Issues in Providing Long Term Public Health and Environmental Protection from Redeveloped Brownfield Properties

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As defined by the US EPA [http://epa.gov/brownfields/]),*"Brownfields are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties protects the environment, reduces blight, and takes development pressures off greenspaces and working lands."* These properties typically contain mixtures of known, recognized, reasonably expected, as well as unrevealed or presently unrecognized chemicals that pose, or could pose, a threat to public health and the environment. It has been our experience that owners of such properties, city officials, potential property developers, and even some regulatory agency staff are eager to "remediate" urban brownfields sufficiently to enable redevelopment. This eagerness to return a hazardous chemical "brownfield" site to productive use, combined with economic considerations, can lead to effecting the least possible remediation to just get by minimum regulatory agency staff requirements. The remediation approach often involves "containment" of considerable amounts of hazardous chemicals at the site with a soil layer between the chemicals and the facilities to be constructed; there is often inadequate attention to realistic long-term potential impacts of the residual hazardous chemicals that are being left on the "remediated" property.

Presented herein is a discussion of some of the key issues that need to be considered in protecting public health and environmental quality from impacts of residual chemicals left at brownfield sites. This discussion is primarily based on a review of potential public health and environmental problems associated with developing the Brisbane Baylands area properties in:

> Lee, G. F., and Jones-Lee, A., "Report on the Adequacy of the Investigation/Remediation of the Brisbane Baylands UPC Property Contamination Relative to Development of That Property," PowerPoint Slides for Presentation prepared for Brisbane Baylands Community Action Group (BBCAG), Brisbane, CA, October 19 (2010).
> http://www.gfredlee.com/Landfills/BrisbaneBaylandsSlides.pdf
>
> Lee, G. F., and Jones-Lee, A., "Report on the Adequacy of the Investigation/Remediation of the Brisbane Baylands UPC Property Contamination Relative to Development of That Property," Prepared for Brisbane Baylands Community Action Group (BBCAG), Brisbane, CA, Report of G. Fred Lee & Associates, El Macero, CA, November 1, (2010).

Hazardous Chemicals versus Hazardous Wastes

One of the issues that can cause confusion in the evaluation of brownfield sites for development is the characterization of chemicals as "hazardous wastes" or "hazardous chemicals," and the differentiation between "hazardous" and "non-hazardous" materials. "Hazardous chemical" is a general term used to label chemicals that, either alone or in combination with other chemicals, can be toxic (poisonous) or carcinogenic to humans or adversely affect wildlife. Few of the myriad chemicals in use today that can be hazardous to humans or wildlife are subject to environmental regulation. “Hazardous waste” is a regulatory term covering a small group of hazardous chemicals that the US EPA defined as such in the 1970s associated with its defining waste disposal sites and requirements. The differentiation between “hazardous” and “non-hazardous” waste is a regulatory one; a “non-hazardous” waste can, in fact, be deleterious.

A more in-depth discussion of these issues is presented beginning on page 51 in the Lee and Jones-Lee Flawed Technology review,

> 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 June (2010).
> http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

They are also discussed in several issues of Drs. Lee and Jones-Lee’s “Stormwater Runoff Water Quality Newsletter” devoted to unrecognized pollutants (NL 7-3, 8-5, 9-3, 10-7, 11-7/8, 11-11, 12-6, and 13-1) and to pharmaceuticals and personal care products (PPCPs) (7-3, 8-5, 10-7, 11-7/8, and 13-1) (available on their website, www.gfredlee.com, at http://www.gfredlee.com/newsindex.htm). As discussed in those writings, typical hazardous chemical monitoring programs focus on 100 to 200 or so chemicals (primarily those on the list of “Priority Pollutants”) of the many thousands of chemicals that can be present in wastes. The Priority Pollutant list was developed in the 1970s out of a litigation settlement between attorneys for an environment group and US EPA attorneys. That list was not peer-reviewed within the US EPA, much less in the public or broader technical arenas. Every year “new” hazardous chemicals are found in wastes and the environment – chemicals that have been there for many years but have not been detected by the limited-scope monitoring programs that have been, and continue to be, used. These newly found chemical pollutants are not necessarily added to the list of chemicals that are part of the suite of chemicals monitored at hazardous chemical sites.

Unrecognized/Unregulated Hazardous Chemicals

An example of a group of unrecognized, unregulated hazardous chemicals that has existed in wastes and in the environment for many decades is the polybrominated diphenyl ethers (PBDEs). PBDEs have characteristics similar to PCBs and are used as flame retardants on furniture, curtains, and many other products. The US Department of Health and Human Services Agency for Toxic Substances and Disease Registry (ATSDR) (2004) developed a fact sheet (ToxFAQs™) for PBDEs (available at http://www.atsdr.cdc.gov/tfacts68-pbde.html) that provides information on the nature, occurrence, toxicity, etc. of PBDEs. Additional information on that group of chemicals is available on the Internet by searching PBDEs and in the Lee and Jones-Lee Stormwater Newsletters NL 7-3 NL 9-3 (available at http://www.gfredlee.com/Newsletter/swnewsV7N3.pdf) and NL 9-3 (http://www.gfredlee.com/Newsletter/swnewsV9N3.pdf).

As discussed in the literature, PBDEs have been found in aquatic organisms in many parts of the world, including in San Francisco Bay. Studies have shown that PBDEs have been bioaccumulating in archived human breast milk for several decades. As summarized in NL 7-3, according to McDonald (2003) of California Environmental Protection Agency, Office of

Environmental Health Hazard Assessment:
"Approximately 75 million pounds of PBDEs are used each year in the U.S. as flame retardant additives for plastics in computers, televisions, appliances, building materials and vehicle parts; and foams for furniture. PBDEs migrate out of these products and into the environment, where they bioaccumulate. PBDEs are now ubiquitous in the environment and have been measured in indoor and outdoor air, house dust, food, streams and lakes, terrestrial and aquatic biota, and human tissues. Concentrations of PBDE measured in fish, marine mammals and people from the San Francisco Bay region are among the highest in the world, and these levels appear to be increasing with each passing year."

Despite their widespread presence and accumulation in organism tissue, and the concern for their impacts on organisms, PBDEs are not subject to environmental regulation through water quality standards.

The environmental pollution by PBDEs is but one example of the significant deficiencies in conventional water quality monitoring for detecting the wide range of hazardous chemicals that are in wastes and in their leachates. Because of the limited scope of the list of chemicals typically monitored in hazardous chemical site investigations, it should never be assumed that leachate from landfills (even so-called "non-hazardous" municipal solid waste landfills), or other complex mixtures of wastes, represents no threat to human health or the environment on the basis of the reporting that the concentrations of all the chemicals measured in the characterization of the waste are below detection limits or below current regulatory limits.

Perchlorate is another unregulated/unmonitored chemical that has long been, and continues to be a widespread environmental pollutant that is a public health hazard that is highly mobile in groundwaters. An important source of environmental pollution by perchlorate is its use in roadside safety flares. "Wikipedia" provides some background information on its use in flares (pyrotechnic) in http://en.wikipedia.org/wiki/Flare_(pyrotechnic).

As discussed in our Stormwater Runoff Water Quality Newsletter NL 7-available at http://www.gfredlee.com/Newsletter/swnewsV7N3.pdf:
"*Silva (2003) of the Santa Clara Valley Water District, has discussed the potential for highway safety flares to be a significant source of perchlorate (ClO-4-) contamination to water, even when the flares are 100-percent burned*." Silva pointed out, "*More than 40 metric tons of flares were used/burned in 2002 alone in Santa Clara County*."

> Silva, M. A., "Safety Flares Threaten Water Quality with Perchlorate," Report of Santa Clara Valley Water District (2003).
> http://www.valleywater.org/Water/Water_Quality/Protecting_your_water/_Lustop/Perchlorate.shtm

The US EPA website [http://water.epa.gov/drink/contaminants/unregulated/perchlorate.cfm] under Perchlorate, contains information on perchlorate as an environmental pollutant.

Hazardous chemical sites also contain a variety of chemicals, such as salts and organics, that can cause tastes and odors in water, fish, wildlife, etc. While those materials and their tastes/odors may not necessarily be toxic, they can be detrimental to water quality/organism quality. Thus, consideration of "impact" extends beyond measured chemicals that are labeled "hazardous."

It is important to understand that hazardous chemical sites can contain a wide variety of hazardous and otherwise deleterious chemicals that are not necessarily regulated or monitored, that are not adequately regulated, and/or that are not presently known or recognized as potentially hazardous to public health or environmental quality.

Water Quality Criteria

The typical approach for evaluating the potential threat of a hazardous chemical site such as a closed landfill is to monitor the concentrations of potential pollutants (i.e., those regulated chemicals that can be a threat to public health and/or the environment); the concentrations found in the waters of concern are compared to a list of water quality criteria/standards and drinking water maximum contaminant levels (MCLs). If none of the analyzed chemicals exceeds a regulatory limit, the water is presumed to be "safe" to drink and to not be adverse to aquatic life or to higher trophic level organisms that use the aquatic life as food. While this is the approach typically used, it by no means ensures protection of public health or environmental quality. Lee and Jones-Lee discussed concern associated with reliance on meeting US EPA drinking water MCLs for the protection of human health in their report:

> Lee, G. F., and Jones-Lee, A., "Monitoring Pollutants in Stormwater Runoff from Superfund Sites and Other Locations," Report of G. Fred Lee & Associates, El Macero, CA, November 5 (2009).
> http://www.gfredlee.com/HazChemSites/MonitorRunoffSuperfund.pdf

and in,

> Lee, G. F., and Jones-Lee, A., "Issues in Monitoring Hazardous Chemicals in Stormwater Runoff/Discharges from Superfund and Other Hazardous Chemical Sites," Journ. Remediation 20(2):115-127 Spring (2010).
> http://www.gfredlee.com/HazChemSites/MonitoringHazChemSW.pdf

Factors other than human health impacts, such as the cost to remove a chemical from drinking water, are used in the setting of MCLs. An example of implications of that approach is found in the MCL for arsenic. The US EPA arsenic MCL is about 500 times the cancer risk of 1×10^{-6} typically used for developing MCLs for many other chemicals. (1×10^{-6} represents a cancer risk of one additional cancer in a population of 1 million people who consume 2 liters (0.5 gallon) per day for a life time.) The US EPA established the MCL for arsenic well-above levels recognized to be associated with a higher cancer risk in order to shield domestic water utilities from the cost of having to treat the water sufficiently to achieve the lower cancer risk.

Similar problems exist in relying on some of the aquatic life criteria for ensuring protection of aquatic life from toxic chemicals. Some aquatic life water quality criteria ignore the toxicity of chemicals to zooplankton, which are important as fish food. Thus while meeting such criteria may protect fish from direct harm by toxicity, it may not provide protection for their food sources, a condition that could adversely affect the fish population.

The senior author (Lee) has been involved in the development, evaluation, and appropriate use of water quality criteria and standards since the mid-1960s. He served as: an invited peer reviewer for the National Academies of Science and Engineering "Blue Book" of Water Quality Criteria developed in 1972; a member of the American Fisheries Society Water Quality Section Review Panel for the US EPA "Red Book" of Water Quality Criteria of 1976; and an invited peer reviewer for the development approach and several criterion documents of the US EPA 1987 "Yellow Book" of Water Quality Criteria. He is therefore familiar with how water quality criteria and drinking water MCLs are developed. Drs. Lee and Jones-Lee have also published a number of papers on these issues, including:

> Lee, G. F., and Jones-Lee, A., "Clean Water Act, Water Quality Criteria/Standards, TMDLs, and Weight-of-Evidence Approach for Regulating Water Quality," Water Encyclopedia: Water Law and Economics, Wiley, Hoboken, NJ, pp 598-604 (2005). http://www.gfredlee.com/SurfaceWQ/WileyCleanWaterAct.pdf
>
> Lee, G. F. and Jones-Lee, A., "Appropriate Use of Numeric Chemical Water Quality Criteria," *Health and Ecological Risk Assessment*, **1**:5-11 (1995). http://www.gfredlee.com/SurfaceWQ/chemcri.htm

It is not uncommon for those with limited understanding of how water quality criteria and standards are developed to mechanically use them to judge if a water is "safe" or not; if none of the criteria is exceeded, the water is considered "safe." That approach can readily lead to both under- and over-protection of the beneficial uses of a water. First, water quality criteria have been developed for only a very few of the many thousands of chemicals that are present in wastes and that have the potential to be adverse to public health and the environment. Second, the current approach for developing water quality criteria does not consider even known additive and synergistic properties of mixtures of chemicals; the toxicity of a mixture of such chemicals is greater than the sum of toxicity caused by each chemical alone. Third, as noted above, some water quality standards, such as MCLs for drinking water, incorporate factors outside of the potential impacts on public health and environmental quality, such as treatment costs.

Another area of concern in regulating some chemicals is their effecting changes in "biomarkers" in organisms, as evidenced by changes in biochemical cycles within the organism. While it has been known for more than four decades that those types of changes occur, the significance of such biomarker responses to a particular organism, much less a population of organisms, is generally not understood.

Gaseous Emissions

The potential for landfill gas and volatile organic chemicals (VOCs) to be emitted from the existing wastes and soils is another area of concern in the development of a hazardous chemical site. Such emissions can cause hazardous conditions to develop in buildings overlying the areas where the emission occurs. While HDPE layers can, for some period of time, help to reduce the entrance of volatile chemicals into structures, there is need to develop a system to collect the volatile emissions in the area between the floor of structures and the HDPE or other suitable barrier layer, and to treat the volatile emissions as necessary before release to the atmosphere. Further, there should be ongoing periodic monitoring of the volatile chemicals in the buildings and in the vapor exhaust ventilation system, and a reliable protocol in place to address the emissions at the source.

Clean Closure Issues

An issue that is frequently raised, especially by the public and other groups concerned about the adequacy of a hazardous chemical site remediation, is whether a site should be remediated to the point of “clean closure,” i.e., the removal of all the known hazardous chemicals from the site, prior to development. By contrast, the remediation approach adopted for many brownfield hazardous chemical sites is to leave known and yet-to-be-identified hazardous/deleterious chemicals on the property and establish procedures to try to control the releases from the polluted areas by containment or by collection and treatment.

In principle, a “clean closure” provides the greatest protection of public health and environmental quality for the site provided that all hazardous and otherwise deleterious chemicals are, in fact, removed from the site. However as discussed in the paper cited below, providing “clean closure” is not straightforward as all concerned grapple with the issue of “how clean is clean?” and can leave the public with a false sense of security regarding the site.

> Lee, G. F. and Jones-Lee, A., "Does Meeting Cleanup Standards Mean Protection of Public Health and the Environment?," IN: Superfund XV Conference Proc., Hazardous Materials Control Resources Institute, Rockville, MD, pp. 531-540 (1994). http://www.gfredlee.com/HazChemSites/hmcrstd.htm

The typical approach taken for “clean closure” is the removal of hazardous chemicals that are included in the list of conventionally measured pollutants. While such an approach can provide a sense of protection, it cannot be relied upon to ensure protection of public health or environmental quality at the site. As discussed in the paper referenced above, complex chemical sites, at which a large number of a variety of hazardous chemicals are likely to be present, often also contain other, unmeasured and/or unregulated chemicals that were disposed of at the site or that were formed through transformation of other chemicals at the site. Therefore, it should never be assumed that a contaminated site – even one that underwent a so-called “clean closure” – no longer represents a threat to public health and the environment. Ongoing monitoring of the developed area should continued with particular reference to newly identified hazardous chemicals.

Remediated sites that incorporate structures that are relied upon for waste/chemical containment for protection of public health and the environment (such as a cap) need to carry land-use restrictions that protect the integrity and functioning of the containment system; land-use activities allowed need to be compatible with and support the containment system, and not facilitate breaches, which that can lead to release of hazardous chemicals to structures and/or the environment. Of particular concern is excavation for utilities, and the development of deep-rooted plants that can bring hazardous chemicals to the surface. It is important to understand that hazardous chemicals contained on a site will be a threat effectively forever; they do not necessarily become innocuous over time. As the containment systems deteriorate, the containment diminishes. Therefore, a key to long-term protection of public health and environmental quality associated with “remediated” sites will be the effectiveness and reliability of the implementation of the restrictions on land-use activities at the site that could lead to release of hazardous chemicals. Enforcement would need to be continued even if, after a few years, decades, or longer, no release of chemicals has been revealed. As long as hazardous chemicals are present on the site, proper land-use restrictions, as well as systems and water quality maintenance and monitoring must be continued. All of these issues should be understood by those interested in the remediation/development of brownfield sites and addressed in formulating the plans for developing such areas.

On-Site Landfills

It has been the experience of the authors that some brownfield sites and Superfund sites contain on-site landfill that have been deemed to meet minimum landfill design and closure requirements, such as US EPA Subtitle D regulations. Some sites contain waste piles or old, unlined landfills that have been covered with a “RCRA” cap. There are many long-term potential public health and environmental pollution concerns associated with on-site landfills and capped waste piles/unlined landfills that must be considered and prepared for in developing remediation approaches for brownfield sites. Such remediation measures do not necessarily provide for long-term protection of public health or the environmental as discussed in the following publications:

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 June (2010). http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf http://www.gfredlee.com/Landfills/BrisbaneBaylands.pdf

Lee, G. F., "Redevelopment of Brownfield Properties: Future Property Owners/Users Proceed with Your Eyes Open," Environmental Progress 16(4):W3 (1997). http://www.gfredlee.com/HazChemSites/brownfield.html

Lee, G.F. and Jones-Lee, A., "Evaluation of the Adequacy of Hazardous Chemical Site Remediation by Landfilling," IN: Remediation of Hazardous Waste Contaminated Soils, Marcel Dekker, Inc., NY pp 193-215 (2000). http://www.gfredlee.com/HazChemSites/chem_remed.pdf

Lee, G.F., and Jones-Lee, A., "Hazardous Chemical Site Remediation Through Capping: Problems with Long Term Protection," Remediation 7(4):51-57 (1997). http://www.gfredlee.com/HazChemSites/pbrwnfld.htm

Lee, G. F. and Jones, R. A., "Redevelopment of Remediated Superfund Sites: Problems with Current Approaches in Providing Long-Term Public Health Protection," Proc. Environmental Engineering 1991 Specialty Conference, ASCE, New York, pp. 505-510, July (1991). http://www.gfredlee.com/HazChemSites/remsprfd.htm

Lee, G. F., and Jones-Lee, A., “Disposal of Contaminated Sediments/Soils in MSW Landfills: Need to Consider the True Cost," Journ. Remediation 15(3):95-101 (2005). http://www.gfredlee.com/Landfills/LF-DredgedSed.pdf

Lee, G. F., and Jones-Lee, A., “Municipal Solid Waste Landfills – Water Quality Issues,” IN: Water Encyclopedia: Water Quality and Resource Development, Wiley, Hoboken, NJ pp 163-169 (2005). http://www.gfredlee.com/Landfills/WileyLandfills.pdf

Lee, G. F., and Jones-Lee, A., "Superfund Site Remediation by Landfilling - Overview of Landfill Design, Operation, Closure and Postclosure Care Issues," Remediation 14(3):65-91, Summer (2004). http://www.gfredlee.com/Landfills/LFoverviewRemediation.pdf

Lee, G. F. and Jones-Lee, A., "Improving Public Health and Environmental Protection Resulting from Superfund Site Investigation/Remediation," Remediation 14(2):33-53, Spring (2004). http://www.gfredlee.com/HazChemSites/remediation-paper.pdf

Lee, G. F., "Problems with Landfills for Superfund Site Remediation." Presentation at US EPA National Superfund Technical Assistance Grant (TAG) Workshop, Albuquerque, NM, February (2003). http://www.gfredlee.com/Landfills/Show-SuperfundAlbuquerque.pdf

Lee, G. F., and Jones-Lee, A., "Overview of Landfill Post Closure Issues," Presented at American Society of Civil Engineers session "Landfill Closures - Environmental Protection and Land Recovery," New York, NY, October (1995). http://www.gfredlee.com/Landfills/asceco2a.htm

Lee, G. F., and Jones-Lee, A., "Issues in Monitoring Hazardous Chemicals in Stormwater Runoff/Discharges from Superfund and Other Hazardous Chemical Sites," Journ. Remediation 20(2):115-127 Spring (2010). http://www.gfredlee.com/HazChemSites/MonitoringHazChemSW.pdf

Lee, G.F., and Jones-Lee, A., "Evaluation of Surface Water Quality Impacts of Hazardous Chemical Sites," Remediation 9:87-118 (1999). http://www.gfredlee.com/HazChemSites/eval_sfcwaters.pdf

Third-Party Independent Monitoring and Review of the Developed Properties

An issue that has occurred at some hazardous chemical sites is that once the regulatory agency adopts a remediation approach it can be difficult to get the agency to reopen the site for further study, even though the new evidence strongly supports the need for additional study. Typically regulatory agencies do not have adequate resources to revisit a site, especially when there are other sites that require examination. This situation provides justification for third-party, independent monitoring and review of a site with reporting to a citizen/agency board overseeing the site. In order to provide a higher degree of protection for public health and the environment, developers and future property owners of brownfield developments should provide and maintain sufficient independently managed funds to enable third-party, independent monitoring of the property for hazardous/deleterious chemicals that are a threat to public health and the environment. Such monitoring, which would need to be continued indefinitely, should be done by a contractor who is hired by a citizens/regulatory agency board and report at least annually to that board and the public. The amount of funding should be sufficient to enable periodic monitoring of all potential pathways for release of hazardous/deleterious chemicals, and to allow for expansion of the scope of monitoring should new chemicals be identified as chemicals of concern.

Further, periodic reviews should be conducted, such as the five-year reviews delineated in the US EPA Superfund regulations, to ascertain whether new information has been developed that should prompt reopening of the site investigation and remediation. As with the independent monitoring, those periodic reviews should be done with full public participation; the public should also be provided funds for independent, third-party technical assistance to review the adequacy of the periodic review. As part of the closure of a site, even if it is considered to be a “clean closure,” funding should be made available by the responsible parties or the regulatory agency to enable the public to actively participate in site review such as suggested herein, with independent, third-party technical assistance.