality is to be achieved in "dry tomb" landfills. While it is beyond the scope of this review to discuss the details of the various technologies that are available for treatment of municipal solid wastes so that they do not represent a significant threat to groundwater quality, there are a number of technologies available for this purpose. Lee and Jones-Lee (1993g) have recently described the "wet-cell" fermentation leaching for in situ treatment of MSW that will produce solid waste residues that represent limited long-term threats to groundwater quality. In summary, an alternative, more protective approach for managing municipal solid wastes would include:

- recycling as much MSW as possible (50% is readily obtainable), and
- treating non-recyclable residues to stabilize the fermentable/decomposable components and leach the residues, and

- burial of leached residues by methods and at locations where residual potentially leachable components would not be a significant threat to groundwater quality at any time in the future.

The treatment of non-recyclable components can be accomplished with a variety of technologies:

- incineration, using properly designed, controlled, operated, and maintained incinerators equipped with highly effective air pollution control technology and proper management of ash. Today's MSW incineration approaches, however, typically do not provide that level of protection.

- aerobic composting of degradable wastes with complete odor control, waste separation to remove components from the waste that can cause the compost to pollute surface and groundwaters, and the development of markets/uses for the compost.

- anaerobic fermentation and leaching in reusable lined treatment cells by leaching of the more readily leachable components of the waste. The residues will represent a significantly smaller threat to groundwater quality. (Lee and Jones, 1990b and Lee and Jones-Lee 1993g)

Treatment of MSW before or at the time of burial, while initially more expensive for today's society, places the cost responsibility on the waste generators, and in the long run will be less expensive and more protective of the nation's groundwater resources.

Inappropriate Approaches for Addressing Legitimate NIMBY

Today, those responsible for developing solid waste management capacity in a particular jurisdiction are adopting a public participation process in which the public is provided the opportunity to actively participate in site selection. Typically, a site selection committee representing the various interests in solid waste management in the area where the wastes are generated and in the areas where a landfill could be located will develop, under the guidance of the department of public works or some other entity responsible for solid waste management in the region, a numeric site ranking procedure, in which various criteria that are judged to be important by the site selection committee (committee) are identified. The committee then arbitrarily assigns a numeric value with a possible range of 1 to 10 to each of these criteria that represents the committee's consensus on their importance. Examples of such criteria include groundwater quality protection, solid waste transportation distance, significance of aboriginal artifacts, and various social/political/legal factors that could influence the siting of a landfill.

The department of public works then provides, sometimes blind, information on candidate sites within the region based on the information that is readily available on the characteristics of the area. The selected possible sites are then evaluated in accord with the criteria selected by the committee and a "best possible" site(s) is selected.

This process is claimed to be technically valid, unbiased, value-driven, well thought-out, rational, objective, and defensible. The authors have been involved in reviews of such site selection processes (Lee and Jones-Lee, 1993h) and have typically found that this type of site selection process is not technically valid and can be readily manipulated to select a particular site or group of sites. Repeatedly, the authors have found that the committee does not have the expertise, nor is it provided with the expertise, to evaluate the technical validity of the information provided it by the department of public works. Typically, such committees will rank groundwater quality protection very high in site selection. Ordinarily, at the time that the committee is selecting the best possible site, there is insufficient information available on both the design of the proposed landfill, with particular reference to its ability to provide for groundwater quality protection for as long as the wastes in the landfill represent a threat, and the hydrogeological characteristics of the areas where the landfill could be sited.

The committee is typically led to believe that a landfill will be constructed at a site that will protect the groundwater resources of the region. However, it is typically found that the regulatory agency's minimum prescriptive standards for landfill, such as those of the US EPA Subtitle D requirements, design, construction, operation, closure and post-closure care and its associated funding do nothing more than postpone when groundwater pollution occurs. Landfill proponents will often claim that the proposed landfill will meet or exceed regulatory requirements. At this time, few state regulatory agencies have requirements that assure high degrees of groundwater quality protection for as long as the municipal solid wastes that will be present in the landfill will represent a threat to groundwater quality. Further, even in those states where such requirements exist, such as California, the implementation of the requirements falls far short of achieving this performance standard.

While the site selection committees rank groundwater quality protection as an area of great concern in landfill siting, the information provided to the committees in ranking sites is inadequate to properly evaluate the site either for its natural ability to protect groundwater from leachate pollution, or the ability of the "engineered" containment system - liners, etc. - to prevent groundwater pollution for as long as the wastes represent a threat. Therefore, the committees numerically ranks their perceived importance of not disturbing aboriginal artifacts with unreliable information on groundwater quality protection. As discussed by Lee and Jones-Lee (1993h), it is clear, for example, that it is inappropriate to give comparative scores to the importance of future generations' groundwater resources and the presence of aboriginal culture remnant artifacts - on a scale of 1 to 10 or some other scale

contrived to yield a numeric score that can be mechanically plugged into the site selection process. The authors have frequently found that inadequate attention is given in the early phases of landfill site selection to the long term groundwater quality issues. However, once the best site for the landfill has been selected by a committee using this process, it becomes very difficult, if not impossible, to admit the errors that were made in site selection and start over.

The arbitrarily developed numeric scoring and ranking procedure that is being frequently used today to select sites for landfills, while giving the aura of being technically valid and unbiased, is obviously flawed and without technical merit. A proper review of the process shows that the selection of a site as the best possible site is often arbitrary, capricious, and certainly not well thought-out, rational, objective or defensible.

The committee, the public and their representatives, such as the county board of supervisors, are rarely provided with the information they need to properly evaluate the appropriateness of siting a landfill at a particular location. MSW landfills are known to be bad neighbors. This arises out of the fact that those who generate the wastes that are placed in the landfill have not been asked or required to spend the funds necessary in increased garbage disposal fees to properly control many of the significant adverse impacts that are readily controllable in landfilling of MSW. As discussed elsewhere in this paper, most of the justifiable NIMBY that occurs today associated with the siting of new or expanded landfills can be readily addressed through adequate funding of solid waste management. Further, appropriate financial compensation packages can typically be developed from increased garbage collection fees to compensate those within the sphere of influence of a proposed or existing landfill to enable them to readily leave the area or to accept the non-health and environmental impact related effects of the landfill, such as altered/degraded view shed.

Another significant problem with landfill site selection is the way in which those responsible for site selection interact with the potentially impacted public. Previously, those responsible for developing solid waste management capacity would work behind the scenes until a site had been selected, then force that selection on property owners in the region. Today, the public (NIMBYs) have become sufficiently organized and effective so that they can, in many cases, block the siting of a landfill in their area. This has led to attempts to involve the potentially impacted public in the decision-making process. With few exceptions, however, the authors find that this so-called public involvement means that those potentially impacted are merely given the opportunity to express their views on why a landfill in their area is inappropriate. Rarely does such an expression result in any significant change in the landfill location and its design. The landfill is still forced on those potentially impacted in the region where it will be sited. The potentially impacted public is rarely involved in the decision-making process in a meaningful way. To ensure that the potential adverse

impacts of the landfill are controlled and that appropriate compensation is made for the non-controllable impacts, so long as landfills are forced on people, there will be justifiable NIMBY.

Conclusion

Municipal solid waste landfills can, and usually do, have a significant adverse impact on the individuals who own property, reside or otherwise use areas near the landfill. This leads to a justifiable NIMBY on the part of those who are potentially adversely affected by the landfill. The "dry tomb" landfilling approach for managing municipal solid waste adopted by the US EPA in October 1991 at best only postpones groundwater pollution. It does not adequately address the legitimate concerns that individuals who own, live or use properties near landfills have for the potential impact of the landfill on their interests. While the US EPA asserts that the adoption of these regulations should enable the permitting of landfills for municipal solid waste management, it is clear that this will not be the case, since the agency has yet to effectively address the wide range of legitimate concerns that individuals within the sphere of influence of a landfill can and will experience because of the landfill. The "dry tomb" landfilling approach is obviously a flawed technology that did not work for hazardous wastes and will not work for municipal solid wastes. It has become clear that municipal solid wastes should be treated to remove components that can generate leachate that adversely affects groundwater quality. Until such approaches are adopted in the US as a general approach for managing municipal solid waste, the solid waste management capacity crisis that now exists will continue to exist.

Even with appropriate treatment of MSW so that the residues do not represent a significant threat to public health, groundwater resources and the environment, it will be necessary to continue to develop landfills for management of treated residues. In addition to developing technically valid, cost-effective and protective approaches for groundwater quality associated with municipal solid waste management for as long as the wastes represent a threat, it will be necessary to significantly change the approach that is being used to address the concerns of those individuals who are within the sphere of influence of an existing or proposed landfill. Certain specific approaches are recommended to address these concerns. These include:

- providing unequivocal public health, groundwater, air and environmental quality protection from MSW wastes and treated residues
- funding concerned citizens' activities so that they may effectively express their concerns in the permitting of new or expanded landfills
- funding the purchase of an adequate land buffer around proposed landfills so that those who own, reside or use properties adjacent to or near the landfill property will not be adversely affected by the landfill operations that can be

addressed by separation of the landfill waste containment area from adjacent properties

- purchasing properties at at least fair market value from all landowners who wish to sell their property within the potential sphere of influence of the landfill

- providing financial compensation to all owners/residents of land within the sphere of influence of the landfill to cover non-preventable adverse impacts of the landfill on them

- funding third-party independent monitoring of landfill activities for those who are potentially adversely affected by the landfill

- establishing a post-closure care trust fund of sufficient magnitude to ensure that funds will be available when needed to remediate to the extent possible the contaminated groundwaters and, if necessary, exhume the wastes from the landfill and treat the residues that have a potential to cause groundwater pollution

- modifying the "dry tomb" landfilling approach so that "dry tomb" landfills that accept untreated wastes are considered to be useful for temporary storage of the wastes which will cease upon leachate penetration of the uppermost composite liner with sufficient leachate to potentially cause, under worst case scenario conditions, groundwater pollution in the vicinity of the landfill.

The source of the funds for each of these activities should be derived from garbage disposal fees contributed by those who generate the wastes and do not wish to have a landfill in their backyard. Where long term funding is needed, these funds should be deposited in a trust fund(s) of sufficient magnitude to ensure that all plausible worst case scenarios can be immediately effectively addressed upon their detection, before they become significant problems to those who own property, reside or otherwise use lands under the sphere of influence of the landfill.

In this discussion, a number of suggestions are made on distances, amounts of funds needed and related topics which are based on the authors' experience in the topic area. The magnitude of the values presented is subject to revision based on site specific evaluations. In some cases, lesser values for distances and funding may be possible. At others increased values will be needed.

While the approach advocated represents an increase in cost to the public for MSW management compared to what has been paid in the past, which has been about ten cents per person per day, in the long term this approach will be less expensive for society as a whole, since it will represent a significant initiative toward municipal solid waste management in a manner that will protect the interests of the public.

Acknowledgements

This prescription for an alternative approach for managing municipal solid wastes other than the "dry tomb" landfilling of untreated wastes has evolved out of the authors' over 20 years of work on the issues of municipal solid waste pollution of groundwaters. The authors wish to acknowledge the support of all of those who have supported their efforts in reviewing and addressing the potential problems associated with the "dry tomb" landfilling approach for management of municipal solid wastes.

References

Cherry, J., "Groundwater Monitoring: Some Deficiencies and Opportunities," IN: Hazardous Waste Site Investigations; Towards Better Decisions, Proceedings of 10th ORNL Life Sciences Symposium Gatlinburg, TN, May 1990, Lewis Publishers (1990).

GAO (General Accounting Office), "Hazardous Waste Funding of Postclosure Liabilities Remains Uncertain," Report to Congress, CAO/RCED-90-64, GAO, Washington, D.C., June (1990).

Hickman, H. L., "Financial Assurance - Will the Check Bounce?," Municipal Solid Waste News, Solid Waste Association of North America, Vol. 14, No. 3, p.4-5, March (1992).

Jones-Lee, A., and Lee, G. F., "Groundwater Pollution by Municipal Landfills: Leachate Composition, Detection and Water Quality Significance," Proceedings of Sardinia '93 IV International Landfill Symposium, Sardinia, Italy, October (1993).

Lee, G. F., and Jones, R. A., "Use of Landfill Mining in Solid Waste Management," Proc. Water Quality Management of Landfills, Water Pollution Control Federation, Chicago, IL, July (1990a).

Lee, G. F., and Jones, R. A., "Managed Fermentation and Leaching: An Alternative to MSW Landfills," Biocycle 31(5):78-80,83 (1990b).

Lee, G. F., and Jones, R. A., "Landfills and Ground-water Quality," Guest editorial, J. Ground Water 29:482-486 (1991a).

Lee, G. F., and Jones, R. A., "Regulating Drinking Water Quality at the Source," proceedings University of California Water Resources Center Conference, "Protecting Water Supply Water Quality at the Source," Sacramento, CA, April (1991b).

Lee, G. F., and Jones, R. A., "Review of Proposed Landfills: Questions that Should be Answered," Statement prepared by G. Fred Lee & Associates, El Macero, CA, November (1991c).

Lee, G. F., and Jones-Lee, A., "Municipal Landfill Post-Closure Care Funding: 30-Year Post Closure Care Myth," report, G. Fred Lee & Associates, El Macero, CA (1992).

Lee, G. F., and Jones, R. A., "Municipal Solid Waste Management in Lined, 'Dry Tomb' Landfills: A Technologically Flawed Approach for Protection of Groundwater Quality," Short course notes for American Society of Civil Engineers short course, New York City and Atlanta, GA, January (1993).

Lee, G. F., and Jones-Lee, A., "Landfill Post-Closure Care: Can Owners Guarantee the Money Will Be There?", Solid Waste and Power, 7(4):35-39 (1993a).

Lee, G. F., and Jones-Lee, A., "Excerpts from 'Municipal Solid Waste Management: Long-Term Public Health and Environmental Protection,'" Report of G. Fred Lee & Associates, El Macero, CA and short course notes, Landfills and Groundwater Quality short course, University of California, Riverside Extension, Riverside, CA, May (1993b).

Lee, G. F., and Jones-Lee, A., "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?," Submitted to Civil Engineering, ASCE, May (1993c).

Lee, G. F., and Jones-Lee, A., "Groundwater Quality Monitoring at Lined Landfills: Adequacy of Subtitle D Approaches," Report of G. Fred Lee & Associates, El Macero, CA and short course notes, Landfills and Groundwater Quality short course, University of California, Riverside Extension, Riverside, CA, June (1993d).

Lee, G. F., and Jones-Lee, A., "Environmental Impacts of Alternative Approaches of Municipal Solid Waste Management: An Overview," report, G. Fred Lee & Associates, El Macero, CA July (1993e).

Lee, G. F., and Jones-Lee, A., "Revisions of State MSW Landfill Regulations: Issues for Consideration for the Protection of Groundwater Quality," Journal of Environmental Management Review, August (1993f).

Lee, G. F., and Jones-Lee, A., "Landfills and Groundwater Pollution Issues: 'Dry Tomb' vs F/L Wet-Cell Landfills," Proceedings of Sardinia '93 IV International Landfill Symposium, Sardinia, Italy, October (1993g).

Lee, G. F., and Jones-Lee, A., "Comments on Alachua Department of Public Works' Landfill diting Process and Selection of Site E as Best Available Site for County Landfill," report, G. Fred Lee & Associates, El Macero, CA July (1993h).

Reilly, William K., "Environmental Equity: EPA's Position," EPA Journal, 18, No. 1, March/April (1992).

US EPA, "Solid Waste Disposal Facility Criteria; Proposed Rule," Federal Register 53(168):33314-33422, 40 CFR Parts 257 and 258, US EPA, Washington, DC, August 30 (1988a).

US EPA, "Criteria for Municipal Solid Waste Landfills," Draft Background Document, Closure/Postclosure Care and Financial Responsibility Requirements, 40 CFR Part 258 Subpart C 258.30-258.32, EPA/530-SW-88-041, US EPA, Washington, DC (1988b).

US EPA, "Solid Waste Disposal Facility Criteria; Final Rule," 40 CFR Parts 257 and 258, Federal Register 56(196):50978-51119, October 9 (1991).