

Review of the Justification for Meriwether County, Georgia, to Prohibit MSW Landfills in Water Supply Watershed District

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The Meriwether County Building and Zoning Department/County Planning Commission has adopted a zoning ordinance that prohibits the siting of landfills in small domestic water supply watersheds (Meriwether County Code, Chapter 11 Environmental Protection, Article 5 Water Supply Protection Sec. 11-85 Prohibited Uses). Greenbow, LLC, has applied for rezoning and conditional use approval for a proposed Turkey Run Landfill that is to be sited in the Blue Creek watershed which is a domestic water supply watershed for the city of Hogansville, GA. In support of this application, Greenbow has asked the Meriwether County Court to overturn the Counties zoning ordinance that would prohibit the siting of a landfill in a small domestic water supply watershed. The County has requested that I review this matter where I am to provide information that can help the County Court understand the justification for adopting an ordinance to protect a small domestic water supply from pollution by a municipal solid waste (MSW) landfill. As part of developing this review I have examined the “Rezoning and Conditional Use Approval Application (and Supporting Documents),” dated April 22, 2005, that was submitted by Greenbow, LLC, to the Meriwether County Building and Zoning Department as well as Georgia Environmental Protection Division regulations that are pertinent to monitoring/management of landfills.

Overall Conclusion

Meriwether County is justified in prohibiting the construction of landfills with and without synthetic liners and leachate collection systems within a water supply watershed district. Municipal solid wastes (MSW) contain a variety of constituents that are a threat to public health and the environment. This threat is related to stormwater runoff from the active and closed (no longer accepting wastes) landfill as well as through the inevitable groundwater pollution that will occur at minimum design US EPA Subtitle D landfills of the type allowed in Georgia.

Current and proposed revised Georgia Environmental Protection Division stormwater runoff water quality monitoring/management requirements from municipal solid waste landfills are not adequate to detect/control landfill derived wastes in stormwater runoff that are a threat to public health and the environment. As part of US EPA Safe Drinking Water Act Source Water Quality Protection, a community/agency needs to address the deficiencies in requirements for stormwater runoff monitoring/management from landfill properties and take action to protect domestic water supply water quality from the landfill derived pollutants.

Today's dry tomb type landfills, in which there is an attempt to isolate the wastes from the environment, cause waste components in such landfills to be a threat to public health and the environment, effectively, forever. Today's lined landfills at best only delay when releases of waste components will occur to the environment. Such releases are a threat to domestic water supply water quality and surface and groundwater quality.

It is in Meriwether County's best interests to prohibit the construction of landfills in those areas that are part of a small domestic water supply watershed district as part of protecting domestic water supply source water quality.

Qualifications

My qualifications to undertake this review are summarized below. They include a Bachelor of Arts degree from San Jose State College, a Master of Science in Public Health from the University of North Carolina, Chapel Hill, and a PhD degree from Harvard University, obtained in 1960. For 30 years I held university graduate-level teaching and research positions at several major US universities. During that time I conducted a number of studies on the impacts of solid waste landfills on public health and the environment, including research sponsored by the US EPA on landfill liner integrity issues. During my teaching and research career, I conducted over \$5 million in research and published over 500 papers and reports on these studies. In 1989, I retired from university teaching and research and expanded my part-time consulting into a full-time activity. At that time I held a Distinguished Professorship in Civil and Environmental Engineering at the New Jersey Institute of Technology. I was also Director of the Site Assessment and Remediation Division of a multi-university hazardous waste research center.

Since 1989, I have been a full-time consultant, where a considerable part of my activities are concerned with review of the potential impacts of proposed new or expanded landfills. I have been involved in reviewing over 75 landfills. These reviews were conducted primarily on behalf of municipalities, counties, water utilities and other entities that were concerned about the potential impacts of a landfill on water supply water quality. My work has been done in conjunction with Dr. Anne Jones-Lee. We have published extensively on the potential problems of today's minimum US EPA Subtitle D municipal solid waste landfills in providing containment of waste components for as long as the wastes in the landfill will be a threat to public health and the environment. We have also discussed how landfills can be developed to protect public health and the environment for as long as the wastes in the landfill will be a threat. These approaches have not been adopted since they would increase the costs of solid waste management. This leads to a situation where today's landfills will pollute surface and groundwaters. We maintain a website, www.gfredlee.com, where many of our papers and reports are available as downloadable files. Additional information on my qualifications to undertake this review is appended to these comments.

Deficiencies in Current Landfilling Practice - Stormwater Runoff Pollution Control

Stormwater runoff from landfills can have a significant adverse impact on water quality of the receiving waters for the runoff with respect to their use for domestic water supplies and to aquatic life. Stormwater runoff from landfill property can contain a variety of regulated and

many unregulated pollutants that are a threat to health of those who use the treated waters for domestic purposes. Also while not necessarily a human health threat, MSW contains a large of number of chemicals that can highly detrimental to the use of MSW leachate polluted water supply that can render a water supply unusable for domestic purposes. Of particular concern are those chemicals that can cause tastes and odors. Current water quality regulatory programs only regulate 100 to 200 chemicals of the many thousands of chemicals that are present in municipal and industrial solids wastes that can be legally added to the MSW waste stream that is deposited in MSW landfills. As discussed below, the monitored/regulated chemicals in landfill leachate and stormwater runoff represent a very small part of the chemicals present in MSW wastes that are a threat to public health and the environment.

During the active life of landfills (when wastes are being deposited in the landfill) waste derived constituents can escape from the landfill active face through wind blown transport, via bird, insect and vermin transport, and by stormwater runoff from the active face. While typical state and local landfilling regulations require the active face of the landfill be kept to a “small” area, there is still escape of waste derived constituents that when contacted by stormwater can transport waste derived chemicals to off site water courses.

A source of pollutants for stormwater runoff from landfill property is leachate spills on the ground surface. These spills are associated with inadequate handling of leachate from the leachate collection system discharge point to the location where it is transported offsite or at the onsite treatment works. Also of concern is the breakage of leachate transmission pipes that results in the discharge of leachate to the ground surface. These types of problems are especially prevalent in climates where freezing of the leachate pipes can occur.

At one time the use of landfill leachate for dust control was widely practiced. Since this approach can lead to highly polluted stormwater runoff it should not be allowed. Also of concern is the use of other types of wastes for dust control. These wastes/chemicals can cause stormwater runoff to pollute waters receiving the runoff. Garbage truck traffic, landfill equipment such as bulldozers, compactors etc, spills of fuels and engine oil where the old oil is allowed to be dumped on the ground etc can be sources of pollutants for runoff from landfills.

Current federal and many state stormwater runoff regulations governing landfills do not require that the stormwater runoff from a landfill area be treated to reduce the waste derived chemicals to meet water quality criteria and drinking water maximum contaminant levels (MCLs). The only treatment typically provided is a settling basin that will detain low volumes of stormwater runoff. The design of these detention basins where, if adequately maintained, where the accumulated sediments are removed to adequately maintain the basin volume.

Under the current US EPA regulations where there is no assured funding for more than 30 years after closure of the landfill, there are significant questions about whether the limited stormwater runoff monitoring and maintenance of detention basins that are designed to only contain the 25 year 24 hour storm will be contained/maintained for as long as the wastes in the landfill are a threat to generate leachate which for dry tomb type landfills can be forever. The 25 year 24 hour storm limitation in the design of the detention basins means that larger storms will discharge pollutants to nearby water courses without even removal of the large size erosion particles and

wastes. If two storms occur after each other where the detentions basin still has appreciable water from the first storm means that the second storm runoff will likely pass through the detention basins even if neither storm exceeds the design capacity of a 25 year 24 hour storm.

For those landfills with a single composite liner, the leachate pollution of shallow groundwater can be a source of surface water pollution at those landfills where the polluted shallow groundwater enters the surface waters through above water surface springs or below water surface discharges to streams, rivers, lakes and nearshore/off shore marine/estuarine waters.

The use of pesticides/herbicides to control insects/weeds at the landfill can be a source of pollutants in stormwater runoff that can be adverse to drinking water quality and a threat to aquatic life in the receiving waters for the runoff.

The area where waste is dumped for load inspection where the area is washed down can be a source of stormwater runoff pollutants if the wash down water is not adequately controlled. A similar situation can exist in areas where mud on trucks tires are washed off to keep from transporting landfill area derived mud to the public roads.

In addition to deficiencies in chemical monitoring many regulatory agencies do not require aquatic life toxicity monitoring. Such monitoring should include the standard three species toxicity testing required by the US EPA that is conducted on domestic and industrial wastewater effluents.

The nature of stormwater runoff impacts is that of pulses of pollutants that can be disruptive to water supply ability to adequately treat the stormwater runoff polluted water to maintain high water quality in the treated waters. At this time the information on the water quality impacts of stormwater runoff from landfill areas is not sufficiently known to be able to qualitatively predict the potential impacts of a landfill stormwater runoff on receiving water quality. However, it is well known that municipal solid waste landfills contains large amounts of chemicals that have the potential to adversely impact domestic water supply water quality and the aquatic life resources of waterbodies.

Current Regulatory Approach. The regulation of landfill stormwater runoff water quality impacts occurs under the US EPA National Stormwater Runoff permit system. The State of Georgia Department of Natural Resources Environmental Protection Division (EPD) website states, “*In April 1998 in compliance with the provisions of the Georgia Water Quality Control Act (Georgia Laws 1964, p. 416, as amended), hereinafter called the "State Act," the Federal Clean Water Act, as amended (33 U.S.C.1251 et seq.), hereinafter called the "Clean Water Act," and the Rules and Regulations promulgated to each of these Acts, new and existing storm water point source discharges associated with industrial activity within the State of Georgia, upon submittal of a Notice of Intent, are authorized to discharge storm water associated with industrial activity to the waters of the State of Georgia in the accordance with the limitations, monitoring requirements and others conditions set forth in Parts I through VIII hereof.*”

Nationally and in Georgia stormwater runoff from a landfill is regulated as an “industrial” source. The GA EPD is in the process of updating the industrial stormwater runoff water quality regulations. The following is from the GA EPD website,

- **“Industrial Stormwater**

April 28, 2005 Update: The 2005 - 2010 NPDES General Permit No. GAR000000 for Storm Water Discharges Associated with Industrial Activity has been appealed by two parties. The permit has therefore been stayed pending an administrative hearing, and will not become effective as planned on May 2, 2005. The Notice of Intent (Version 2005) will not be released until the appeals are resolved and the permit is either reinstated or reissued. The extended 1998 - 2003 General Permit will remain in effect until that time, and all industrial storm water dischargers should continue to meet the requirements of that permit. “

State of Georgia Department of Natural Resources Environmental Protection Division fact sheet National Pollutant Discharge Elimination System General Permit no. Gar000000 Storm Water Discharges Associated with Industrial Activity September 13, 2004 available at, http://www.dnr.state.ga.us/dnr/enviro/techguide_files/wpb/Fact_Sheet_04_Ind_SW_permit.htm

Inadequate Monitoring. A critical review of the existing EPD (1998) landfill stormwater runoff monitoring requirements shows that they are seriously deficient in providing the monitoring needed to insure with a reasonable degree of certainty that the landfill stormwater runoff will not pollute the waters receiving the runoff for the landfill. While the proposed regulations, if adopted as proposed, is improved in terms of the number of parameters monitored, MSW and its leachate contains thousands of chemicals that are not monitored/regulated that are a threat to public health and the environment. Some of the unmonitored constituents can be adverse to public health at very low concentrations. Dr. Christian Daughton (2005), Chief of the Environmental Chemistry Branch, National Exposure Research Laboratory, Office of Research and Development, US EPA, Las Vegas, Nevada, has discussed the inadequacy of water quality monitoring programs in identifying pollutants in wastewaters/stormwater runoff for the range of chemicals that could be impacting public health and the environment. In his presentation he stated,

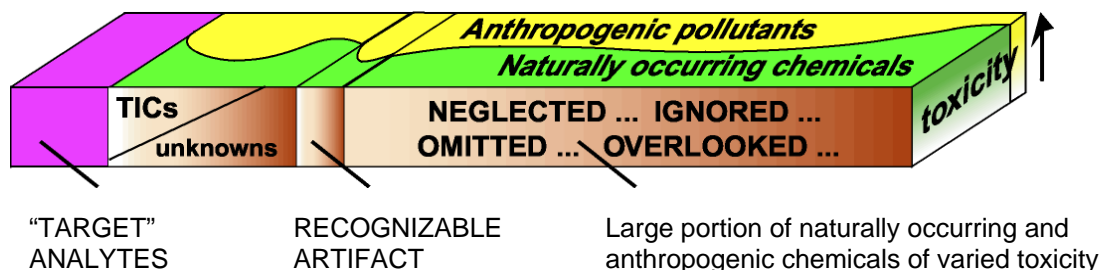
“Further Truisms Regarding Environmental Monitoring

- *What one finds usually depends on what one aims to search for.*
- *Only those compounds targeted for monitoring have the potential for being identified and quantified.*
- *Those compounds not targeted will elude detection.*
- *The spectrum of pollutants identified in a sample represent but a portion of those present and are of unknown overall risk significance.”*

Figure 1 presents a diagram of this situation. As indicated in this figure, only a small part of the chemical pollutants that can be present in a water impacted by waste associated constituents are identified/monitored under the current regulatory approach. In addition to failing to monitor for many potentially hazardous/deleterious chemicals in landfill stormwater runoff, landfill monitoring programs only monitor a few storms per year. Such infrequent monitoring could

readily fail to detect the release of waste constituents that are derived from spills and short term waste release events. Such events could readily be significantly adverse to water quality.

Figure 1
Chemical Analysis Output for a Typical Environmental Sample



TICs = tentatively identified compounds, from: C.G. Daughton, US EPA (July 2002)

This figure is from web page: "The Critical Role of Analytical Chemistry," C.G. Daughton, July 2002 <http://www.epa.gov/nerlesd1/chemistry/pharma/critical.htm>

Background information on unrecognized/unregulated chemicals as environmental pollutants is available at <http://www.epa.gov/nerlesd1/chemistry/pharma/> and at, <http://www.epa.gov/nerlesd1/chemistry/ecb-posters.htm>. Lee and Jones-Lee (2005a) have recently published a review on unrecognized pollutants.

Safe Drinking Water Act.

The federal Safe Drinking Water Act as amended in 1996 established the requirements that each state must develop a source water quality protection program that identifies the potential sources of pollutants in a domestic water supply watershed that are a threat to the water supply water quality. It should be understood that the US EPA Subtitle D regulations and state regulations governing developing MSW landfills do not adequately consider the protection of domestic water supply water from landfill area stormwater runoff derived pollutants. The US EPA national stormwater runoff water quality regulations also do not adequately and reliably establish stormwater runoff water quality management programs to protect domestic water supplies from landfill waste derived pollutants.

The Safe Drinking Water Act regulates the degree of treatment that is needed to produce an acceptable treated water. This Act, while helping state regulatory agencies and water utilities assess potential pollutant sources that could adversely impact domestic water supply water quality, has no regulatory authority to restrict land use in a water supply watershed. Since neither the US EPA Subtitle D landfill regulations and the US EPA stormwater runoff water quality regulations can be used to adequately protect domestic water supply water quality, the burden of watershed water supply water quality will fall to the water utility and the those concerned with protecting water quality in a domestic water supply. Water utilities should work

with the watershed area planning agency to restrict the development of new sources of pollutants that are a significant new source of pollutants. The development of new landfills in a small domestic water supply watershed is a situation where water utilities should work with local zoning agencies to restrict the development new landfills in their watershed. This is prudent public health and aquatic life water quality protection policy.

The agencies responsible for the domestic water source water quality assessment should identify MSW landfills as a potential long term source of a wide variety of pollutants that must be carefully monitored to insure the during the active life of the landfill and the postclosure period, i.e., while the wastes are still a threat to generate leachate when contacted with water.

As part of Safe Drinking Water Act requirements, the Chattahoochee-Flint Regional Development Center had WWETCO develop “The Coweta, Meriwether and Troup County Regional Source Water Assessment Plan (WWETCO 2003). This plan presents information on the current threats to the city of Hogansville, GA domestic water supply water quality. As part of the general discussion of activities in a water supply watershed, WWETCO identified municipal landfills as a potential source of pollutant that can be adverse to a domestic water supply. This Plan specifically identifies the city of Hogansville Blue Creek watershed as a small watershed that is subject to pollution by various types of land use activities.

The Meriwether County, GA zoning ordinance that prohibits the siting of MSW landfills in small domestic water supply watersheds is in accord with protection of the water quality impacts of landfill releases of waste derived constituents. This approach is appropriate as part of source water quality protection.

Deficiencies in Current Landfilling Practice – Groundwater Pollution by Landfill Liner Failure

In the 1980s the US EPA, under the requirements established by the US Congress within the Resource Conservation and Recovery Act (RCRA), established that landfilling of wastes shall be conducted with a “dry tomb” approach, where the wastes are to be isolated from the environment. The basic principle of dry tomb type landfilling is that if the wastes in the landfill can be isolated from water, then landfill leachate (garbage juice) generation can be controlled. In 1991 the US EPA (1991), as part of implementing RCRA under Subtitle D, adopted thin plastic sheeting and compacted clay as a minimum liner for dry tomb type landfills. The US EPA required that US states adopt as a minimum the Subtitle D landfill design requirements. Georgia, in Georgia Department of Natural Resources Rules of Solid Waste Management, Chapter 391-3-4 and Circular “14,” like many (but not all) other states, adopted minimum Subtitle D landfill siting, design, closure and postclosure care requirements. The current Georgia EPD landfilling regulations became effective on August 20, 1997.

It is widely recognized that minimum Subtitle D landfilling requirements will not necessarily be protective of public health and the environment from landfilled wastes for as long as the wastes in a dry tomb type landfill will be a threat. The US EPA, as part of promulgating Subtitle D landfilling regulations, stated in the draft regulations (US EPA, 1988a),

“First, even the best liner and leachate collection system will ultimately fail due to natural deterioration, and recent improvements in MSWLF (municipal solid waste landfill) containment technologies suggest that releases may be delayed by many decades at some landfills.”

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

“Once the unit is closed, the bottom layer of the landfill will deteriorate over time and, consequently, will not prevent leachate transport out of the unit.”

As part of a litigation settlement for failing to adopt Subtitle D regulations in accord with the Congressionally mandated timetable, the US EPA adopted the Subtitle D regulations knowing that ultimately the landfill liner systems that were allowed under these regulations will fail to prevent releases from the landfill.

I have been involved in review of the properties of landfill liners since the mid-1970s when, under US EPA research support, I conducted university-based studies on the characteristics of clay liners for landfills. In the 1980s I conducted university-based research on the properties of high-density polyethylene (plastic sheeting) liners of the type used to line municipal solid waste landfills. Since that time I have published numerous papers and reports that review the literature on the expected behavior of municipal solid waste landfill liner systems with respect to containing the waste components in a dry tomb type landfill for as long as the wastes will be a threat. Beginning in the summer of 2004, Dr. Anne Jones-Lee and I developed an updated comprehensive review of what we call the “flawed technology” of minimum design Subtitle D landfills in protecting public health and the environment from landfilled wastes for as long as the wastes will be a threat. This review (Lee and Jones-Lee 2005b) has been periodically updated as new information becomes available. It is available in its latest form on our website, www.gfredlee.com, at <http://www.members.aol.com/apple27298/SubtitleDFlawedTechnPap.pdf>.

As discussed by Lee and Jones-Lee (2005b), the most recent information from the US EPA supported contractors (Bonaparte et al. 2002) continues to conclude that the plastic sheeting and clay liners used in minimum design Subtitle D MSW landfills will ultimately deteriorate and become ineffective in collecting leachate that is generated within the landfill, and thereby lead to groundwater and, at some sites, surface water pollution. Lee and Jones-Lee (2005b) provided a summary of the literature on the various mechanisms that are involved in causing the deterioration of plastic sheeting and clay liners’ ability to prevent leachate from passing through them into the underlying groundwaters.

Lee and Jones-Lee (2005b) also discuss, based on their own research and the literature, a number of other significant deficiencies in the current allowed design of MSW landfills, one of the most important of which is the inability to prevent a closed MSW landfill (no longer accepting wastes), with its plastic sheeting layer in the cover, to prevent water from entering the wastes in the landfill and generating leachate and landfill gas. While a new landfill cover, if properly constructed, can be effective in preventing water from entering the landfill that will generate leachate, over time the integrity of the plastic sheeting in the cover will deteriorate and thereby allow water to penetrate into the wastes. One of the basic problems with the design of Subtitle D

landfill covers is that the plastic sheeting layer, which is the key to preventing water from entering the landfill, is buried below several feet of topsoil and a porous drainage layer, and therefore is not subject to inspection which would readily detect its deterioration to the point of allowing water to pass through it.

As discussed by Lee and Jones-Lee (2005b), US EPA officials claimed that the Subtitle D landfilling requirements, which call for groundwater monitoring at a point of compliance, would detect the ultimate failure of the landfill liner system while the polluted groundwater was still on the landfill owner's property. However, this assumption fails to recognize that in many groundwater systems underlying areas where landfills can be sited, the allowed groundwater monitoring well array at the point of compliance has a low probability of detecting leachate-polluted groundwater when it first reaches the point of compliance. The net result is that the failure of the landfill liner system and the ultimate pollution of groundwaters underlying the landfill will likely first be detected in adjacent properties' production wells or in surface waters where the polluted groundwaters enter streams, rivers or lakes.

Probably one of the most significant deficiencies of Subtitle D landfilling is that RCRA and Subtitle D only require 30 years of postclosure funding for monitoring and maintenance of the landfill. As discussed by Lee and Jones-Lee (2005b), and as is well recognized in the literature, municipal solid wastes in a dry tomb type landfill will be a threat to generate leachate and landfill gas, effectively, forever. Thirty years is an infinitesimally small part of the time that there will be need for postclosure funding for landfill monitoring, maintenance and, ultimately, a "Superfund"-like cleanup of polluted groundwaters. While RCRA/Subtitle D contains a provision for regulatory agencies to extend the postclosure funding requirements beyond 30 years after closing the landfill, there is no assurance for privately owned landfills that the landfill owner will still be in business, much less be financially able to continue to fund landfill monitoring and maintenance and groundwater remediation for the hundreds to 1,000 or more years that the wastes in the landfill will be a threat.

Recently, Lee and Jones-Lee (2005c,d) have conducted a review of the potential problems that can occur in a privately owned municipal solid waste landfill located in Pottstown, Pennsylvania. This review was conducted for the Pottstown Landfill Closure Committee. This Committee consists of representatives from Pottstown and several other nearby communities, and two counties that are impacted by the landfill. The long-term problems that Pottstown, et al., face with the closure of the Pottstown Landfill are an example of the kinds of problems that will occur at essentially all Subtitle D landfills when they ultimately close.

Overall Assessment

Landfills that can be developed in Georgia under Chapter 391-3-4 and Circular "14," which are essentially equivalent to US EPA Subtitle D landfilling regulations, will not necessarily prevent ground and surface water pollution by landfilled wastes for as long as the wastes in the dry tomb type landfill will be a threat. Ultimately, such landfills will be a threat to pollute domestic water supplies, rendering them a public health threat and, in many cases, unusable. Meriwether County is justified in prohibiting the siting of landfills in water supply watershed. This prohibition recognizes the deficiencies in currently allowed MSW landfilling.

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**Expertise and Experience in Hazardous Chemical Site and
Municipal/Industrial Landfill Impact Assessment/Management**

Dr. G. Fred Lee's work on hazardous chemical site and municipal/industrial landfill impact assessment began in the mid-1950s while he was an undergraduate student in environmental health sciences at San Jose State College in San Jose, California. His course and field work involved review of municipal and industrial solid waste landfill impacts on public health and the environment.

He obtained a Master of Science in Public Health degree from the University of North Carolina, Chapel Hill, in 1957. The focus of his masters degree work was on water quality evaluation and management with respect to public health and environmental protection from chemical constituents and pathogenic organisms.

Dr. Lee obtained a PhD degree specializing in environmental engineering from Harvard University in 1960. As part of this degree work he obtained further formal education in the fate, effects and significance and the development of control programs for chemical constituents in surface and ground water systems. An area of specialization during his PhD work was aquatic chemistry, which focused on the transport, fate and transformations of chemical constituents in aquatic (surface and ground water) and terrestrial systems as well as in waste management facilities.

For a 30-year period, he held university graduate-level teaching and research positions in departments of civil and environmental engineering at several major United States universities, including the University of Wisconsin-Madison, University of Texas at Dallas, and Colorado State University. During this period he taught graduate-level environmental engineering courses in water and wastewater analysis, water and wastewater treatment plant design, surface and ground water quality evaluation and management, and solid and hazardous waste management. He has published over 850 professional papers and reports on his research results and professional experience. His research included, beginning in the 1970s, the first work done on the impacts of organics on clay liners for landfills and waste piles/lagoons.

His work on the impacts of hazardous chemical site and municipal/industrial solid waste landfills began in the 1960s when, while directing the Water Chemistry Program in the Department of Civil and Environmental Engineering at the University of Wisconsin-Madison, he became involved in the review of the impacts of municipal solid waste landfills on groundwater quality.

In the 1970s, while he was Director of the Center for Environmental Studies at the University of Texas at Dallas, he was involved in the review of a number of municipal solid and industrial (hazardous) waste landfill situations, focusing on the impacts of releases from the landfill on public health and the environment.

In the early 1980s while holding a professorship in Civil and Environmental Engineering at Colorado State University, he served as an advisor to the town of Brush, Colorado, on the potential impacts of a proposed hazardous waste landfill on the groundwater resources of interest to the community. Based on this work, he published a paper in the Journal of the American Water Works Association discussing the ultimate failure of the liner systems proposed for that landfill in preventing groundwater pollution by landfill leachate. In 1984 this paper was judged by the Water Resources Division of the American Water Works Association as the best paper published in the journal for that year.

In the 1980s, he conducted a comprehensive review of the properties of HDPE liners of the type being used today for lining municipal solid waste and hazardous waste landfills with respect to their compatibility with landfill leachate and their expected performance in containing waste-derived constituents for as long as the waste will be a threat.

In the 1980s while he held the positions of Director of the Site Assessment and Remediation Division of a multi-university consortium hazardous waste research center and Distinguished Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology, he was involved in numerous situations concerning the impact of landfilling of municipal solid waste on public health and the environment. He has served as an advisor to the states of California, Michigan, New Jersey and Texas on solid waste regulations and management. He was involved in evaluating the potential threat of uranium waste solids from radium watch dial painting on groundwater quality when disposed of by burial in a gravel pit. The public in the area of this state of New Jersey proposed disposal site objected to the State's proposed approach. Dr. Lee provided testimony in litigation, which caused the judge reviewing this matter to prohibit the State from proceeding with the disposal of uranium/radium waste at the proposed location.

Beginning in the 1960s, while a full-time university professor, Dr. Lee was a part-time private consultant to governmental agencies, industry and environmental groups on water quality and solid and hazardous waste and mining management issues. His work included evaluating the impacts of a number of municipal and industrial solid waste landfills. Much of this work was done on behalf of water utilities, governmental agencies and public interest groups who were concerned about the impacts of a proposed landfill on their groundwater resources, public health and the environment.

In 1989, he retired after 30 years of graduate-level university teaching and research and expanded the part-time consulting that he had been doing with governmental agencies, industry and community and environmental groups into a full-time activity. A principal area of his work since then has been assisting water utilities, municipalities, industry, community and environmental groups, agricultural interests and others in evaluating the potential public health and environmental impacts of proposed or existing hazardous, as well as municipal solid waste landfills. He has been involved in the review of approximately 75 different landfills and waste piles (tailings) in various parts of the United States and in other countries.

Dr. Anne Jones-Lee (his wife) and he have published extensively on the issues that should be considered in developing new or expanded municipal solid waste and hazardous waste

landfills in order to protect the health, groundwater resources, environment and interests of those within the sphere of influence of the landfill. Their over 50 professional papers and reports on landfilling issues provide guidance not only on the problems of today's minimum US EPA Subtitle D landfills, but also on how landfilling of non-recyclable wastes can and should take place to protect public health, groundwater resources, the environment, and the interests of those within the sphere of influence of a landfill/waste management unit. They make many of their publications available as downloadable files from their web site, www.gfredlee.com.

Their work on landfill issues has particular relevance to Superfund site remediation, since regulatory agencies often propose to perform site remediation by developing an onsite landfill or capping waste materials that are present at the Superfund site. The proposed approach frequently falls short of providing true long-term health and environmental protection from the landfilled/capped waste.

In the early 1990s, Dr. Lee was appointed to a California Environmental Protection Agency's Comparative Risk Project Human Health Subcommittee that reviewed the public health hazards of chemicals in California's air and water. In connection with this activity, Dr. Jones-Lee and he developed a report, "Impact of Municipal and Industrial Non-Hazardous Waste Landfills on Public Health and the Environment: An Overview," that served as a basis for the human health advisory committee to assess public health impacts of municipal landfills.

In 2004 Dr Lee was selected as one of two independent peer reviewers by the Pottstown. PA Pottstown Landfill Closure Committee to review the adequacy of the proposed closure of the Pottstown Landfill to protect public health, groundwater resources and the environment for as long as the wastes in the closed landfill will be a threat.

In addition to teaching and serving as a consultant in environmental engineering for over 40 years, Dr. Lee is a registered professional engineer in the state of Texas and a Diplomate in the American Academy of Environmental Engineers (AAEE). The latter recognizes his leadership roles in the environmental engineering field. He has served as the chief examiner for the AAEE in north-central California and New Jersey, where he has been responsible for administering examinations for professional engineers with extensive experience and expertise in various aspects of environmental engineering, including solid and hazardous waste management.

His work on landfill impacts has included developing and presenting several two-day short-courses devoted to landfills and groundwater quality protection issues. These courses have been presented through the American Society of Civil Engineers, the American Water Resources Association, and the National Ground Water Association in several United States cities, including New York, Atlanta, Seattle and Chicago, and the University of California Extension Programs at several of the UC campuses, as well as through other groups. He has also participated in a mine waste management short-course organized by the University of Wisconsin-Madison and the University of Nevada. He has been an American Chemical Society tour speaker, where he is invited to lecture on landfills and groundwater quality protection issues, as well as domestic water supply water quality issues throughout the United States.

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Delano, California, USA	(home/office)	(home/office)

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EDUCATION

Ph.D. Environmental Engineering & Environmental Science, Harvard University,
Cambridge, Mass. 1960

M.S.P.H. Environmental Science-Environmental Chemistry, School of Public Health,
University of North Carolina, Chapel Hill, NC 1957

B.A. Environmental Health Science, San Jose State College, San Jose, CA 1955

ACADEMIC AND PROFESSIONAL EXPERIENCE

Current Position:

Consultant, President, G. Fred Lee and Associates

Previous Positions:

Distinguished Professor, Civil and Environmental Engineering, New Jersey Institute of
Technology, Newark, NJ, 1984-89

Senior Consulting Engineer, EBASCO-Envirosphere, Lyndhurst, NJ (part-time), 1988-89

Coordinator, Estuarine and Marine Water Quality Management Program, NJ Marine
Sciences Consortium Sea Grant Program, 1986

Director, Site Assessment and Remedial Action Division, Industry, Cooperative Center for
Research in Hazardous and Toxic Substances, New Jersey Institute of Technology et al.,
Newark, NJ, 1984-1987

Professor, Department of Civil and Environmental Engineering, Texas Tech University,
1982-1984

Professor, Environmental Engineering, Colorado State University, 1978-1982

Professor, Environmental Engineering & Sciences; Director, Center of Environmental
Studies, University of Texas at Dallas, 1973-1978

Professor of Water Chemistry, Department of Civil & Environmental Engineering,
University of Wisconsin-Madison, 1961-1973

Registered Professional Engineer, State of Texas, Registration No. 39906

Diplomate, American Academy of Environmental Engineers, Certificate No. 0701

PUBLICATIONS AND AREAS OF ACTIVITY

Published over 1,060 professional papers, chapters in books, professional reports, and similar materials. The topics covered include:

- Studies on sources, significance, fate and the development of control programs for chemicals in aquatic and terrestrial systems.
- Analytical methods for chemical contaminants in fresh and marine waters.
- Landfills and groundwater quality protection issues.
- Impact of landfills on public health and environment.
- Environmental impact and management of various types of wastewater discharges including municipal, mining, electric generating stations, domestic and industrial wastes, paper and steel mill, refinery wastewaters, etc.
Stormwater runoff water quality evaluation and BMP development for urban areas and highways.
- Eutrophication causes and control, groundwater quality impact of land disposal of municipal and industrial wastes, environmental impact of dredging and dredged material disposal, water quality modeling, hazard assessment for new and existing chemicals, water quality and sediment criteria and standards, water supply water quality, assessment of actual environmental impact of chemical contaminants on water quality.

LECTURES

Presented over 760 lectures at professional society meetings, universities, and to professional and public groups.

GRANTS AND AWARDS

Principal investigator for over six million dollars of contract and grant research in the water quality and solid and hazardous waste management field.

GRADUATE WORK CONDUCTED UNDER SUPERVISION OF G. FRED LEE

Over 90 M.S. theses and Ph.D. dissertations have been completed under the supervision of Dr. Lee.

ADVISORY ACTIVITIES

Consultant to numerous international, national and regional governmental agencies, community and environmental groups and industries.

Municipal Solid Waste Landfills and Groundwater Quality Protection Issues Publications

Drs. G. Fred Lee and Anne Jones-Lee have prepared several papers and reports on various aspects of municipal solid waste (MSW) management and hazardous waste management by landfilling, groundwater quality protection issues, as well as other issues of concern to those within a sphere of influence of a landfill. These materials provide an overview of the key problems associated with landfilling of MSW and hazardous waste utilizing lined "dry tomb" landfills and suggest alternative approaches for MSW management that will not lead to groundwater pollution by landfill leachate and protect the health and interests of those within the sphere of influence of a landfill. Copies of many of these papers and reports are available as downloadable files from Drs. G. Fred Lee's and Anne Jones-Lee's web page (<http://www.gfredlee.com>). Recent papers and reports on landfilling issues are listed below. Copies of the papers and reports listed below as well as a complete list of publications on this and related topics are available upon request.

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Lee, G. F., Jones, R.A., "Municipal Solid Waste Management: Long-Term Public Health and Environmental Protection," University of California, Davis Landfills and Groundwater Quality Short Course Materials, April (1991).
<http://www.members.aol.com/annejlee/MSWMANAGT.pdf>

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Landfill Mining

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**Landfills Evaluated by
G. Fred Lee and Anne Jones-Lee**

Arizona <i>(State Landfilling Regulations)</i>	Verde Valley - Copper Tailings Pile Closure Southpoint Landfill, Mobile
California <i>(State Landfilling Regulations)</i>	Colusa County - CERRS Landfill San Gabriel Valley - Azusa Landfill City of Industry - Puente Hills Landfill North San Diego County, 3 landfills San Diego County - Gregory Canyon Landfill El Dorado County Landfill Yolo County Landfill Half Moon Bay - Apanolio Landfill Pittsburg - Keller Canyon Landfill Chuckwalla Valley - Eagle Mountain Landfill Barstow - Hidden Valley Broadwell Hazardous Waste Landfills Cadiz - Bolo Station-Rail Cycle Landfill University of California-Davis Landfills (4) San Marcos - San Marcos Landfill Placer County - Western Regional Sanitary Landfill Placer County – Turkey Carcass Disposal Pits Imperial County - Mesquite Landfill Los Angeles County - Calabasas Landfill Los Angeles County – Palos Verdes Landfill Contra Costa County – Concord Naval Weapons Station Tidal Area Landfill Nevada County, CA Lava Cap Mine Area Landfill Sylmar, CA Sunshine Canyon Landfill
Colorado <i>(State Landfilling Regulations)</i>	Last Chance/Brush - Hazardous Waste Landfill Denver - Lowry Hazardous Waste Landfill Telluride/Idarado Mine Tailings
Florida <i>(State Landfilling Regulations)</i>	Alachua County Landfill
Illinois <i>(State Landfilling Regulations)</i>	Crystal Lake - McHenry County Landfill Wayne County Landfill
Indiana <i>(State Landfilling Regulations)</i>	Posey County Landfill New Haven-Adams Center Landfill (Hazardous Waste)
Michigan <i>(State Landfilling Regulations)</i>	Menominee Township - Landfill Ypsilanti- Waste Disposal Inc. (Hazardous Waste - PCB's)
Minnesota	Reserve Mining Co., Silver Bay - taconite tailings Wright County - Superior FCR Landfill
Missouri	Jefferson County - Bob's Home Service Hazardous Waste Landfill
New Jersey <i>(State Landfilling Regulations)</i>	Meadowlands – Landfill Fort Dix Landfill Scotch Plains Leaf Dump
New York	Staten Island - Fresh Kills Landfill, Niagara Falls - Hazardous Waste Landfill, New York City – Ferry Point Landfill

Ohio	Clermont County - BFI/CECOS Hazardous Waste Landfill, Huber Heights - Taylorville Road Hardfill Landfill
Pennsylvania <i>(State Landfilling Regulations)</i>	Pottstown, PA - Pottstown Landfill Closure Committee
Rhode Island	Richmond Landfill
South Carolina	Spartanburg - Palmetto Landfill
Texas <i>(State Landfilling Regulations)</i>	Dallas/Sachse – Landfill Fort Worth - Acme Brick Hazardous Waste Landfill City of Dallas - Jim Miller Road Landfill
Vermont	Coventry, Vermont – Coventry Landfill
Washington <i>(State Landfilling Regulations)</i>	Tacoma - 304th and Meridian Landfill
Wisconsin	Madison and Wausau Landfills
INTERNATIONAL LANDFILLS	
Belize	Mile 27 Landfill
Ontario, Canada <i>(Prov. Landfilling Regulations)</i>	Greater Toronto Area - Landfill Siting Issues Kirkland Lake - Adams Mine Site Landfill Pembroke - Cott Solid Waste Disposal Areas
Manitoba, Canada <i>(Prov. Landfilling Regulations)</i>	Winnipeg Area - Rosser Landfill
New Brunswick, Canada <i>(Prov. Landfilling Regulations)</i>	St. John's - Crane Mountain Landfill
England	Mercyside Waste Disposal Bootle Landfill
Hong Kong	Three New MSW Landfills
Ireland	Bottlehill Landfill, County Cork Central Waste Management Facility, Ballyduff, County Clare
Korea	Yukong Gas Co. - Hazardous Waste Landfill
Mexico <i>(Haz. Waste Landfilling Regulations)</i>	San Luis Pontosi - Hazardous Waste Landfill
New Zealand	North Waikato Regional Landfill
Puerto Rico	Salinas - Campo Sur Landfill

**Surface and Groundwater Quality Evaluation and Management
and
Municipal Solid & Industrial Hazardous Waste Landfills**

<http://www.gfredlee.com>

Dr. G. Fred Lee and Dr. Anne Jones-Lee have prepared professional papers and reports on the various areas in which they are active in research and consulting including domestic water supply water quality, water and wastewater treatment, water pollution control, and the evaluation and management of the impacts of solid and hazardous wastes. Publications are available in the following areas:

Landfills and Groundwater Quality Protection

Water Quality Evaluation and Management for Wastewater Discharges

Stormwater Runoff, Ambient Waters and Pesticide Water Quality Management Issues,
TMDL Development, Water Quality Criteria/Standards Development and
Implementation

Impact of Hazardous Chemicals -- Superfund

LEHR Superfund Site Reports to DSCSOC

Lava Cap Mine Superfund Site reports to SYRCL
Smith Canal

Contaminated Sediment -- Aquafund, BPTCP, Sediment Quality Criteria

Domestic Water Supply Water Quality

Excessive Fertilization/Eutrophication, Nutrient Criteria

Reuse of Reclaimed Wastewaters

Watershed Based Water Quality Management Programs:

Sacramento River Watershed Program

Delta -- CALFED Program

Upper Newport Bay Watershed Program

San Joaquin River Watershed DO and OP Pesticide TMDL Programs

Stormwater Runoff Water Quality Science/Engineering Newsletter

G. Fred Lee & Associates was organized in the late 1960s to cover the part-time consulting activities that Dr. Lee undertook while a full-time university professor. In 1989, when Dr. Lee retired from 30 years of graduate-level teaching and research, he and Dr. Anne Jones-Lee, who was also a university professor, expanded G. Fred Lee & Associates into a full-time business activity. Examples of governmental agencies, consulting firms, citizens groups, industries and others for whom G. Fred Lee has served as an advisor include the following:

U.S. Environmental Protection Agency - Various Locations
Vison, Elkins, Searls, Connally & Smith, Attorneys - Houston, TX
International Joint Commission for the Great Lakes
U.S. Public Health Service - Washington, DC
Attorney General, State of Texas - Austin, TX
Madison Metropolitan Sewerage District - Madison, WI
Great Lakes Basin Commission - Windsor, Ontario
U.S. Army Environmental Hygiene Agency - Edgewood Arsenal, MD
City of Madison - Madison, WI
Council on Environmental Quality - Washington, DC
National Academies of Sciences and Engineering - Washington, DC
Water Quality Board State of Texas - Austin, TX
U.S. General Accounting Office - Washington, DC
U.S. Army Corps of Engineers - Vicksburg, MS
Tennessee Valley Authority - Various locations in Tennessee Valley
National Oceanic & Atmospheric Administration - Various locations
Organization for Economic Cooperation & Development - Paris
Attorney General, State of Illinois - Chicago, IL
State of Texas Hazardous Waste Legislative Committee - Austin
State of New Mexico Environmental Improvement Agency - Santa Fe
New York District Corps of Engineers - New York, NY
San Francisco District Corps of Engineers - San Francisco, CA
Wisconsin Electric Power Company - Milwaukee, WI
WAPORA - Washington, DC
Reserve Mining Company - Silver Bay, MN
United Engineers - Philadelphia, PA
Automated Environmental Systems - Long Island, NY
Procter & Gamble Company - Cincinnati, OH
Inland Steel Development Company - Chicago, IL
Kennecott Copper Corporation - Salt Lake City, UT
U.S. Steel Corporation - Pittsburgh, PA
Nekoosa Edwards, Inc. - WI
Zimpro, Inc. - Rothschild, WI
FMC Corporation - Philadelphia, PA
Acme Brick Company - Forth Worth, TX
Monsanto Chemical Company - St. Louis, MO
Gould, Inc. - Cleveland, OH
Illinois Petroleum Council - Chicago, IL
Inland Steel Corporation - Chicago, IL
Industrial Biotest Laboratories - Northbrook, IL
Wisconsin Pulp & Paper Industries - Upper Fox Valley, WI

Thilmany Pulp & Paper Company - Green Bay, WI
Chicago Park District - Chicago, IL
Nalco Chemical Company - Chicago, IL
Boise Cascade Development Company - Chicago, IL
Foley & Lardner, Attorneys - Milwaukee, WI
Timken & Lonsdorf, Attorneys - Wausau, WI
Strasburger, Price, Kelton, Martin & Unis, Attorneys - Dallas, TX
Rooks, Pitts, Fullagar & Poust, Attorneys - Chicago, IL
Jones, Day, Cockley & Reaves, Attorneys - Cleveland, OH
Sullivan, Hanft, Hastings, Fride & O'Brien, Attorneys - Duluth, MN
Hinshaw, Culbertson, Molemann, Hoban & Fuller, Attnys - Chicago, IL
Colorado Springs - Colorado Springs, CO
Mayer, Brown & Platt, Attorneys - Chicago, IL
Pueblo Area Council of Governments - Pueblo, CO
Platte River Power Authority - Fort Collins, CO
Linguist & Vennum, Attorneys - Minneapolis, MN
Norfolk District Corps of Engineers - Norfolk, VA
Spanish Ministry of Public Works - Madrid, Spain
The Netherlands - Rijkswaterstaat - Amsterdam, The Netherlands
U.S. Department of Energy - Various locations in US
King Industries - Norwalk, CT
Attorney General, State of Florida - Tallahassee, FL
State of Colorado Governor's Office - Denver, CO
Cities of Fort Collins, Longmont, and Loveland - CO
E.I. DuPont - Wilmington, DE
Allied Chemical Company - Morristown, NJ
Outboard Marine - Waukegan, IL
Amoco Oil Company - Denver, CO
Appalachian Timber Services - Charleston, WV
Mission Viejo Development - Denver, CO
Fisher, Brown, Huddleston & Gun, Attorneys - Fort Collins, CO
Tom Florczak, Attorney - Colorado Springs, CO
Wastewater Authority - Burlington, VT
Tad Foster, Attorney - Pueblo, CO
Holmes, Roberts & Owen, Attorneys - Denver, CO
Center for Energy and Environment Research - Puerto Rico
City of Brush - Brush, CO
Rock Island District Corps of Engineers - Rock Island, IL
Santo Domingo Water Authority - Dominican Republic
Ministry of Public Works and Environment - Buenos Aires, Argentina
Neville Chemical - Pittsburgh, PA
Fike Chemical Company - Huntington, WV
Stauffer Chemical Company - Richmond, CA
Adolph Coors Company - Golden, CO
Water Research Commission - South Africa
Grinnell Fire Protection Systems - Lubbock, TX

City of Lubbock Parks Department - Lubbock, TX
National Planning Council - Amman, Jordan
City of Olathe - Olathe, KS
City of Lubbock - Lubbock, TX
US AID - Amman, Jordan
Buffalo Springs Lake Improvement Association - Buffalo Springs, TX
Union Carbide Company - Charleston, WV
Canadian River Municipal Water Authority - Lake Meredith, TX
Mobil Chemical Company - Pasadena, TX
Unilever Ltd. - Rotterdam, The Netherlands
Brazos River Authority - Waco, TX
U.S. Army Construction Engineering Research Laboratory - Champaign, IL
James Yoho, Attorney - Danville, IL
Zukowsky, Rogers & Flood, Attorneys - Crystal Lake, IL
State of California Water Resources Control Board - Sacramento
Public Service Electric & Gas - Newark, NJ
Health Officer - Boonton Township, NJ
Scotland & Robeson Counties - Lumberton, NC
International Business Machines Corporation - White Plains, NY
Newark Watershed Conservation & Development Authority - NJ
State of Vermont Planning Agency - Montpelier, VT
CDM, Inc. - Edison, NJ
Attorney General, State of North Carolina - Raleigh, NC
City of Vernon - Vernon, NJ
Ebasco Services - Lyndhurst, NJ
Kraft, Inc. - Northbrook IL, with work in Canada, FL and MN
USSR Academy of Sciences - Moscow, USSR
Tillinghast, Collins & Graham, Attorneys - Providence, RI
City of Richmond, RI
Idarado Mining Company - Telluride, CO
Levy, Angstreich, Attorneys - Cherry Hill, NJ
Newport City Development - Jersey City, NJ
Orbe, Nugent & Collins, Attorneys - Ridgewood, NJ
Schmeltzer, Aptaker & Shepard, Attorneys - Washington, DC
CP Chemical - Sewaren, NJ
Dan Walsh, Attorney - Carson City, NJ
William Cody Kelly - Lake Tahoe, NV
NJ Department of Environmental Protection - Trenton, NJ
Hufstедler, Miller, Kaus & Beardsley, Attorneys - Los Angeles, CA
Main San Gabriel Basin Watermaster - CA
Metropolitan Water District of Southern California - Los Angeles, CA
San Diego Unified Port District - San Diego, CA
Delta Wetlands - CA
Simpson Paper Company - Humboldt County, CA
City of Sacramento - CA
Northern California Legal Services - Sacramento, CA

Rocketdyne - Canoga Park, CA
RR&C Development Co. - City of Industry, CA
American Dental Association - Chicago, IL
Emerald Environmental - Phoenix, AZ
Clayton Chemical Company - Sauget, IL
Stanford Ranch - Rocklin, CA
Public Liaison Committee - Kirkland Lake, Ontario
Miller Brewing Company, Los Angeles, CA
ASARCO Inc., Tacoma, WA
CALAMCO, Stockton, CA
Yunkong Gas Company, South Korea
Sutherlands, Pembroke, Ontario
Silverado Constructors, Irvine, CA
Agricultural Interests in Puerto Rico
City of Winnipeg, Manitoba
Strain Orchards, Colusa, CA
Davis South Campus Superfund Oversight Committee, Davis, CA
Monterrey County, California Housing Authority, Salinas, CA
CROWD, Tacoma, WA
Newport Beach, CA
SOLVE, Phoenix, AZ
Sports Fishing Alliance, San Francisco, CA
Caltrans (California Department of Transportation)
Citizens Group near St. John's, New Brunswick
Colonna Shipyards, Norfolk, VA
Clermont County, OH
Wright County, MN
Waikato River Protection Society, New Zealand
Drobac & Drobac, Attorneys, Santa Cruz, CA
Phelps Dunbar, L.L.P., Houston, TX
Walters Williams & Co, New Zealand
Environmental Protection Department, Hong Kong
NYPRIG New York City, NY
DeltaKeeper, Stockton
City of Stockton, CA
Central Valley Regional Water Quality Board, Sacramento, CA
Carson Harbor Village, Carson, CA
Sanitary District of Hammond, IN
South Bay CARES, Los Angeles, CA
Memphremagog Regional Council, Quebec, CANADA
Mobile, AZ
Pottstown Landfill Closure Committee, Pottstown, PA
Grand Forks County Citizens Coalition, Grand Forks, ND
Sunshine Canyon Landfill, Sylmar, CA