Detection of the Failure of Landfill Liner Systems

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It has been found that frequently, as part of permitting a new landfill or landfill expansion, landfill applicants and/or their consultants will claim that there is no evidence that the US EPA RCRA Subtitle C (hazardous waste) double composite-lined landfills and Subtitle D (municipal solid waste - MSW) single composite-lined landfills have failed to prevent leachate from passing through the liner system and polluting groundwaters. This situation then leads landfill applicants to try to convince regulatory agencies and others that, since there is no evidence for groundwater pollution by the plastic sheeting-lined landfills, this approach must be protective of groundwater quality and therefore a proposed landfill with this type of liner should be approved. Basically, the landfill applicants are trying to shift the burden of proof for protection of groundwater from the applicant to the regulatory agencies and/or the public where it is up to the agency - public to prove that the plastic sheeting-lined landfills will be protective of the groundwater resources in the vicinity of the landfill for as long as the wastes in the landfill will be a threat. As discussed herein, such an approach is highly inappropriate.

Burden of Proof for Groundwater Quality Protection Should Be on the Landfill Applicant

It is important that as part of developing a landfill, the landfill applicant, whether public or private, be required to convincingly demonstrate that a proposed landfill will be sited, designed, constructed, operated, closed and provide post-closure care such that it will protect the groundwater resources, public health, environment and the interests of those within the sphere of influence of the landfill, for as long as the wastes in the landfill represent a threat. For planning purposes, the wastes in a municipal solid waste landfill or the treated waste residues in a hazardous waste landfill should be considered a threat to public health, the environment and groundwater resources forever (Jones-Lee and Lee 1993). It is now well-understood that today's plastic sheeting-lined landfills that meet minimum or even somewhat above minimum design requirements will, at best, only postpone when groundwater pollution occurs by landfill leachate generated within the landfill. This issue is discussed in detail in the papers and reports developed by the authors. A list of these papers and reports is appended to these comments. Copies of them are available upon request.

Since, as discussed in the report entitled, "Recommended Design, Operation, Closure and Post-Closure Approaches for Municipal Solid Waste and Hazardous Waste Landfills," (Lee and Jones-Lee, 1995a) it is possible today to develop landfills that will be protective of public health, the environment and groundwater resources and the interests of those within the sphere of influence of the landfill, the landfill applicant should be required to develop landfills that will be protective for as long as the wastes in the landfill will be a threat.

If there are questions about any particular landfill being appropriately sited, designed, constructed, operated and whether there will be adequate post-closure care funding for as long as the wastes represent a threat, i.e., forever, then the landfill should not be developed or expanded. Those who own or use properties near proposed landfills should be protected from adverse impacts of the landfill. This will require those who generate wastes that are placed in a landfill pay the true cost associated with landfilling the wastes. In those situations where there is inadequate information to evaluate whether a proposed landfill will be protective, it is appropriate to err on the side of protection of public health, the environment and the interests of those who live near landfills rather than on the side of cheaper-than-real-cost waste disposal. The cost of proper solid waste management only represents a few cents per day more for those who generate the wastes than the cost associated with minimum Subtitle D landfills (Lee and Jones-Lee, 1993a). Similarly, the proper management of landfill hazardous waste would not significantly increase the cost of the goods that generate the waste.

Detection of the Leakage of Landfill Liner Systems

The basic reasoning (no pollution of groundwaters by landfill leachate has been detected) that is being used in support of continued development of Subtitle D minimum single composite-lined landfills and Subtitle C double composite-lined landfills is fundamentally flawed for a variety of reasons. These issues are discussed below.

Travel Time of Leachate. The way that leakage through a Subtitle D single composite liner is detected is by pollution of the groundwaters at the point of compliance for monitoring the presence of leachate. The point of compliance can, in a properly developed landfill that complies with minimum Subtitle D requirements, be no more than 150 meters from the down groundwater gradient edge of the waste management units. This means that any leakage from a Subtitle D landfill liner system must travel through the liner and unsaturated geological strata below the liner to the groundwaters and then horizontally to the point of compliance. Since Subtitle D landfill liner systems have only been required by the US EPA for less than three years, it is entirely possible that at many landfill sites the leakage through the liner that is likely occurring has not yet reached the point of compliance.

Unreliable Groundwater Monitoring. One of the primary reasons why Subtitle D and, for that matter, Subtitle C landfills have not been found to be polluting groundwaters is that the method of detection of groundwater pollution involves vertical monitoring wells spaced hundreds to a thousand or more feet apart at the point of compliance for monitoring. These monitoring wells have zones of capture into the aquifer of about one foot based on a three borehole volume purge of the well before sampling. This means that unless there is widespread general leakage throughout the whole bottom of the landfill liner system, the plumes that are generated from initial leakage would not likely be detected by the groundwater monitoring wells. Parsons and Davis (1992) have discussed the approach that should be used to develop reliable groundwater monitoring systems for lined landfills. Basically, the zone of capture of the monitoring wells at the point of compliance for groundwater monitoring must be of such dimensions (lateral extent) to intersect the leachate plumes that arise from leaks through the liner system.

Cherry (1990) and Lee and Jones-Lee (1994a) have reported that typically the plumes that are developed from plastic sheeting-lined landfills are fingerlike, i.e. with limited lateral dispersion. This creates a situation in which the groundwater monitoring systems used have a low probability of detecting groundwater pollution before widespread pollution occurs beyond the point of compliance for groundwater monitoring. In most plastic sheeting-lined landfills there will be several long, finger-like plumes of leachate extending well beyond the point of compliance before the failure of the liner system to prevent groundwater pollution is detected. This is one of the primary reasons why it is fundamentally flawed reasoning to assert that because the groundwater monitoring systems at Subtitle C and D landfills have not yet detected groundwater pollution that these types of landfills will be protective of groundwater resources for as long as the wastes in the landfill will be a threat.

Leakage Through Double-Lined Landfills. One of the best ways to judge whether leakage will occur through a single composite liner is to examine the results obtained for leaks into the leak detection system for landfills lined with double composite liners that have a leak detection system between the two composite liners. Examining this issue is the best indicator available at this time on what can be expected in the way of leaks through both the double composite liner and a single composite liner landfill system. As discussed by Lee and Jones (1992), Bonaparte and Gross (1990) reported on finding significant leaks in new landfills constructed with double-lined systems.

One of the issues that is of considerable concern with respect to leakage through composite liners in a double composite-lined system is the approach that is used to establish excessive leakage rates through the upper composite liner. Several years ago the US EPA attempted to establish a Liner Action Leakage Rate of a few gallons per acre per day as the rate at which a single composite liner in a double composite-lined system would be allowed to leak before remediation efforts would have to be undertaken. As it turned out, based on the review by Bonaparte and Gross, allowing only a few gallons per acre per day of leakage through the upper composite liner would mean that essentially all of the upper composite liners of double composite-lined systems would be found to have failed. This caused the US EPA and the states to take a different approach where the Liner Actual Leakage Rate is based on what can be achieved with current liner technology, rather than what is necessary to protect groundwater from pollution by landfill leachate.

As discussed by Lee and Jones (1992), the appropriate approach to take in establishing the Liner Action Leakage Rate is not what can be achieved with these types of liner materials, but what is necessary to protect the groundwaters from pollution by landfill leachate. This is the purpose of the liners. The approach that should be used is to determine, on a site-specific basis, the rate of leakage through the upper composite liner that can be allowed and not result in groundwater pollution if the lower composite liner were not present. For most situations, this will be on the order of a few gallons per acre per day.

Development of Liner Leak Detection Systems. While landfill applicants and their consultants often claim that a single and/or double composite liner system will not leak, it is obvious from the literature, principles of chemical thermodynamics and common sense that such claims have no technical validity. The facts are that composite-lined systems often can leak at the time of

construction due to imperfections in the construction. It is for this reason that I-Corp International of Daytona Beach, Florida; Gundle - GSE of Houston, Texas; and Robertson Barrier System Corp. of Vancouver, British Columbia have developed leak detection systems for liners. Such leak detection systems are needed to detect leaks that are occurring at the time of construction of the liner system that are not detected by conventional QA/QC approaches.

Landfill Operations Caused Leaks. Another important source of leaks for new landfills is the inadequate protection of the liner system from the initial placement of the wastes in the landfill. Often inadequate attention is given to developing a protective layer between the liner system and the lowermost layer of wastes to prevent punctures from occurring in the liner system associated with the initial placement of the wastes. An example of this type of problem occurred with Chemical Waste Management of Indiana's hazardous waste landfill unit located near New Haven, Indiana where as part of placing the first layer of wastes in that landfill, the landfill operator punched 83 holes in the liner. The leakage through these holes was of sufficient magnitude so that the state of Indiana required that the wastes that had been placed in the landfill be removed and the liners repaired.

Solvent Permeation. There is a special type of leakage of landfill liners that, thus far, is largely being ignored by the regulatory agencies, even though it is well-documented in the literature. This is the problem associated with permeation of the liner by various types of organic solvents. Common organic solvents that are present in municipal solid wastes and in treated hazardous waste residues such as the chlorinated solvents, benzene, TCE and its degradation products such as vinyl chloride, etc., can pass through an intact, with no holes, flexible membrane liner in a short period of time. This is a chemical process that does not cause the liner to deteriorate, but involves the diffusion of the organics into the plastic sheeting and then through the plastic sheeting into the media on the other side of the plastic sheeting which typically is the compacted clay layer. Permeation of dilute solutions of organic solvents through HDPE liners was discussed by Haxo and Lahey (1988). This process has been investigated in detail by Sakti et al. (1991). Recently, Buss et al. (1995) have published further information on it.

It is important to note that this mechanism of leakage is particularly significant since it results in the transport of highly hazardous persistent mobile constituents through the liner system under conditions where the liner is perfectly formed and intact. It occurs not only from concentrated solvent solutions, but also occurs with dilute aqueous solutions of the solvents. The various solvents that are of concern can be purchased by the public at the local hardware store and therefore are not exotic chemicals that would not be expected at a landfill, but are common chemicals that are expected in today's municipal landfills. Many of these solvents are known or expected carcinogens. The US EPA (1988a), as part of promulgating Subtitle D regulations, noted that one of the best ways to detect liner leakage of leachate is through measurement of organic solvents.

Long-Term Plastic Sheeting Liner Deterioration. Even if the liner is perfectly formed and no holes are punched in the liner at the time of waste deposition and if no organic solvents are present in the landfill, it is still only a matter of time until the liner system fails to prevent leachate from passing through it. The US EPA (1988a), as part of promulgating Subtitle D regulations governing municipal landfills, 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."

The US EPA (1988b) Criteria for Municipal Solid Waste Landfills stated,
"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."

Since the US EPA developed that position on the ultimate deterioration of flexible membrane liners, considerable additional work has been done which now further strongly supports this position. A recent example of this is the work of Hsuan and Koerner (1995) where they have reported on the initial phase of some long-term (10-year) studies that are underway on examining the rates of deterioration of flexible membrane liners. The focus of the Hsuan and Koerner's work is on the breakdown of the polymers in the plastic sheeting liners. They predict that this breakdown will occur due to free radical polymer chain scissions in 40 to 120 years. These estimates are indicated by Koerner to consider only some of the key issues that could cause breakdown. It is possible that breakdown could begin much earlier. Even if the breakdown of the plastic sheeting polymers took 100 years or so, there is still no question that ultimately the plastic sheeting in the flexible membrane liners will break down leading to an inability to prevent leachate from passing through it leading to groundwater pollution in the area.

It is important to put the ultimate breakdown of the flexible membrane liner in the perspective of the time at which the treated waste residues in a hazardous waste landfill and in a municipal solid waste landfill represent a threat. Both types of landfills contain waste components that will be a threat, effectively forever. Therefore, since it is only a matter of time until disintegration of the flexible membrane liner occurs, it is only a matter of time until groundwater pollution occurs at landfills lined with HDPE plastic sheeting.

Compacted Clay Liners. Today's Subtitle C and D landfills require that the plastic sheeting layer(s) be backed by compacted clay. The minimum design requirements for the clay layer is two feet of clay that has a permeability, at the time of construction, of no greater than 10-7 cm/sec. There are a variety of well-known mechanisms (see Lee and Jones 1992) that cause the compacted clay layers to increase their permeability over time. Factors such as desiccation cracking are important causes of increased permeability for clay liners.

There is an increasing tendency to substitute thin bentonite mats of clay for the two feet of compacted clay. These bentonite mats have advective permeabilities of about 10-9 cm/sec. However, the diffusional transport through such layers is much higher than this amount. Gray (1988) has found that diffusion is a much more important process for determining the transport through bentonite mats than the advective permeability. Further, as discussed by Lee and Jones (1992), bentonite clays are subject to significant shrink/swell properties where, for certain types of wastes that have excess calcium and magnesium over sodium, the sodium bentonite clay present in these mats would undergo ion exchange with calcium and magnesium, leading to a shrinkage of the clay and increased permeability. There are significant questions about the advisability of relying on bentonite mats as a reliable barrier for the transport of landfill leachate through them.

Overall, compacted clay layers will not prevent leachate transport through them. They have finite permeabilities which will ultimately allow, under design specifications, the transport of leachate through the layer. Further, there are a variety of mechanisms which can result in an increased permeability from that prescribed in the design and achieved at the time of construction.

Reliable Reporting on FML Properties

One of the problems with addressing the ultimate breakdown of the liner system is the failure of landfill applicants and their consultants to reliably report on the long-term stability problems with flexible membrane liners. There are numerous examples in the literature such as Fluet et al. (1992), Tisinger and Giroud (1993) and Flood (1994) where individuals who work for landfill applicants inadequately and/or unreliably report on the ultimate breakdown of flexible membrane liners. As discussed by Lee and Jones-Lee (1993b), the typical approach used by landfill consultants is to claim that the liner system will be "protective." However, they fail to discuss their definition of the duration of time in which they will be protective and fail to mention the fact that, ultimately, this protective definition that they use will result in groundwater pollution beyond the time that they are considering to be of significance. Often this time is considered to be only 30 years beyond the closure of the landfill.

As discussed by Lee and Jones-Lee (1994b), this 30-year post-closure care period, which is mandated as the minimum for Subtitle C and D landfills, is an infinitesimally small part of the total time that will ultimately have to be considered during which the wastes in the landfill will be a threat to cause groundwater pollution. Basically, the 30-year post-closure care period was an error on the part of the US Congress and environmental groups which the US EPA and Congress has yet to correct as part of the revisions of RCRA.

The problem of landfill applicants and those who serve as consultants to them not disclosing the "whole truth" about the ultimate failure of the landfill liner system to protect groundwaters for as long as the waste is a threat, is of sufficient concern such that the authors have developed a discussion of professional ethics issues. They discuss the situations associated with professional engineers failing to disclose the long-term public health and safety issues associated with a particular landfill as part of their advocating the construction of a landfill at a particular location based on a minimum or near-minimum Subtitle C or D landfill liner - containment system design.

As discussed by Lee and Jones-Lee (1995b), professional civil engineers and those who are members of the National Association of Professional Engineers are obligated to conform to the organizations' code of ethics which requires full disclosure of potential problems in those situations where public health and safety is at stake. This situation is routinely ignored by professional engineers, where they adopt an adversarial approach of only informing regulatory agencies of the potential benefits of a particular landfill liner - cover containment and monitoring system design and fail to disclose the significant long-term deficiencies with this design. This issue is discussed further by Lee and Jones-Lee (1995b) where they recommend that the landfill siting process be conducted in a true peer review arena where all advocates of a particular

position must present, for full public and peer review, the technical basis for their position under the conditions where their peers can discuss the validity of that position.

Developing Protective Landfills

One of the issues that needs to be considered is whether Subtitle C and D landfills could be developed using the "dry tomb" landfilling approach that would be protective of groundwater resources for as long as the wastes in the landfill represent a threat. Lee and Jones-Lee (1995a) have provided guidance on how this can be accomplished. Basically, it involves the construction of all hazardous waste landfills and so-called non-hazardous waste landfills using double composite-lined systems with a reliable leak detection system between the two composite liners. This is the approach that is used in Michigan's Rule 641 for municipal solid waste landfills. Such landfills consist of a double composite lined system where the lower composite liner is part of a leak detection system for the upper composite liner. It is also the approach that is used by the US EPA in Subtitle C landfills except that the US EPA has failed to develop adequate Liner Action Leakage Rates which will be protective of the groundwaters in the vicinity of the landfill when the lower composite liner is no longer an effective barrier and leachate passes through it.

The approach that should be followed is that whenever the leachate leakage through the upper composite liner is sufficiently great so that the groundwaters under the landfill could be polluted, i.e. impaired use for domestic or other purposes, by the leakage through the liner, then the landfill owner/operator must stop the leakage through the upper composite liner or exhume the waste.

Since this liner cannot be inspected and repaired without removal of the wastes, stopping the leakage through it will require that an impermeable cover be installed on the landfill which has a primary component a leak detection system that is operated and maintained in perpetuity, i.e. as long as the wastes in the landfill represent a threat. The Robertson system, the Gundle -GSE leak detection system, the I-Corp leak detection system as well as others that are being developed can all potentially be used for this purpose. While these systems cannot function effectively in the landfill liner system, they can be made to work in the landfill cover, which is accessible for repair.

Todays RCRA Subtitle C and D landfill covers involve the use of the equivalent of a composite liner in which thin plastic sheeting and a compacted clay layer is constructed on top of the waste layer. This low permeability layer is designed to minimize but not prevent moisture from entering the landfill and generating leachate. Daniel and Koerner (1991) discuss the variety of factors that influence the stability of a landfill cover such as the differential settling of the waste which can be highly disruptive of the cover integrity. Typically landfill owners/operators will assert at a landfill permitting hearing that if any problems develop in the integrity of the landfill cover, that these will be repaired. However, the low permeability layer of the landfill cover (the plastic sheeting and compacted clay) are buried below several feet of top soil and a drainage layer. Cracks can develop in the low permeability layer which cannot be perceived upon visual inspection of the landfill cover. It is for this reason that Lee and Jones-Lee (1995c) advocate that leak detectable covers be used in Subtitle C and D landfills.

If the landfill owner/operator cannot or will not stop the leakage of leachate through the upper composite liner, then the owner/operator must remove (exhume) the wastes in the landfill, properly treat them, and manage the residues from such treatment in such as way as to not lead to further groundwater pollution. Failure to adopt this approach will mean that the waste in a landfill will pollute the groundwaters of the area. As discussed by Lee and Jones-Lee (1995a), such an approach requires that a dedicated trust fund be developed from disposal fees during the landfill's active life. This trust fund should be of sufficient magnitude to ensure that sufficient funds are present to operate and maintain the leak detectable cover, leachate collection system and the leak detection system between the two composite liners. While other financial instruments are currently allowed in RCRA post-closure funding, such financial instruments are likely to be unreliable. Hickman (1992, 1995) has discussed the importance of using a dedicated trust as a reliable financial instrument to address long-term contingencies associated with "dry tomb" type landfills.

The typical 30-year post-closure fund associated with both hazardous and non-hazardous waste landfills is grossly deficient compared to the funds that will likely be required during the 30-year period, much less the infinite period of time that funds will be needed to address contingencies that will ultimately have to be addressed at the landfill. An important aspect of this situation is whether private landfilling companies will, in fact, be economically viable in the future when the funds will be needed--20, 50, 100 or so years from now. As discussed by Lee and Jones-Lee (1993c, 1994b), private landfilling companies are accruing massive liabilities that ultimately will cause these firms stockholders to sell their stock from the firms, making the firms financially unstable, ultimately leading to their bankruptcy. This past year, at the annual meeting of the Waste Management of North America Stockholders, the WMX CEO, D. Buntrock, noted that WMX was losing money on its hazardous waste management business. D. Buntrock is quoted in the Chicago Tribune as stating at this meeting, "Most of us in the company wish today we never heard of the business." Situations such as this give little confidence that landfill companies will, in fact, meet their long-term obligations associated with post-closure care of landfills.

The US Congress General Accounting Office (GAO 1990) informed Congress in a report entitled, "Hazardous Waste Funding of Postclosure Liabilities Remains Uncertain," that the current regulatory approaches do not necessarily provide the funding that will be needed to address contingencies during their post-closure period, i.e., while the wastes remain a threat. Further, the GAO (1995) has reviewed the potential for funding the monitoring and maintenance of hazardous waste landfills and concluded that, at this time, there are high degrees of uncertainty about whether federal and state funds will, in fact, be available to provide for monitoring and maintenance and periodic (five year review) of hazardous waste landfills in accord with current regulatory requirements.

Some states, such as South Carolina, are beginning to address this issue by requiring that waste management companies post cash bonds to address long-term landfill contingencies.

While generally today, regulatory agencies are not adequately addressing the long-term issues associated with municipal and hazardous waste landfills ultimately failing to protect public health, groundwater resources and the environment from waste derived constituents, there is growing recognition of the deficiencies of current regulatory approaches where the minimum

landfill design for Subtitle C and D landfills is recognized as being badly out of date and not protective of public health and the environment for as long as the wastes in the landfill will be a threat. An encouraging situation recently developed in the state of Indiana where the Hazardous Waste Facility Siting Authority reviewed a Chemical Waste Management of Indiana proposal to expand a hazardous waste landfill where it became clear, that ultimately, that landfill would pollute groundwaters of interest to the city of New Haven which is located immediately adjacent to this landfill. The Siting Authority concluding in an eight to one vote that the landfill should not be expanded because of its potential to ultimately pollute groundwaters of interest to New Haven, Indiana.

With respect to Subtitle D landfills, a number of states, such as New York, New Jersey, Michigan, Pennsylvania, Kentucky, Oregon and Arizona, have adopted double composite-lined landfills as the minimum landfill liner design for situations where there are groundwaters underlying the landfill that could be polluted by landfill leachate at any time in the future. California has had regulations (Water Resources Control Board, Chapter 15) since the mid-1980s that require that hazardous waste landfills not leak leachate through the liner system for as long as the wastes in the landfill represent a threat, and municipal solid waste landfills not allow sufficient leachate to pass through the liner system to potentially impair the uses of the groundwaters based on the concentrations of constituents in the unsaturated zone underlying the landfill for as long as the wastes represent a threat. While, such approaches appear, from a regulatory perspective to be highly protective, in fact, based on the way in which the Chapter 15 regulations have been implemented at the regional board level do not provide for this level of protection. Instead, the regional boards have been allowing landfill applications to construct landfills that, obviously, will not protect groundwaters from pollution by landfill leachate for as long as the wastes in the landfill will be a threat.

The justification for this approach is based on that mention is made in the regulations of minimum landfill liner cover - containment system design requirements. Even though the regulations explicitly state that the minimum requirements are not necessarily protective at all sites and that the liner cover - containment system must protect groundwaters from impaired use for as long as the wastes in the landfill represent a threat. The inappropriate interpretation of the regulations that is routinely occurring today in California by regional boards where the minimum design is determined to be equivalent to the groundwater quality protection performance standards set forth in the regulations is extremely short-sighted and contrary to public health, groundwater resources and the protection of the environment. This approach has allowed the construction of municipal solid waste landfills that will obviously not conform to the basic regulatory requirements of protecting groundwaters from impaired use from waste associated constituents for as long as the waste represent a threat.

Summary and Conclusions

Municipal solid waste and hazardous waste landfills of the type being developed today in which either a single composite or a double composite-liner is used as a containment system for the wastes and collection system for landfill leachate are likely and will ultimately lead to groundwater pollution by leachate for those landfills sited at locations where there is a hydraulic connection between the base of the landfill and groundwaters that are or could be used for

domestic and other water supply purposes at any time in the infinite future. The failure of being able to specifically show groundwater pollution by Subtitle C and D landfills today should not be interpreted to mean that groundwater pollution has not nor will not occur in the future. The basic problem with such an approach is that the monitoring systems used to detect landfill liner leakage involving vertical monitoring wells at the point of compliance for groundwater pollution is a fundamentally flawed approach that has a low probability of detecting initial liner leakage before widespread groundwater pollution occurs.

Based on characteristics of the rate of movement of leachate through the unsaturated and saturated zone, the characteristics of the liners and the reliability of the groundwater monitoring systems that are being used today, it is concluded that it would be, indeed, rare that groundwater pollution at the point of compliance for Subtitle C and D landfills would, in fact, be detected today. These landfills have only been constructed for a relatively short period of time. In many situations, the rate of migration of leachate through the liner and subsurface strata would not be sufficiently great to be detected in monitoring wells that happen to intercept the finger plumes of leachate that are being generated or will be generated by leakage through the liner system.

Ultimately, all Subtitle C and D landfills have the potential to pollute groundwaters hydraulically connected to them. It is only a matter of time when this occurs. There is an urgent need to update RCRA to develop regulatory approaches that will, in fact, protect groundwaters from pollution by landfill leachate for as long as the wastes in a hazardous waste or municipal solid waste landfill represent a threat. Until this update occurs, the siting of landfills should be done in accord with reliably informing the regulatory agencies and the public that the current regulatory approach in developing Subtitle C and D landfills is not protective of public health, groundwater resources and the environment from pollution by landfill leachate for as long as the wastes in the landfill represent a threat.

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