

**Comments on the SWANA Summary -Report “Recent Studies Indicate
Minimal Heavy -Metal Releases from MSW Landfills,”
with Responses by Jeremy O'Brien for SWANA¹
With Responses by Lee to O'Brien's Comments**

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Original Comments by
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The May/June 2005 issue of *MSW Management* contains a review of the Solid Waste Association of North America (SWANA) Applied Research Foundation report in which J. O'Brien, executive director of the SWANA Research Foundation, presents a summary of the potential for heavy metals in today's municipal solid waste (MSW) leachate to pollute groundwater.

MSW Management considers this such an important topic that we are presenting Drs G. Fred and Anne Jones-Lee's challenge and SWANA's response to the article as the basis for an ongoing dialog on our Web site. To facilitate this we are appending this to the basic article at www.mswmanagement.com/mw_0505_recent.html. We then invite you to avail yourself of the “Comment on This” button found in the left margin of the web page. These comments will be added to the Web discussion.

The Counterpoint presented here stems from O'Brien's conclusion: “Based on a review of recent studies and published literature, the SWANA report concluded that MSW landfills can provide for the safe, efficient, and long-term management of disposed products containing RCRA heavy metals without exceeding limits that have been established to protect public health and the environment. It further concluded that MSW landfills should contain the releases of RCRA heavy metal pollutants at levels that protect public health and the environment for extremely long periods of time if not forever.”

Lee Challenge

The SWANA Applied Research Foundation report to which O'Brien (2005) refers is “The Effectiveness of Municipal Solid Waste Landfills in Controlling Releases of Heavy Metals to the Environment,” dated March 2004 (SWANA 2004). Lee (2004) provided a detailed review of this report.

SWANA Response

The SWANA report was prepared by Jeremy O'Brien, P.E., SWANA's director of applied research. To provide an independent review of the research findings and conclusions presented in the report, SWANA engaged the services of the late Dr. Frederick Pohland. Dr. Pohland was the Weidlein Chair of Environmental Engineering in the Department of Civil and Environmental Engineering at the University of Pittsburgh. In addition, the report was subjected to an outside

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peer review by an independent panel comprising the leading academicians and researchers in this field.

- Dr. Debra R. Reinhart, chair, Civil and Environmental Engineering Department and professor and associate dean, College of Engineering and Computer Science, University of Central Florida
- Dr. Morton A. Barlaz, professor and associate head, Department of Civil, Construction, and Environmental Engineering, North Carolina State University
- Dr. Timothy G. Townsend, associate professor, Department of Environmental Engineering Sciences, University of Florida

All of the reviewers agreed that the report accurately and correctly presents the findings of the studies reviewed in the report.

Lee's Response to O'Brien's Comment

The statement by O'Brien that the SWANA report was peer-reviewed reflects on the inadequacy of the peer review process conducted by SWANA, which should have been done by individuals who have in-depth knowledge of the potential for constituents in landfill leachate to pollute groundwaters. This is an issue to which I have devoted considerable professional attention over the past 30 years. Further, the issue of properly classifying wastes as hazardous versus nonhazardous has been a focal point of my career since the US EPA first proposed the EP Tox test, which evolved into the TCLP test. Dr. Jones-Lee and my work on this issue has been recognized by professionals in the field concerned with waste classification issues, through our receiving the Charles B. Dudley Award, awarded by the American Society for Testing and Materials for contribution to Hazardous Solid Waste Testing, for our paper "Application of Site-Specific Hazard Assessment Testing to Solid Wastes" (Lee and Jones, 1981).

Lee Challenge

As Lee comments, the SWANA Applied Research Foundation report, which claims that heavy metals in municipal solid waste (MSW) landfill leachate do not represent a threat to cause groundwater pollution, is based on a flawed approach for assessing the critical concentrations of heavy metals in MSW leachate that can be adverse to groundwater quality. The SWANA report uses the US EPA TCLP regulatory limit as a measure of the concentrations of heavy metals in MSW leachate that would not cause groundwater pollution. However, this is not the purpose for which TCLP regulatory limits were developed. TCLP regulatory limits were established to classify wastes as "hazardous" versus "nonhazardous." So-called "nonhazardous" waste components can still generate leachate that is a significant threat to public health and the environment. The TCLP regulatory limits were arbitrarily established without proper regard to how constituents such as heavy metals in MSW leachate can impair the beneficial uses of groundwaters and surface waters.

SWANA Response

The report compares average heavy metal concentrations in landfill leachate to five different regulatory limits, not just the TCLP. These regulatory standards include (1) the TCLP test limit, (2) the groundwater 'Maximum Contaminant Levels' (MCLs) established in Subtitle D regulation for performance-based landfill liners, (3) US Primary Drinking Water Standards 4) Final Effluent Limitations, Guidelines and Pretreatment Standards for the Landfill Point Source Category, and (5) selected local pretreatment standards for industrial wastewaters. The SWANA

report does not suggest that because a waste passes TCLP regulatory limits, it poses no risk to groundwater.

Lee's Response to O'Brien's Comment

Basically, O'Brien agrees that the TCLP limit is an improper basis for assessing the potential threat that landfill leachate-associated constituents represent to pollute groundwaters. However (see below), it was the primary basis by which SWANA concluded that heavy metals in MSW leachate do not represent a threat to pollute groundwaters. O'Brien's mention of the other standards does not address the fundamental issue raised by Lee, of the inappropriate approach used by SWANA to assess concentrations of constituents present in leachate that can pollute groundwaters, rendering them a threat to public health and/or the environment.

Lee Challenge

The SWANA report presents concentrations of heavy metals in today's MSW leachate, which are sufficient at some locations to cause significant adverse impacts to groundwater quality and surface water quality. Under US EPA Subtitle D landfilling practices, there is potential justification for limiting the concentrations of heavy metals in the municipal solid waste stream as part of an effort to reduce the heavy metal concentrations in MSW leachate.

The O'Brien *MSW Management* article contains the same misrepresentation of the potential water quality significance of heavy metals in MSW leachate as was presented in the SWANA (2004) report, where O'Brien states that the heavy metal concentrations in MSW leachate listed in Table 2 "... are all lower than the TCLP regulatory limits." However, as discussed by Lee (2004), the issue is not the concentrations of heavy metals in leachate relative to TCLP regulatory limits, but whether the concentrations of heavy metals in leachate are at concentrations that, when the landfill liner system in the minimum Subtitle D landfill ultimately fails to prevent leachate passage through it, can cause groundwater pollution that is a threat to public health and/or the environment. As discussed by Lee (2004), the US EPA TCLP is not a reliable indication of potential impacts on public health. The TCLP was a political testing procedure that was used to distinguish between hazardous and nonhazardous wastes, where heavy metal concentrations that can be over 30 times (for lead) the US EPA drinking water MCL are used to determine if the waste should be placed in a hazardous waste landfill.

Lee (2004) discusses that there are situations where heavy metals in MSW leachate can be transported for considerable distances in groundwater systems with little or no attenuation in the aquifer. Of particular concern are sand and gravel, fractured rock, and cavernous limestone aquifers.

SWANA Response

The public health threat to groundwater from heavy metal leachate concentrations is dependent on (1) the concentrations of heavy metals in the leachate, (2) the quantities and flow rates of leachate that escapes through the landfill's composite liner system, (3) the degree of attenuation of the heavy metals in the escaped leachate quantities that would occur before the leachate reached the groundwater source, and (4) the dilution of the leachate heavy metal concentrations in the groundwater. For leachate that does escape through the liner system, there would be some reduction in leachate heavy metal concentrations due to attenuation even for landfills located above fractured rock systems. (Landfills are required to have a minimum of 10 feet of soil above bedrock).

For landfills that exhibit the average heavy metal concentrations indicated in the report, SWANA's conclusion is that—due to (1) the low heavy metals concentrations in the leachate and (2) the minimal quantities of leachate that are expected, on average, to escape from lined, Subtitle D landfills, the environmental and public health threat are—on average—relatively low. Further, the scenario described by Dr. Lee assumes no treatment of the groundwater prior to consumption. The scenario described by Dr. Lee also appears to represent a worst case. Finally, it would be useful for the reader if Dr. Lee were to describe the level of peer review associated with Lee (2004).

Lee's Response to O'Brien's Comment

With respect to O'Brien's questioning whether the Lee (2004) paper was peer-reviewed, as with all of my publications, it was widely distributed to individuals knowledgeable in the field prior to release, for review and comment. The comments received were, to the extent appropriate, incorporated into the final version of the paper. The Lee (2004) report on the significant deficiencies in SWANA's assessment that heavy metals in municipal landfill leachate do not represent a threat to cause groundwater pollution represents a synthesis and integration of over 30 years of work on the potential for MSW leachate to pollute groundwaters, rendering them unusable for domestic water supply and many other purposes.

With respect to the basis for SWANA's conclusion listed by O'Brien, a critical review of the US EPA Leach 2000 database, which was cited by SWANA as the source of information on the concentrations of heavy metals in leachate, shows that the concentrations of heavy metals in some MSW leachate are not low relative to the concentrations that can cause a groundwater to be a threat to human health and the environment. While SWANA uses "average" concentrations of metals in leachate in making its comparison, to an individual with a water supply well within the sphere of influence of an MSW landfill, it is not the average concentration that is of concern, but the concentration that can cause a threat to the health of those who use the water.

O'Brien, in his statement, "*(2) the minimal quantities of leachate that are expected, on average, to escape from lined, Subtitle D landfills, the environmental and public health threat are—on average—relatively low,*" has again provided unreliable information on the situation that will develop over the long term with respect to the escape of leachate from plastic sheeting and compacted soil lined MSW landfills. He has not addressed the issue of primary concern, that ultimately the HDPE plastic sheeting liner in these landfills will deteriorate to the point where it is ineffective in collecting leachate. The leachate generated at that time will then pass through the liner system into the groundwaters underlying the landfill. These issues are discussed in detail in Lee and Jones-Lee (2006).

With respect to attenuation, as discussed in the comments, there are hydrogeological situations where there is little attenuation of pollutants in MSW leachate-polluted groundwaters. It is these situations (such as fractured rock, sand and gravel, cavernous limestone, etc.) that must be considered whenever evaluating the potential for heavy metals in MSW leachate to pollute groundwaters, rendering them unusable for domestic water supply and many other purposes. This evaluation should be based on plausible worst-case or near-worst-case assumptions, in order to protect public health and the environment. Assuming average conditions with extensive attenuation, as O'Brien does, perpetuates the justified NIMBY.

O'Brien assumes that there will be treatment of the groundwater before use, where he states, "*Further, the scenario described by Dr. Lee assumes no treatment of the groundwater prior to consumption.*" It is unclear as to whether O'Brien understands that one of the primary areas of concern with respect to polluting groundwaters by MSW leachate is that there are groundwaters within a sphere of influence of landfills, which can be on the order of several miles, that are

consumed by individual property users without treatment. It is certainly inappropriate to assume that all groundwaters that are polluted by MSW heavy metals will be treated before use.

O'Brien's parenthetical statement, "(Landfills are required to have a minimum of 10 feet of soil above bedrock)," reflects the fact that he is not familiar with the permitting of landfills. I have been involved in the review of approximately 75 landfills. Many of these are permitted with less than 10 feet between the water table high and the bottom of the wastes. The state of California allows landfills to be sited with only five feet of separation between the water table high and the wastes. There are a number of states which will allow landfills to be sited where only a foot or two exists between high water table and wastes.

Lee Challenge

The SWANA report and the O'Brien *MSW Management* article attempt to present the image that there are processes that take place in landfills to limit the leaching of heavy metals from MSW components. While there are processes that can limit the mobility of heavy metals in MSW landfills, it is obvious, based on the data presented in O'Brien's Table 2, that the attenuation processes in MSW landfills do not prevent concentrations of heavy metals in MSW leachate that are a threat to public health when the leachate penetrates through the landfill liner system and pollutes groundwater. Table 2 shows concentrations of heavy metals such as lead in some MSW leachate to be 20 times the drinking water MCL. For arsenic the concentration in some MSW leachate is 10 times the MCL.

SWANA Response

The leachate metal concentrations presented in Table 2 are compared in the full SWANA report to the "Maximum Contaminant Levels" (MCLs) established by the US EPA for groundwater protection for landfills that are constructed with "performance-based" liner systems. In developing these MCLs, the EPA assumed that the leachate pollutant concentration would be diluted or attenuated by a factor of 100 by the time the groundwater underlying land parcels adjacent to the landfill site would be impacted. In comparison, SWANA found that a "dilution-attenuation factor" (DAF) of only 10 would be sufficient for all of the average heavy metal concentrations to meet the groundwater MCLs established by the EPA as well as the US Primary Drinking Water Standards. Further, average concentrations for two of the metals—barium and silver—were found to comply with groundwater MCLs (as well as US Primary Drinking Water Standards) with no consideration of dilution or attenuation impacts (i.e., an assumed DAF of 0).

In the examples cited by Dr. Lee, when the average lead concentration of 133 ug/L is compared to the current US Primary Drinking Water Standard for lead—15 ug/L, a DAF of only 10 would be required for the average lead concentration in the leachate to meet the drinking water standard. Similarly, the average concentration of arsenic reported in Table 2—0.441 mg/l—would only have to be diluted or attenuated by a factor of 10 to meet the drinking water standard for arsenic (0.05 mg/l).

Lee's Response to O'Brien's Comment

Contrary to O'Brien's statement, the drinking water MCL for arsenic is not 0.05 mg/L, but (as cited in my comments), 0.01 mg/L. As discussed in detail and as is well known, the US EPA's assumed 100 attenuation/dilution factor was an arbitrarily established political value that enables the Agency to limit the size of the solid waste stream that has to be managed as hazardous waste. There are many situations where dilution/attenuation of 100 will not be achieved by the time that the leachate-polluted groundwaters reach adjacent properties' property line. Further, O'Brien/SWANA perpetuates the approach of using average concentrations, and not the

concentrations that could readily be present in some groundwaters polluted by leachate under properties adjacent to a landfill. It is important to note that the regulatory agencies do not regulate compliance with drinking water standards based on an average concentration of a pollutant. It is inappropriate for SWANA to use averages in making this evaluation.

Lee Challenge

Another topic area that the SWANA report and O'Brien inadequately discuss is the so-called protective nature of today's minimum design US EPA Subtitle D landfills. O'Brien states, *"Landfill liner systems substantially prevent the leaking of leachate from the landfill to the land upon which the landfill is constructed. Based on recent investigations, these liners appear to have a 'half life' (i.e., a time frame during which a 50% change in the material properties of the liner occurs) of 970 years. Therefore, the integrity of the liner system can be expected to last through the time frame when significant quantities of leachate are being generated."*

While O'Brien did not reference the so-called "recent investigations," he lists as a reference a US Environmental Protection Agency report with a date of December 2002. This reference listing is incorrect in that it should have been referenced as Bonaparte et al. (2002), which was issued as a US EPA report in December 2002. A critical review of this report (see Lee and Jones-Lee 2005) shows that there are many reasons why the period of time before failure of a minimum design Subtitle D landfill liner system can be much less than the extrapolated value of 970 years.

SWANA Response

The referenced report ("Assessment and Recommendations for Improving the Performance of Waste Containment Systems," July 2002) was authored by leading experts (Rudolph Bonaparte, GeoSyntec Consultants; David Daniel, University of Illinois; and Robert Koerner, Drexel University) through a cooperative agreement with the US EPA.

Lee's Response to O'Brien's Comment

In my comments on the SWANA report and O'Brien's paper I provided specific reference to a detailed critique of the Bonaparte et al. (2002) US EPA report, where I cited the review of this report by Lee and Jones-Lee (2006). As discussed in our review, Koerner, in concluding that MSW landfills will be "protective," assumed, with no technical basis, that municipal solid wastes in a dry tomb environment will only be a threat for a couple hundred years, and that the plastic sheeting liners would be effective in collecting all leachate for a longer period than the wastes will be a threat. As discussed in our comments (Lee and Jones-Lee 2006) and as is obvious to those who understand the processes that take place in dry tomb landfills, many MSW components in a dry tomb type landfill will be a threat, effectively, forever. The key to rendering a landfill non-polluting is water. So long as the wastes in the landfill are dry, nothing happens to them. However, over the infinite period of time that the wastes in a dry tomb type landfill can be a threat, failure to maintain the cover integrity to prevent moisture from entering the landfill will lead to leachate generation, which can lead to groundwater pollution when the plastic sheeting liner in the landfill ultimately degrades to become an ineffective barrier to preventing leachate from passing through it. Further, Koerner's approach for extrapolating short-term experiments on plastic sheeting liner degradation, involving the extreme extrapolation of the Arrhenius equation, is highly speculative and could readily be in significant error.

Those familiar with this situation know that a significant error was made by the US Congress and the US EPA in adopting dry tomb type landfilling, because of the inevitable groundwater pollution associated with it. Efforts are being made to abandon this approach in favor of the so-called "bioreactor" approach, where water is added to the landfill in order to bring about fermentation and leaching of the wastes. As discussed by Jones-Lee and Lee (2000), appropriately conducted

fermentation leaching of MSW is an approach to managing the long-term threat to groundwater pollution that MSW represents to public health and the environment.

Lee Challenge

O'Brien states, "MSW landfills should contain the releases of RCRA heavy metal pollutants at levels that protect the environment for extremely long periods of time if not forever." This statement is based on an unreliable assessment of the critical concentrations of heavy metals in landfill leachate relative to the potential for heavy metals in MSW leachate to cause groundwater pollution that is a threat to those who use leachate-polluted groundwaters as a domestic water supply. A proper analysis of the threat that heavy metals in MSW leachate represent to cause groundwater pollution that is a threat to domestic water supplies must be made on a site-specific basis considering the characteristics of the aquifer system that will be polluted when the landfill liner system eventually fails to prevent leachate from penetrating the liner system.

SWANA Response

The scenario presented by Dr. Lee of leachate penetrating through the liners system appears to assume that (1) substantial quantities of leachate are leaked at significant rates at the future point in time when the landfill's top and bottom liner systems are determined to have ultimately failed, (2) no metal attenuation occurs either in the soil portion of the composite liner or the soil underneath the liner, (3) no dilution of the leachate occurs in the groundwater, and (4) no treatment of the impacted water source occurs before human consumption. As stated earlier, SWANA found that a DAF of only 10 would be sufficient for the all of the average heavy metal concentrations reported for MSW leachate to meet the groundwater MCLs established by the EPA as well as US Primary Drinking Water Standards.

SWANA's intent in this report was to make a general assessment of the public health and environmental risks associated with heavy metal releases from Subtitle D landfill based on average concentrations reported in leachate and landfill gas. As indicated in the report, there are some locations where pretreatment of the leachate is required to meet local pretreatment standards. Similarly, there may be instances where local leachate concentrations, combined with local hydrogeologic conditions and liner system failures, may warrant a site-specific analysis of the threat to domestic water supplies presented by heavy metal leachate concentrations. However, for landfills that exhibit the average heavy metal concentrations indicated in the report, SWANA's conclusion is that due to (1) the low heavy metals concentrations in the leachate and (2) the minimal quantities of leachate that are expected, on average, to escape from lined, Subtitle D landfills, the environmental and public health threat are—on average—relatively low. SWANA would agree that the implications of siting a landfill are site-specific but this is typically part of the original siting and permitting process.

Lee's Response to O'Brien's Comment

O'Brien's summary statement, in which he again presents the basis for his conclusion that heavy metals in MSW do not represent a threat to groundwater quality, have been commented on above. I am pleased to see that he now appears to agree that there are situations where heavy metals in MSW leachate can be a threat to groundwater quality and that a site-specific evaluation of each landfill is required in order to determine the magnitude of this threat. This was the message in our comments on the SWANA report and O'Brien's *MSW Management* article. However, his statement, "SWANA would agree that the implications of siting a landfill are site-specific but this is typically part of the original siting and permitting process," again reflects a misunderstanding of how landfills are permitted. As mentioned above, I have been involved in

the review of approximately 75 landfills in various parts of the US. Many of these involved my reviewing the adequacy of regulatory agency review of a proposed landfill. At none of the landfills that I am aware of has a regulatory agency ever required a site-specific evaluation of the potential for a landfill to pollute groundwaters underlying adjacent properties, rendering them unusable for domestic water supply and many other purposes.

Lee Challenge

An issue that evolves from this discussion is whether it is appropriate to restrict the heavy metal content of the MSW wastestream. Of particular concern are the large amounts of electronic items that are being deposited in MSW landfills. The SWANA report is being used, albeit incorrectly, to claim that there is no need to restrict electronic waste deposition in MSW landfills. The SWANA (2004) report and O'Brien (2005) summary paper on this report do not provide information that can be reliably used to justify allowing electronic waste items in the MSW wastestream. At this time it is unclear whether allowing consumer electronic waste items in the solid wastestream will significantly increase the threat to public health through pollution of groundwaters by MSW leachate. However, since minimum design US EPA Subtitle D landfills will ultimately cause groundwater pollution, it is appropriate to reduce items in the MSW wastestream that potentially lead to increased pollution of groundwater.

SWANA Response

As indicated in the report, the major heavy metal of concern with respect to electronic discards is lead, due to its large quantities in CRTs (on average, 4 pounds of lead per device) and its large fraction (97.6%) of the heavy metal portion of the municipal solid wastestream. The SWANA report concludes that, despite the recent increase in discarded consumer electronics, the quantities of lead being disposed in MSW landfills have decreased in the last 15 years. Further, the average concentrations of lead in MSW leachate are less than a factor of 10 higher than the US Primary Drinking Water standard, even before considering the impacts of dilution and attenuation should a portion of the leachate escape through the landfill liner system. There are physical, biological and chemical processes that occur within MSW landfills (high pH; reducing environment; precipitation due to presence of sulfides and sorption in the waste mass) that serve to keep disposed lead from leaching out of the waste mass. For these reasons, SWANA has concluded that MSW landfills provide an effective safety net for the management of electronic discards that are not recycled.

Based on an overall review of his comments, Dr. Lee's argument appears to be with the efficacy of US EPA Subtitle D regulations in general rather than the specific issue of whether or not discarded consumer electronics represent a significant public health threat, in and of themselves, when landfilled. It appears that many of Dr. Lee's concerns would apply to many other types of discards and wastes that are currently permitted to be disposed in Subtitle D landfills.

Lee's Response to O'Brien's Comment

With respect to O'Brien's concluding statement, *"It appears that many of Dr. Lee's concerns would apply to many other types of discards and wastes that are currently permitted to be disposed in Subtitle D landfills,"* his assessment of my concerns is correct with respect to many MSW waste components that are deposited in the minimum design single composite liner landfill with groundwater monitoring wells at the point of compliance spaced hundreds of feet apart and no assured long-term funding for landfill monitoring and maintenance for as long as the wastes in the landfill will be a threat. There are components in municipal solid wastes, including heavy metals, that can lead to groundwater pollution of offsite groundwaters. O'Brien's restatement of

factors influencing this potential in his concluding paragraph has been addressed above. The bottom line on the unreliability of his statement is that according to the US EPA Leach 2000 database, some municipal landfill leachate contains heavy metals at concentrations that can pollute groundwaters, rendering them a threat to public health and the environment where groundwaters become part of the surface waters.

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Jeremy O'Brien is executive director of the SWANA Research Foundation and may be reached at [www.swana.org](http://www.swana.org).

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