Electronic Wastes and MSW Landfill Pollution of Groundwater

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Summary

The issue of potential water quality impacts caused by the disposal of electronic wastes in municipal solid waste (MSW) landfills has recently surfaced again in a New York Times article. That article advanced the position that the disposal of electronic wastes in municipal landfills leads to groundwater pollution by heavy metals. The US EPA headquarters responded to that article claiming that the disposal of electronic wastes in municipal landfills will not lead to groundwater pollution by heavy metals owing in part to the protection afforded groundwater resources by current landfill regulations. Presented below is a discussion of the current technical understanding regarding the potential for heavy metals associated with electronic wastes disposed of in MSW landfills to cause groundwater pollution. Included is pertinent information on the potential pollution of groundwaters by today's so-called modern landfills. Leachate from some MSW landfills contains sufficient heavy metals to pollute groundwaters, and can be expected to cause such pollution as the landfill liner systems deteriorate and fail to completely or reliably collect and remove the leachate. At this time it is unclear whether or not the disposal of electronic wastes in MSW landfills will significantly increase the heavy metal-pollution of groundwaters once the liners systems fail to collect and remove all leachate generated in the landfill. It is clear, however, that the US EPA's assessment, in response to the NY Times article on the potential of electronic wastes to cause groundwater pollution, is not in accord with technical information available on this issue. Until such time as it is demonstrated that electronics-derived heavy metals make inconsequential contributions to MSW landfill leachate heavy metal concentrations, prudent public health and groundwater protection policy and practice would indicate that disposal of electronic wastes in MSW landfills should be prohibited.

Background

On June 29, 2009, Leslie Kaufman, a writer for the New York Times, published an article at NYTimes.com entitled, "A Green Way to Dump Low-Tech Electronics," that advocated for recycling, rather than landfilling, electronic wastes. That article elicited response from the US EPA that the deposition of electronic wastes in municipal solid waste landfills does not, and will not, cause groundwater pollution by heavy metals. We have been involved in reviewing environmental quality impacts of municipal solid waste (MSW) landfills since the 1960s, including impacts of heavy metals in MSW leachate ("garbage juice" produced when water contacts the waste). Presented herein is a discussion of technical aspects surrounding the potential impacts on groundwater quality associated with the disposal of electronic wastes in today's "modern" MSW landfills. This discussion is provided in the context of the presence of heavy metals in MSW leachate and the ability of today's MSW landfills to prevent groundwater pollution by heavy metals in MSW leachate.

Heavy Metals in Leachate from Today's MSW Landfills

Lee has reviewed many aspects of the presence and potential consequences of heavy metals in MSW leachate in several reports and publications including:

- Lee, G. F., "Comments on the SWANA Summary Report, 'Recent Studies Indicate Minimal Heavy Metal Releases from MSW Landfills,' with Responses by Jeremy O'Brien for SWANA, and with Responses by Lee to O'Brien's Comments," Report of G. Fred Lee & Associates, El Macero, CA, August (2006). (Published in *MSW Management* – Counterpoint, June 1 (2006).
  [http://www.mswmanagement.com/elements-2007/comments-on-obriens-responses-on-water-quality-significance.aspx?ht=])
  [http://www.gfredlee.com/Landfills/CommSWANASummary.pdf]
- Lee, G. F., "Comments on 'The Effectiveness of Municipal Solid Waste Landfills in Controlling Releases of Heavy Metals to the Environment,'" Report of G. Fred Lee & Associates, El Macero, CA, July (2004).
  http://www.gfredlee.com/Landfills/SWANA-heavymetals-comments.pdf

Those comments were prepared in response to J. O'Brien's (Executive Director of the Solid Waste Association of North America (SWANA)) claims that municipal solid waste landfills are not a significant source of heavy metals that could pollute groundwaters and pose a threat to the health of those who use the groundwaters as domestic water supplies. His claim was fundamentally that MSW does not generate significant amounts of heavy metals in leachate, and even if it did, MSW landfills that are built today so as to prevent pollution of groundwater. Neither of his arguments is reliable. As discussed by Lee (2004, 2006) cited above, O'Brien's position was based in what are demonstrably technically invalid approaches for evaluating whether the heavy metals in MSW landfill leachate represent a threat to pollute groundwater to a sufficient extent to impair its use for domestic water supply. Those bases included results of contrived TCLP (Toxicity Characteristic Leaching Procedure) evaluations and the perceived perpetual integrity of landfill systems to prevent leakage of leachate.

Lee (2004) discussed, at length, the issue of the leaching of heavy metals from MSW, and significant technical deficiencies in the use of TCLP results for assessing leachability of MSW components. Lee also discussed how even the SWANA-reported concentrations of heavy metals in today's MSW leachate are sufficient at some locations to cause significant adverse impacts on groundwater quality and surface water quality. Among heavy metals in MSW leachate, lead presents the greatest threat for pollution of groundwater that serves as domestic water supply. Lee (2004, 2006) noted that leachate from some MSW landfills contains sufficient concentrations of lead to cause leachate-contaminated groundwater to contain levels of lead that impair the use of the groundwater for domestic water supply.

Another fundamental fallacy contributing to O'Brien's conclusions regarding the threat posed by heavy metals such as lead in MSW landfills is his assumption that the siting, design, operation, closure, 30-year postclosure care, monitoring, and remediation provisions are such as to preclude the pollution of groundwater by landfill leachate-associated pollutants. However, as discussed by Lee and Jones-Lee 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 December (2008).

which is available on our website at:
http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

today's Subtitle D landfills at best only postpone groundwater pollution by landfill leachate.

The truth is that today's so-called modern MSW landfills will, over time, allow the development of landfill leachate and the penetration of leachate through the landfill liner. Further, the monitoring, maintenance, and funding provisions are such that consequent pollution of groundwater with a wide range of pollutants that are typically present in MSW leachate, including heavy metals, can occur and pose a threat to the health of those who use the groundwater as a domestic water supply. Today's Subtitle D MSW landfills are based on a "dry tomb" approach by which an attempt is made to prevent water from contacting the wastes once the landfill is closed, i.e., no longer accepts solid wastes and is covered by a landfill cover. Such landfills also include a leachate collection system that is intended to collect all leachate generated in the landfill and remove it from the landfill, thus, in principle, prevent groundwater pollution by landfill leachate. However, among other deficiencies in the approach, the US EPA only requires that funding of monitoring and maintenance of the landfill cover and leachate collection system be conducted for 30 years after the landfill is closed (the postclosure period). The specification of a 30-year postclosure period was one of the most significant errors made by the US EPA in adopting Subtitle D MSW landfilling regulations because in a dry-tomb-type landfill (in which an attempt is made to isolate the wastes from water) the wastes in the landfill will be threat to generate leachate for very long periods of time well-beyond the 30-year required minimum postclosure care period. There is no assured funding for postclosure care for as long as the wastes in the MSW landfill will be a threat, which can readily be many decades to hundreds or thousands or more years.

Minimum-design Subtitle D MSW landfills that are typically being allowed under current US EPA and many states' regulations rely on plastic-sheeting and compacted clay liners to prevent the escape of leachate from the landfill. While a dry-tomb containment system may be effective in keeping the wastes dry and thus retarding the production of leachate for a few decades, and during the 30-year postclosure period, give the impression that the landfill is "safe," over time, cover and liner systems deteriorate and fail to prevent passage of moisture into the landfill and leachate through the liner that can lead to groundwater pollution. Inasmuch as liner systems are buried beneath the MSW, they are not amenable to thorough inspection and repair. Further, and most importantly, the groundwater monitoring systems being allowed by many states to comply with Subtitle D regulations have a low probability of detecting leachate-polluted groundwater before it has migrated to off-site groundwaters. As discussed in the Lee and Jones-Lee (2008) "Flawed Technology" review cited above, the US EPA Subtitle D landfilling regulations adopted in the early 1990s are fundamentally technically flawed and landfills that meet the minimum design requirements prescribed cannot be relied upon to protect groundwater from hazardous and otherwise deleterious components of MSW wastes for as long as the wastes are a threat.

Recognizing the inadequacy of single-composite plastic sheeting and compacted clay liners allowed by minimum-design requirements of the US EPA and many states, some states do not allow the construction of MSW landfills with single-composite liners. Also, several states explicitly require that postclosure funding for landfill monitoring and maintenance be continued for as long as the wastes in the landfill are a threat to generate leachate when contacted by water. Lee and Jones-Lee (2008) discussed key elements in the location, design, operation, closure, and postclosure care that need to be reliably addressed to provide the best assurance of protection of groundwater pollution by landfill leachate for as long as the wastes in the landfill will be a threat. Incorporating such provisions, however, can be expected to double or triple the cost of MSW management by landfills. Those additional costs would have to be passed on to the residential, commercial, and industrial sources of the solid wastes.

In proposing its MSW landfilling regulations in 1989, the US EPA acknowledged that the landfill liner systems as proposed and prescribed would eventually fail to prevent leachate from leaving the landfill and polluting groundwater. Despite pressure to incorporate greater protection for groundwater resources in those regulations, the US EPA, under the influence of the Office of Management and Budget (OMB), adopted the current MSW Subtitle D landfilling regulations while continuing to recognize that minimum-design subtitle D landfills will not be protective of groundwater resources for as long as the wastes in the landfills will be a threat. Additional information on the inability of today's so-called "modern" MSW landfills to prevent groundwater pollution for as long as the wastes represent a threat is available on the authors' website [www.gfredlee.com] in "Landfills/Groundwater" section
[http://www.gfredlee.com/plandfil2.htm]. Their website also contains numerous other papers and reports of theirs that address various aspects and experience in these issues.

In a more recent "comment" entitled "SWANA" published by MSW Management [http://www.mswmanagement.com/june-2009/environment-landfills-risks.aspx?ht=]
O' Brien (2009) acknowledged that there are significant long-term problems the ability of today's MSW landfills to prevent groundwater pollution by landfill leachate for as long as the wastes are a threat to groundwater. That admission is in keeping with statements made by J. Skinner (former Executive Director of SWANA and former US EPA official in the Office of Solid Waste and Emergency Response) on pg.16 of the July/August 2001 *MSW Management* Journal,

> *"The problem with the dry-tomb approach to landfill design is that it leaves the waste in an active state for a very long period of time. If in the future there is a breach in the cap or a break in the liner and liquids enter the landfill, degradation would start and leachate and gas would be generated. Therefore, dry-tomb landfills need to be monitored and maintained for very long periods of time (some say perpetually), and someone needs to be responsible for stepping in and taking corrective action when a problem is detected."*

L. Hickman, another former executive director of SWANA, published a series of articles in the early- to mid-1990s on the deficiencies of Subtitle D landfill, including one article entitled, "Ticking Time Bomb," in reference to Subtitle D landfills.

It is with this background that the current US EPA position regarding the addition of heavy metals, specifically those in discarded consumer electronics, to MSW in landfills is examined as a source of heavy metals that can pollute groundwaters with sufficient concentrations to be a threat to be those who use leachate polluted groundwater as a source of domestic water supply. While, as discussed above, it has been well-recognized for more than 25 years that plastic-sheeting and clay-lined ("dry-tomb") landfills will not prevent the pollution of groundwaters by landfill leachate for as long as the wastes in the landfill will be a threat, the current US EPA administration has not acknowledged that significant deficiency or the ramifications of it.

Electronic Wastes as a Cause of Groundwater Pollution

Leslie Kaufman of the New York Times published an article in that publication on June 29, 2009 entitled, "A Green Way to Dump Low-Tech Electronics." She cited US EPA estimates of the millions of tons of electronic wastes being deposited in landfills and the posturing of both manufacturers and regulators in the matter of evaluating and regulating their environmental quality impacts. In a July 2, 2009 email to Ms Kaufman headed, "Clarifications to Statements in the NY Times article 'A Green Way to Dump Low Tech Electronics,' 7-2-09," Tisha Petteway (Press Officer, US EPA Office of Public Affairs, Washington, DC) noted and attempted to justify, "Statements in the article [Kauman's article] that we request be corrected." Therein Ms Petteway discussed the US EPA headquarters position on disposal of electronic wastes in MSW landfills. Presented below are the authors' comments on many of the issues and US EPA positions presented in that Petteway/US EPA email.

The US EPA stated through Petteway:

> "*According to the US EPA, the disposal of consumer electronics -- including those that qualify as household hazardous waste - in modern, municipal solid waste landfills does not pose a threat to ground water."*

As noted above, electronic wastes add to the heavy metal content of MSW landfill waste streams. Since MSW landfill leachate today contains some heavy metals, such as lead, in concentrations that are a threat to pollute groundwater to a sufficient extent to impair the use of the groundwater for domestic water supply purposes, the addition of electronic wastes to MSW landfills is in the direction of adding to the groundwater-pollution potential of MSW landfill leachate.

The US EPA stated through Petteway:

> "*While the article indicated in several places that electronics in landfills are causing soil and water contamination, EPA has no evidence that this is in fact occurring. EPA believes, based on numerous studies, that modern, permitted municipal landfills are capable of safely managing electronic waste. That said, EPA promotes reuse, refurbishment and recycling of electronics over landfilling. This is not because of dangers inherent in landfilling, but because making use of the resources again yields significant environmental benefits. These benefits include significant energy savings and reduced pollution associated with the extraction and processing of raw materials."*

In their "Flawed Technology" review Lee and Jones-Lee (2008) discussed the fallacy of the claim frequently made by landfill-developer applicants and some regulatory agency

representatives, and now the US EPA, that there is no evidence that the current modern MSW landfills are causing groundwater pollution. As discussed by Lee and Jones-Lee (2008) it could be expected to take about 25 years for a Subtitle D MSW clay liner to be penetrated by landfill leachate that has passed through holes, rips, and tears in the plastic sheeting liner. Since the requirements for Subtitle D landfill single-composite liners have only been in place since the early 1990s, the penetration of the liner would not be expected to be evident at this time.

Furthermore, and most important, the groundwater monitoring system allowed by the US EPA and many states has a very low potential to detect landfill-leachate polluted groundwater when it first reaches the point of compliance for groundwater monitoring. Leachate can be expected to pass from a lined landfill as narrow finger-shaped plumes at some situations. Typically, vertical monitoring wells are spaced a hundred or more feet apart at the point of compliance, and each monitoring well has a zone of capture (area which contributes to the water in the well) of about one foot around the well. With a zone of capture of about one foot, leachate-polluted groundwater could readily pass the point of compliance, undetected, in the hundreds of feet between monitoring wells. Again, failure to detect leachate pollution in a monitoring well at this time cannot be presumed to indicate that there has not been leakage of leachate (for example through holes that existed at the time of construction) or that groundwater has not been polluted; it only means that the monitoring wells have not intercepted migration of leachate. What is clear is that the integrity of the liner system will deteriorate over time, and that by the time the migration of leachate is detected in the monitoring wells, significant offsite groundwater pollution can be expected to have already occurred. This situation is discussed in the Lee and Jones-Lee (2008) "Flawed Technology" review.

The US EPA stated through Petteway in a section labeled, "*Background:*"

> "*Modern municipal solid waste (MSW) landfills were designed to safely store and manage municipal solid waste, including household hazardous waste (i.e., paint, pesticides, lead-acid and other batteries, electronics, etc.) in a manner that is protective of human health and the environment."*
>
> *"A permitted MSW landfill has a composite liner, leachate collection and removal system, and regular groundwater monitoring."*

Those statements are best described as US EPA propaganda in an attempt to justify a fundamentally flawed technology of Subtitle D landfilling and assuage justified concerns about groundwater and environmental quality. Far from being "*protective of human health and the environment,*" the US EPA Subtitle D landfilling approach, at best only postpones, and then obscures, the appearance of groundwater pollution as compared with the classical unlined sanitary landfill. These issues are briefly summarized above and discussed in details in the Lee and Jones-Lee (2008) "Flawed Technology" review.

The US EPA through Petteway stated,

* * * *

"EPA points to the following studies to indicate that groundwater contamination is unlikely to occur as a result of disposal of electronics in modern MSW landfills.

- *A 2003 study by Jang and Townsend compared leaching of lead from CRTs and printed wiring boards using the Toxicity Characteristic Leaching Procedure (TCLP) and using*

leachate from 11 different Florida landfills. [Note: The TCLP is the regulatory test that is used to estimate the leaching potential of a waste to determine whether it should be classified as a federal hazardous waste.] The authors found that the lead extracted using the TCLP was 10 times higher than that which resulted from leaching these products using leachates from Florida landfills. This suggests that the TCLP yields far more lead extraction from these product than is likely to occur in actual landfill conditions."

Jang and Townsend, Leaching of Lead from Computer Printed Wire Boards and Cathode Ray Tubes by Municipal Solid Waste Landfill Leachates, Environmental Science and Technology 37, pages 4778-4784 , 2003

- *The Solid Waste Association of North America conducted a study of heavy metals in landfills and concluded that, "the natural processes that occur within a MSW landfill, such as precipitation and absorption, effectively inhibit heavy metals from dissolving into the leachate or being released from the landfill in the form of landfill gas." The study presents extensive data that show that heavy metal concentrations in leachate and landfill gas are generally far below the limits that have been established to protect human health and the environment.*

  Solid Waste Association of North America. The Effectiveness of Municipal Solid Waste Landfills in Controlling Releases of Heavy Metals to the Environment. March 2004. http://www.swana.org/sections/communicate/pr_viewdetail.aspx?pressId=96

- *A 2008 study by Williams, et. al. that examined the available data on waste electronics and metals in landfills concluded that "The combination of data on heavy metal concentrations in landfill leachate and mercury emissions in landfill gas along with evidence that modern landfill containment systems do an excellent job in preventing migration of these hazardous substances from the landfill suggest that potential for discharge to the environment of hazardous substances from e-waste disposed in a well-run modern landfill is negligible."*

  Williams, Eric and et al. "Environmental, Social, and Economic Implications of Global Reuse and Recycling of Personal Computers." Environmental Science and Technology. Aug. 6, 2008.

- *Results from a study by Spalvins, Dubey, and Townsend "suggest that e-waste disposal in modern MSW landfills is not likely to result in lead leachate conditions at levels of regulatory concern."*

  Spalvins, E., B. Dubey, and T. Townsend. "Impact of Electronic Waste Disposal on Lead Concentrations in Landfill Leachate." Environmental Science and Technology. Vol. 42 (19) 2008.

When EPA examined leachate samples taken from within municipal solid waste landfills, we found that they were substantially below the regulatory level.

- *An EPA study conducted in 2000, found the median concentration of lead in 2,539 leachate samples from over 200 municipal solid waste landfills to be 0.021 mg/L, and the 90th percentile value was 0.250 mg/L, substantially below the regulatory value for lead in leachate of 5.0 mg/l.*

  SAIC. Characterization and Evaluation of Landfill Leachate. Prepared by Science Applications International Corporation, for the US EPA, Sept. 2000."

* * * *

The US EPA representative claims that the above-quoted items serve as supportive background for the Agency's position that the disposal of electronic wastes in MSW landfills does not represent a threat to cause groundwater pollution by heavy metals. Each of those items is rooted in the failure of the subject wastes to exceed a TCLP regulatory limit. The use of the US EPA TCLP regulatory limit as a measure of the concentrations of heavy metals in MSW leachate that would not cause groundwater pollution ignores the purpose and limitations of the TCLP test, and circumvents the proper evaluation of the amount of leaching of heavy metals in a MSW landfill that can cause a groundwater to contain sufficient concentrations of lead and several heavy metals to be a threat to cause a human health threat to those who use a MSW-leachate-polluted groundwater. The senior author (G. Fred Lee) has been involved in several million dollars of research on the leaching of various potential pollutants from solids including solid wastes, and on how to properly evaluate the water quality significance of leached pollutants on various uses of a water including drinking water. Lee and Jones published a number of papers and reports on those findings, including:

> Lee, G.F. and Jones, R.A., "Application of Site-Specific Hazard Assessment Testing to Solid Wastes," IN: Hazardous Solid Waste Testing, ASTM STP 760, American Society for Testing and Materials, pp. 331-344 (1981). http://www.gfredlee.com/HazChemSites/hazassesstest.pdf

and

> Lee, G.F. and Jones, R.A., "A Risk Assessment Approach for Evaluating the Environmental Significance of Chemical Contaminants in Solid Wastes," IN: Environmental Risk Analysis for Chemicals, Van Nostrand, New York, pp. 529-549 (1982). http://www.gfredlee.com/HazChemSites/SiteSpecificTCLP.pdf

The ASTM paper was judged to tie for first place as the "Best Paper" presented at that conference.

The leaching of a pollutant from a solid is highly dependent on the characteristics of the leaching test; the results obtained are governed largely by the design and conduct of the test. During the 1970s, G. Fred Lee conducted about 1 million dollars in research on behalf of the Corps of Engineers on the release and leaching of about 30 pollutants, including various heavy metals, from dredged sediments taken from US waterways. As part of those studies Lee and his associates evaluated the reliability of the elutriate test for assessing and quantifying the potential for the various pollutants to be released from dredged sediments. A significant focus was the evaluation of the influence of the conditions of the test on the release of pollutants from the sediments. It was found that the elutriate test was a good measure of the potential release of pollutants from dredged sediments upon open water disposal of the sediments. The results of these studies were published in several reports and papers including a summary paper,

> Lee, G. F. and Jones-Lee, A., "Water Quality Aspects of Dredging and Dredged Sediment Disposal," IN: Handbook of Dredging Engineering, Second Edition, McGraw Hill, pp. 14-1 to 14-42 (2000). http://www.gfredlee.com/Sediment/dredging.html

In developing the EP Tox leaching test (which subsequently became the TCLP test) for use in the classification of solid wastes as "hazardous" vs "non hazardous," the US EPA chose to incorporate many of the test conditions established for the elutriate test for assessing release of pollutants from dredged sediments. While the conditions used in the elutriate test are appropriate

for testing dredged sediments, they are totally inappropriate for evaluation of the leaching of pollutants in solid wastes. The conditions that exist in an MSW landfill that influence leaching are completely different from the conditions of open water disposal of dredged sediment for which the test conditions were established.

By far the greatest error made by the US EPA in developing and applying the TCLP test is the approach used to characterize excessive leaching. Notwithstanding the aforementioned technical deficiencies, the purpose of the TCLP was to classify wastes as either "hazardous" or "nonhazardous." The regulatory limits established for interpretation of TCLP results are arbitrary, and not based on a proper evaluation of the concentrations of leached pollutants that can pollute groundwater to impair the use of MSW-leachate-polluted groundwater for domestic water supply. For example, the characteristics of the hydrogeology of a site are not properly taken into account in interpreting the results of the test to determine whether a waste can be placed in a nonhazardous waste landfill. The allowed attenuation factor (5-to-1 dilution is assumed) will be overly protective for some hydrogeological groundwater systems, but be insufficiently protective in others. Thus, what are deemed, by virtue of TCLP results, to be "nonhazardous" waste components can still generate leachate that is a significant threat to public health and the environment. The unreliability of this approach is discussed further in Lee and Jones-Lee (2004).

The support provided in the US EPA/Petteway email for the US EPA's position that electronic wastes in landfills are not a threat to groundwater quality was the failure of electronic wastes to release heavy metals above the TCLP regulatory limits. However, the TCLP assessment and regulatory limit is fundamentally flawed for making such an evaluation. This same is true of other approaches that O'Brien/SWANA and the US EPA are using to claim that electronic wastes will not add to the pollution of groundwaters by heavy metals.

The Lee and Jones (1982) paper, "A Risk Assessment Approach for Evaluating the Environmental Significance of Chemical Contaminants in Solid Wastes," (referenced above) discusses technically reliable approaches for evaluating excessive leaching from a solid waste. Necessary for such evaluation is site-specific evaluation of the conditions in the landfill and the hydrogeology of the groundwater system underlying the landfill to determine the amount of leaching that can occur and not pollute groundwater to a sufficient extent to cause it to impair the use of the groundwater for domestic purposes. As part of a US congress-ordered revision of the TCLP test, the US EPA initially proposed a site-specific approach to the evaluation of excessive leaching. However, the Agency failed to follow through with finalizing such an approach and continues the arbitrarily developed TCLP regulatory limit. As discussed by Lee (2004, 2006) that makes the TCLP test unreliable for evaluating excessive leaching of lead and several other pollutants in electronic and other wastes.

Overall, the US EPA has used a technically invalid approach to conclude that the heavy metals in electronic wastes do not represent a threat to pollute groundwaters to a sufficient extent to represent a threat to the health of those who use the groundwater as a domestic water supply source. At this time, however, the technical community has not defined or isolated the significance of allowing the deposition of electronic wastes in MSW landfills to the pollution of groundwaters by landfill leachate that will inevitably occur as the liners fail to prevent leachate-

leakage through the liners. In light of this situation, for now it would be prudent public health and environmental protection policy for state and local jurisdictions to restrict deposition of electronic wastes in MSW landfills. This could also be said of deposition of other wastes that contain hazardous chemicals.

Additional information on Drs. G. Fred Lee and Anne Jones-Lee's expertise and experience to make this assessment is provided on their website [www.gfredlee.com] in the section "About G. Fred Lee & Associates" [http://www.gfredlee.com/gflinfo.htm]. Questions or comments on these issues should be directed to Dr. G. Fred Lee at gfredlee@aol.com.

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