Expectations of Performance of Subtitle D Landfills:
Comments on
"End of Life, Post-Closure Care, and the Sustainable Landfill" by J. Morris

Comments by
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The May 2012 issue of MSW Management carried an editorial (dated Monday, March 19, 2012) by Jeremy W.F. Morris of Geosyntec Consultants, a landfill development consulting firm, entitled, *"End of Life, Post-Closure Care, and the Sustainable Landfill"* (available at: http://www.mswmanagement.com/MSW/Editorial/End_of_Life_PostClosure_Care_and_the_Sustainable_L_16397.aspx).

Presented below are comments on several aspects of that editorial that are misleading or technically inaccurate. Detailed discussion of the issues raised and related concerns, with extensive reference to the technical literature, is provided in:

> Lee, G. F., and Jones-Lee, A., "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004). Updated July (2011). http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf (referred to herein as our "flawed technology" review).

The editorial subtitle/introductory text states:
"*The last few decades have seen tremendous advances in landfill technology and regulation resulting in the complex multidisciplinary, scientifically defensible, and professionally accountable approaches employed today*."
That statement is highly misleading. As discussed below, and as is well-known in the landfill professional literature, today's US EPA-approved Subtitle D "dry-tomb"-type landfills are **not** *"scientifically defensible and professionally accountable"* for providing a high degree of protection of public health and environmental quality from pollution by hazardous and otherwise deleterious components of landfilled wastes for as long as the wastes will be a threat. "*Complex*" and "*multidisciplinary*" requirements are not tantamount to requirements that would actually ensure the achievement of such protection.

MSW "dry-tomb" landfilling is characterized in part in the first two paragraphs of the editorial as follows:
"*The modern technology of MSW landfilling results in anaerobic biodegradation processes occurring in the waste mass, producing leachate and landfill gas (LFG) that are contained and controlled by engineered collection and treatment systems.*"

"*The modern basis for the industry as a whole is integrated control of waste generation, storage, collection, transfer and transport, processing, and disposal in a manner according to best* *principles of public health, economics, engineering, conservation, aesthetics, and environmental performance, and that is responsive to public attitudes.*"

Shielded with the characterization of such landfills as incorporating "*modern*" technology, those statements misrepresent the realities of the aim of, and protection provided by, Subtitle D landfills over the very long periods of time (hundreds to a thousand years or more) during which the buried wastes will be a threat to release pollutants to the environment. The reality is that what is labeled in the editorial as "*modern technology*" – i.e., Subtitle D landfilling – is intended to **prevent** biodegradation of buried wastes. The intent of the "low-permeability" cover placed over buried wastes is to keep moisture, which is requisite for biodegradation, out of the landfill. Biodegradation is an inevitable occurrence only if buried decomposable wastes are exposed to precipitation. Another misleading element of the first statement is that it does not reveal that only some of the components of MSW undergo biodegradation; much of the waste disposed of in MSW landfills is not subject to biodegradation but is, however, capable of leaching hazardous and otherwise deleterious chemicals. In short, the only way that MSW in Subtitle D landfills will lose their potential to generate leachate that can adversely affect groundwater exposed to it is for there to be massive failure of the containment system that lets in moisture to decompose the decomposable organics and to leach and rinse the remaining wastes of leachable components. Only at that point will the buried wastes no longer pose a threat to public health/welfare and environmental quality. However, the point of Subtitle D postclosure care is to keep moisture out of the landfill. And store the wastes in a "dry tomb."

While the second quoted statement sounds comforting and reassuring, the fact is that the MSW landfilling practice is **not** rooted in *"best principles of public health, economics, engineering, conservation, aesthetics, and environmental performance, and that is responsive to public attitudes.*" This has been clear since the US EPA adopted, in the early 1990s, the Subtitle D landfilling regulations that require the use of the "dry tomb" landfilling approach that employs plastic sheeting and compacted clay composite liners and a landfill cover in an effort to entomb waste and delay pollution. At best, Subtitle D landfills that are sited, designed, operated, closed, and receive postclosure care following the standard minimum practice prescribed by Subtitle D will only provide temporary containment of waste-derived chemicals that are a threat to groundwater quality and the public health and welfare of those who own or use properties near the landfill. This reality continues to spawn justified NIMBY positions among those who live, work, or use property near Subtitle D landfills; it also speaks to the overall adequacy of the "*responsiveness to public attitude.*" The long-term consequences of the "modern" Subtitle D landfilling are borne largely by those within the sphere of influence of the landfill, who are typically people in less populated areas. Waste generators in more heavily populated areas enjoy the disappearance of their MSW (i.e., waste "management) for cheaper-than-real costs as the public health and welfare costs of the "management" of their wastes are borne by those in the landfill area.

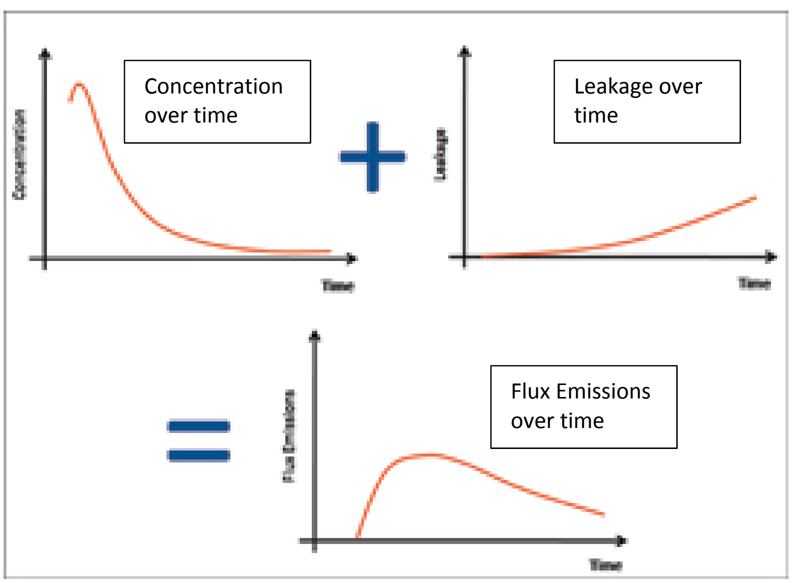
The editorial states in its second paragraph:
"*This article seeks to provide a useful definition of landfill sustainability based to end of life (EOL) considerations, post-closure care (PCC), and the intended end use of the facility once PCC has been completed. By relating sustainability to the "functional stability" of the landfill, that is, the landfill's long-term non-impacting relationship with its receiving environment in the*

absence of some or all active PCC provisions (definition originally proposed by SWANA's Bioreactor Committee, June 2004; cited. in EREF, 2006), it is argued that the path to sustainability can be reached through a combination of enhanced waste degradation (e.g., bioreactor technology), use of passive fail-safe design and engineering features (e.g., wetlands, phytocaps, biocovers, and other self-sustaining natural analog systems that mimic local ecosystems as closely as possible), and by defining PCC control systems and end-use conditions that emphasize environmental responsibility and engagement of the host community, and minimize the need for land-use restrictions and buffers after completion of active PCC. In this way, the landfill property can be a community asset that requires minimal long-term active *maintenance while remaining protective of human health and the environment (HHE)."*

As discussed elsewhere, while those goals and desires are certainly noble, they do not reflect the reality of the nature of the wastes buried or of the limitations of the technology used in their "dry tomb" burial, including the following aspects. MSW buried in "dry tomb"-type landfills will remain a threat to pollute groundwater for as long as they are kept dry. Pollution prevention is dependent on keeping the wastes dry, which greatly limits the appropriate re-use of the closed landfill surface. Breaches and areas of deterioration in the waste containment features will not likely be amenable to ready identification and repair as they will be buried beneath the garbage or landfill cover. In sort, Subtitle D landfill design and engineering features can in no way be considered *"fail-safe."*

In the section entitled, "*Sustainability Concepts*," Morris presented the following figure in describing his understanding of the behavior of landfill characteristics over time (axis description added for clarity).

"*Figure 1. Qualitative Long-Term Behavior of Potential Landfill Emissions*"



The patterns illustrated, however, are not representative of a "modern" Subtitle D "dry tomb"-type landfill. The leachate concentration graph illustrates a pattern characteristic of a classical, unlined "sanitary landfill" in which the soil cover is sufficiently permeable to allow a substantial amount of the moisture that falls on the landfill surface to penetrate into the landfilled wastes. There, the moisture promotes biodegradation of decomposable organics and leaching of leachable components of the buried wastes. Over time, as the wastes are leached and rinsed by incoming moisture, concentrations of waste components in leachate decrease. A "dry tomb"-type landfill is designed with the intention of keeping moisture out of the wastes. As long as the wastes are kept dry, biodegradation will not occur and leachate will not be generated. It is only with failures of the containment system that a closed "dry tomb"-type landfill will generate leachate. During the period that a "dry tomb"-type landfill keeps the wastes dry, however, biodegradable and leachable components of the waste are not decreasing or being transformed into benign materials.

Similarly, the leakage rate graph is indicative of leakage from a classical unlined "sanitary landfill;" for that type of landfill the rate of landfill leakage is directly proportional to the rate of entrance of water through the soil covering. As discussed above, a Subtitle D landfill is intended to keep moisture out of the landfill. A well-designed/constructed, well-maintained, high-functioning Subtitle D landfill may well be capable of delaying the generation of leachate for decades, but irrespective of monitoring and cosmetic maintenance, the containment systems will deteriorate over time and inevitably fail to prevent leachate generation. Failure in one aspect of the system can be expected to accelerate and exacerbate failures in others. To the extent that the sites of breach buried beneath the cover soil and/or wastes can be identified and repaired, leachate generation and leakage may be halted until other breaches occur in the overall aging/degrading system.

In short, the overall message of Morris' Figure 1, that once substantial leakage occurs from a "modern" Subtitle D landfill the concentrations of contaminants in the leachate will be low and will result in minimal flux, is in error. To the contrary, as Subtitle D containment systems fail and the landfill leaks, the buried wastes will not have been degraded and leached to render low pollutant concentrations. Rather, leakage from Subtitle D landfills can be expected to be unpredictable emissions of potent leachate, the duration and recurrence of which will depend on the rate and efficacy of repair and continued maintenance of the landfill cover.

In the section entitled, *"Evaluation of Threats Posed by Landfills,"* the editorial reads: *"If the chemical, biological, or physical constituents of waste, leachate, or LFG come into contact with humans or the environment (i.e., receptors) above certain levels, then it is possible that the constituents could affect the receptors. Releases from landfills can affect the environment by migrating into one or more of four primary media: air, groundwater, surface water, and/or the vadose zone (i.e., soil pore spaces). In general, impacts to humans and other receptors occur through these media and, therefore, they represent the link between the contents of a landfill and potential impacts to HHE* [human health and the environment]. *By understanding the manner in which these media can be affected by a release from a landfill, potential impacts to HHE can be predicted and avoided, and plans can be developed to monitor for the presence of an impact.*

The potential threat to HHE posed by the MSW contained in a landfill is directly associated with its degradable organic carbon content and the presence of other constituents like nitrogen (e.g., ammonia), heavy metals (e.g., arsenic, chromium), and inorganic ions (e.g., chloride). Anaerobic biodegradation of MSW produces leachate and LFG and also results in significant settlement of the waste body over time. The quantity and concentration (flux) of landfill emissions and the extent of settlement will decrease over time. The primary function of the engineering controls, careful siting, and management of landfills is to minimize and mitigate landfill emissions as waste degrades until such time that they are sufficiently low and/or environmentally benign that active operation or maintenance of control systems is no longer required to ensure protection of HHE (at which point the landfill is functionally stable)."

A number of the technical deficiencies manifested in the quoted passage were discussed above, including fundamental flaws in the conclusions regarding "flux." While Morris named a number of materials in MSW that pose a threat to human health and environmental quality, glaringly absent was reference to myriad recognized hazardous or otherwise deleterious chemicals associated with materials that are legally placed in MSW landfills; presently unrecognized, unmeasured, and unregulated hazardous chemicals; pharmaceuticals and personal care products (PPCPs). The final quoted statement is particularly disturbing:
"The primary function of the engineering controls, careful siting, and management of landfills is to minimize and mitigate landfill emissions as waste degrades until such time that they are sufficiently low and/or environmentally benign that active operation or maintenance of control systems is no longer required to ensure protection of HHE (at which point the landfill is functionally stable)."

As discussed above, this statement does not reflect an understanding of the nature of MSW buried in Subtitle D landfills, the processes that act upon those wastes while buried in a Subtitle D landfill as opposed to in a classical "sanitary landfill," or the primary function of the engineering controls in light of the behavior of wastes buried in Subtitle D landfills. It also does not reflect an understanding of the nature and potential impacts of leachate that leaks from Subtitle D landfills, or that engineered containment systems must be maintained and monitored essentially in perpetuity to provide protection of public health and environmental quality from the buried wastes.

Unrecognized in the Morris' editorial is that the presence or absence of water in buried waste controls the rate of landfill gas and leachate formation and that the goal of Subtitle D landfill containment requirements is to keep water out of the buried wastes. As long as the wastes are kept dry (i.e., as long as the containment systems are effective in keeping water out of the landfill), microbiological processes do not take place to decompose decomposable organic matter and chemicals are not rendered innocuous or leached from the solid wastes. As noted above and as discussed in our "flawed technology" review, the prevention of pollution of the environment by wastes buried in a "dry tomb"-type landfill is controlled in substantial part by the ability of the landfill cover to keep water from entering the landfilled wastes. As long as the integrity of a properly designed and placed cover is maintained, the wastes may be expected to remain in a dormant state; in that state, which can last for hundreds of years – as long as the integrity of the cover is maintained – the wastes retain their potential to generate leachate that can lead to groundwater pollution.

As discussed in our "flawed technology" review, based on what is known about even well-developed "dry tomb"-type landfills, a more realistic representation of landfill gas and leachate generation/formation over time would show multiple peaks over decades to centuries. The first peak would be associated with gas generation that occurs during the active life of the landfill before the low-permeability cover is installed; as the wastes dry, generation of gas would decline. A second peak in landfill gas and leachate generation would begin as the integrity of the cover is breached or deteriorates allowing moisture into the landfill to interact with decomposable wastes. When that rise in landfill gas production begins would be a function of the quality of the design, materials, and placement of the cover, as well as the rigor of cover maintenance and repair. How high the peak is and how long it lasts would depend on how quickly the cover breach is detected and located, and how well it is repaired. Because key low-permeability elements of a cover are buried and not amenable to rigorous inspection and immediate repair or replacement, if monitoring for landfill gas had been already been stopped (owing, for example, to the lack of evidence of gas or leachate formation during the dormancy and presumption that it would occur no more) the first evidence of cover failure may be the presence of leachate in a leachate collection system, provided that that system is functioning properly and monitored. If the flaws and/or areas of deterioration in the cover are repaired in a manner that prevents further entrance of water into the landfill, the wastes would eventually dry and gas and leachate production would be expected to subside. This cycle of cover breach, gas generation, cover repair, drying and cessation of gas production will continue until all the fermentable wastes have been fermented. How many cycles occur, and their intervals and severity will depend on long-term landfill maintenance. The better-maintained the landfill is in the decades and centuries after closure, the longer the period over which gas production can occur. The deterioration of plastics in the wastes (such as garbage bags) and the exposure of the wastes contained in them to moisture can be expected to create additional peaks of landfill gas production; the evidence and timing of such peaks depends on how resistant the plastic bags are to degradation. The "output" of simplistic waste fermentation models such as the US EPA LandGem model does not account for these aspects of the characteristics and behavior of "dry tomb"-type landfills.

The cessation of gas generation owing to the fermentation of all fermentable wastes in a landfill does not signal that the potential for leachate generation has ceased. Leachate will be able to be generated as long as leachable wastes remain buried. Thus the sequence of peaks in leachate generation can be expected to continue beyond the point at which gas generation peaks have ceased.

Morris identifies *"Objectives for Landfill Sustainability"* as follows:
"For the purpose of this discussion, and in the spirit of the USEPA's position on sustainability, a sustainable MSW landfill is defined as a landfill whereby

- *byproducts of waste degradation are managed so that outputs are controlled or released in an acceptable manner;*
- *residues will not pose an unacceptable human health or environmental threat to the surrounding natural systems;*

- *the time needed for active management is minimized (albeit that there might be a longer term monitoring period);*
- *costs for long-term active management and monitoring of a closed landfill are not passed onto future generations; and*
- *future uses of groundwater and/or other natural resources are not compromised.*

In practical terms, any discussion on landfill sustainability must include goals for EOL and PCC, because realization of the above sustainability objectives requires a landfill owner/operator to focus on proactively reducing a landfill's threat potential through optimizing design, operations, and management during the operating life of the facility (i.e., long before landfill closure and the onset of PCC). Performance objectives for landfill sustainability (i.e., defining EOL and PCC) are thus related to the following:

- *Waste containment—the integrity of the containment systems is essential to control waste contact/emissions while a threat to HHE remains.*
- *Waste treatment—the extent of biodegradation and proactive efforts to reduce threats to HHE can be achieved through design and operational changes.*
- *Maintenance and monitoring—reliable data of waste byproduct quantity and quality as well as data on potentially affected media is needed to ensure that containment and treatment are ongoing while necessary and to confirm that no significant variations in predicted media conditions have occurred, particularly if changes to containment or treatment systems have been implemented."*

The above listing of "*Objectives for Landfill Sustainability*" reflect appropriate goals for MSW landfills during the active life and throughout the postclosure period while the wastes in the landfill, when contacted with water, can generate landfill gas and/or leachate. However, those objectives have little hope of being realized over the long-term with "dry tomb"-type landfilling as being allowed under Subtitle D. Our overview "flawed technology" discussion referenced above addresses technical aspects of Subtitle D-allowed location, design, operation, closure, and postclosure care that render it a "flawed technology" for developing MSW landfills that can be reasonably expected to protect public health/welfare and environmental quality for as long as the wastes in the dry tomb landfill will be a threat.

The current approach of many state and federal regulatory agencies is to permit MSW landfills without proper determination that the site affords reliable natural protection of groundwater quality. The allowed design of landfill liner systems should be, but is not, tied to the documentation of natural protection of the groundwater system underlying and near the landfill to prevent leachate that will inevitably penetrate the liner system from migrating outside the area under the landfill footprint during the hundreds of years that the wastes in the landfill will be a threat to generate leachate when contacted by water. Without reliable documentation of such natural protection, a single-composite liner should not be permitted at a location where leachate could migrate from beneath the landfill footprint to offsite areas. In addition, rates of groundwater movement should be estimated based on the highest groundwater permeability in the area, not the geometric average permeability as is typically done. Groundwater moving at a rate of a few feet per year will eventually allow offsite groundwater pollution. Single-composite-lined landfills sited in areas where the inevitable eventual liner failure will allow leachate-pollution of offsite groundwater do not provide for protection of groundwater quality.

From G. F. Lee's experience in the review of the siting and design provisions of more than 80 proposed MSW landfills, it is rare that the hydrogeology of the area under a proposed landfill's footprint provides adequate natural protection of groundwater quality from pollution by the eventual failure of a single-composite-liner over the hundreds of years that the wastes in the landfill will be a threat to generate leachate when contacted by water.

Another reason that single-composite liners should not be allowed for MSW landfills is the grossly inadequate and unreliable groundwater monitoring systems that are allowed and relied upon for the detection of incipient groundwater pollution/containment failure. While Subtitle D "requires" that incipient groundwater pollution be able to be detected at the point of compliance, the monitoring programs typically allowed by state and federal regulatory agencies are not capable of providing reliable early detection. State and federal regulatory agencies typically allow groundwater monitoring programs that consist of vertical monitoring wells spaced hundreds of feet apart around the perimeter of the landfill property, the point of compliance. The typical monitoring well has a zone of groundwater capture that extends about one foot around the well after three well-volumes have been purged. It is well-established in the technical literature (as discussed in our "flawed technology" review) that the initial plumes of leachate-polluted groundwater that arise near the down-groundwater gradient side of the landfill will often be narrow, i.e., a few feet wide, finger-like plumes at the point of compliance for groundwater monitoring. Monitoring wells with typical zones of capture and spaced hundreds of feet apart at the point of compliance will have a very low probability of detecting leachate-polluted groundwater when it first reaches the point of compliance as required by US EPA Subtitle D landfill regulations; such groundwater monitoring programs will thus allow offsite pollution before the leakage is detected. First evidence of leachate leakage may well be the pollution of an unsuspecting offsite well.

The typical groundwater monitoring systems allowed by regulatory agencies are largely cosmetic – to give the appearance of protection of offsite groundwater – but will not enable reliable detection of leachate pollution before widespread groundwater pollution occurs offsite. We have recommended that as a starting point for addressing this deficiency, regulatory agencies require landfill developers to conduct detailed analyses of the potential reliability of their proposed point-of-compliance groundwater monitoring well arrays for detecting the front of the finger of leachate-polluted groundwater that would be caused by a two-foot-long tear or area of deterioration in the liner on the down-groundwater-gradient side of the landfill liner. (In reality, the first breach of a landfill liner may well be smaller than a 2-ft rip.) Such an analysis will require the reliable estimation of the width of the leachate-pollution plume at the point of compliance for groundwater monitoring considering the lateral spread of the two-foot-wide leak, as well as the zones of capture of the monitoring wells that will occur. A proper analysis will reveal just how protective of offsite groundwater quality the monitoring well array could be if it were to remain equally functional for the essentially *ad infinitum* period that the groundwater will need protection from wastes buried in the landfill.

Some states such as Michigan have adopted the requirement for double-composite liners for MSW landfills; with such systems, the failure of the upper composite liner is detected by the presence of leachate in the leak detection layer that is present between two composite liners.

When leachate is detected in the leak detection layer then action needs to be taken to improve the integrity of the landfill cover to prevent water from entering the wastes through the cover. This approach also requires that postclosure funding be available to locate the area of deterioration of the plastic sheeting in the landfill cover that is buried under the top soil and drainage layer in the cover over the period that the wastes in the landfill will be a threat to generate leachate when contacted by water. That period can be expected to be hundreds of years.

The typical landfill permit application includes estimates of the amount of leachate that will be generated. Landfill applicants use the HELP model and estimated characteristics of the landfill cover to predict water penetration through the landfill cover. The leakage rate of water through a landfill cover estimated using the HELP model is likely to be reasonably accurate for a newly constructed, high-quality landfill cover. However, over the period of time that the landfill cover is required to keep the wastes dry, the ability of the landfill cover to prevent water from penetration will deteriorate; over time, increasing amounts of water will be expected to penetrate through the cover than those predicted by the HELP model. Basically the HELP model as typically used is not reliable for estimating leachate generation over the hundreds of years that the wastes in a "dry tomb"-type landfill will be a threat.

By far the most significant deficiency in the US EPA Subtitle D MSW landfill regulations is that that they require only 30 years of assured postclosure funding, and that that funding only addresses some of the postclosure issues and activities that will need to be carried out during the time that the wastes in a "dry tomb"-type landfill will be a threat to pollute the environment. The designation of a 30-year period for postclosure funding and care was a significant error made by Congress in adopting RCRA. While it has been widely recognized for more than three decades that 30 years is an infinitesimal portion of the period during which wastes in a Subtitle D landfill will be a threat, Congress and the US EPA have failed to correct this error. As long as the wastes remain in the landfill, funding will be required for monitoring and maintenance activities at Subtitle D landfills, including the following activities:

- removal and treatment of leachate that accumulates in the leachate collection system,
- maintenance and repair of leachate collection system from plugging,
- monitoring and maintenance of the groundwater wells,
- monitoring of the surface runoff from the landfill area,
- operation and maintenance of the landfill gas collection and monitoring system,
- maintenance and repair/replacement of the landfill cover, including the plastic sheeting layer,
- eventual remediation of the polluted groundwater that will occur.

As noted previously, and discussed in our "flawed technology" review, the passage of time does not reduce the need for monitoring and maintenance of a "dry tomb"-type landfill. Rather, it increases the need as well as the public health/welfare and environmental quality impact implications of failing to provide it owing to the inevitable and predictable deterioration of the engineered "containment" systems and the perpetual and inescapable need to keep the buried wastes dry.

A particularly glaring deficiency in postclosure funding is that in enforcing Subtitle D requirements, regulatory agencies do not require that landfill applicants include funds for perpetual repair/replacement of the plastic sheeting layer in the cover. While the integrity of that layer may be retained during the required 30 years of postclosure funding, there is no doubt that over the hundreds of years that the wastes in a dry tomb landfill will be a threat to generate leachate when contacted by water, the integrity of the plastic sheeting layer in the cover will deteriorate and allow water to pass through sections of the cover and generate leachate. Once leachate generation is eventually detected in the leachate collection system, substantial funds will be needed to find the area(s) of deterioration or breach in the plastic sheeting layer and to make necessary repairs. Since the plastic sheeting in the cover is buried within the cover, it is not amenable to routine, thorough inspection that would reveal areas of deterioration/breach before substantial leachate is generated.

It will likely be very difficult to get a private landfill owner (if he is still in business) to provide funds for monitoring, maintenance, repair, and restitution after the end of the mandatory postclosure period; by that time the landfill will not have generated any proceeds from disposal activities for three decades or more. In order to develop a potentially protective MSW "dry tomb" landfill, the permitting of the landfill must include assured funding for replacement of the plastic sheeting layer in the cover multiple times over the hundreds or more years that the wastes will remain a threat. The needs for cover repair can be determined during the postclosure period when leachate is found in the leachate collection system. This applies to both the single and double-composite-lined landfills.

Morris' editorial fails to reliably discuss postclosure funding needs that can be readily anticipated. These issues are discussed in greater detail in the following reports:

> Lee, G. F., and Jones-Lee, A., "Review of Potential Impacts of Landfills & Associated Postclosure Cost Issues," Report of G. Fred Lee & Associates, El Macero, CA, April (2012). http://www.gfredlee.com/Landfills/Postclosure_Cost_Issues.pdf
>
> Lee, G. F., and Jones-Lee, A., "Checklist of MSW Landfill Groundwater and Environmental Protection Issues," Report of G. Fred Lee & Associates, El Macero, CA, April (2012). http://www.gfredlee.com/Landfills/Checklist_LF_Issues.pdf

Morris' editorial includes two examples cited as case studies of approaches for managing excess leachate that cannot be managed by leachate recirculation. Neither of those examples addresses the potential for landfill liner failure that leads to groundwater pollution. While the editorial mentions the use of bioreactor landfill operations to reduce the period of time during which the wastes in a landfill will be a threat, it does not discuss the inherent, significant drawbacks and limitations to the application of those approaches with landfills conforming to Subtitle D requirements. A summary of our experience in reviewing the use of leachate recycle to reduce the period of time that buried wastes will generate leachate and landfill gas that can lead to environmental pollution, as well as of the technical literature on this issue, is included in our "flawed technology" review cited above.

The final section of Morris' editorial begins:
"*The Path Toward Sustainability*
This article has proffered some objectives for landfill sustainability and explored methods by which performance-based evaluations of PCC and proactive design, operation, and end use considerations can aid meeting such objectives. The demonstration of functional stability considered necessary to define PCC in terms of performance requires clear understanding

of site-specific landfill characteristics, not least long-term trends in leachate generation and quality. Innovative operational practices such as bio-reactors are specifically designed to enhance the rate of degradation resulting in a greater rate of LFG production during the period of time the landfill is operating. Such LFG recovery enhancements provide for potential beneficial use LFG recovery projects whether the site is open or closed. Bioreactors can also be designed and operated to manage and reduce the long-term threat of organics and inorganics in the waste mass. For example, recent research provides evidence that landfills have significant capacity to convert nitrate to nitrogen gas that can be safely released to the atmosphere; thus, providing a viable alternative for long term management of nitrogen in landfills (Price et al, 2003)."

While the editorial discusses general aspects of some issues of importance in reducing the long-term pollution by landfills, a key issue that was not emphasized – but that needs to be included in planning for long-term sustainability – is initial permitting and the need to require as part of permitting, appropriate and adequate siting, design, operations, maintenance, and funding for closure and postclosure funding monitoring and maintenance, all with the open recognition of the realities of the limitations of engineered containment systems, of the behavior of wastes in the landfill systems created, and of the long-term threats posed by the wastes. Guidance on addressing these issues is provided in our "flawed technology" review, our "Review of Potential Impacts of Landfills & Associated Postclosure Cost Issues" referenced above, and in other papers and reports in the Landfills and Groundwater section of our website, www.gfredlee.com, at:http://www.gfredlee.com/plandfil2.htm.