Improving Public Health and Environmental Protection from Inadequately Developed Landfills[1]

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In those situations where a landfill will be developed that does not provide for full public health, groundwater resource and environmental protection, such as a minimum design Subtitle D landfill with a single composite liner, the following approach should be incorporated into the permitting of the landfill. In order to significantly improve public health, groundwater and surface water quality protection, a landfill proponent should be required to:

- Conduct sufficient additional hydrogeological investigations to be able to reliably predict (under plausible worst case conditions - most protective) the pathways for adjacent property groundwater pollution, when offsite groundwaters will likely be polluted and when surface water springs and streams in the area of the landfills will be polluted by landfill leachate that penetrates the landfill liners.
- Establish a proactive, comprehensive offsite water quality monitoring program of all offsite water supply wells, springs and surface water streams within several miles of the proposed landfill, which will detect incipient groundwater and surface water pollution by landfill leachate. This distance should be determined based on the hydrogeological conditions that exist in the area of the proposed landfill.

MSW and other types of landfills will contain wastes that generate leachate that will be a significant threat to pollute groundwaters and surface waters in the vicinity of the landfill. This leachate will contain chemicals that can cause groundwater consumed by humans and animals to be a health threat. In addition, leachate-polluted groundwater will contain chemicals that will cause tastes and odors and make the leachate-polluted groundwater unusable for domestic and many other purposes, including as a water supply for animals. Such pollution will cause the well to have to be abandoned.

Landfills that are designed to meet the Subtitle D minimum requirement of a single composite liner will ultimately allow leachate generated within the landfill to penetrate into the groundwater system underlying the landfill. Typically associated with this type of landfill are the highly unreliable groundwater monitoring systems that are allowed by regulatory agencies, involving vertical monitoring wells spaced hundreds to thousands of feet apart at the point of compliance for groundwater monitoring. The hydrogeology of the groundwaters underlying many proposed landfills is complex, with sand layers and fractured rock/clay. The groundwater under such landfills will carry leachate-polluted groundwater that develops under the landfill to

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groundwaters that underlie adjacent properties and, at some landfill locations, to surface waters. At some time in the future, the groundwaters under adjacent properties will be polluted by chemicals in the landfill leachate. This will render the offsite groundwater a health threat and unusable for domestic and many purposes. Surface waters polluted by polluted groundwaters will be a threat to domestic water supplies and to aquatic life.

Need for Improved Hydrogeological Characterization. The complex hydrogeology underlying and in the area of many proposed landfills makes the transport of leachate-polluted groundwater to offsite areas difficult to assess/monitor. Typically the degree of characterization of the geological strata underlying a proposed landfill is inadequate to predict potential pathways and the rate of movement of leachate-polluted groundwater that will occur under the landfill to offsite areas. As part of providing an appropriate degree of offsite groundwater resource and public health protection, it is reasonable to require that a landfill proponent be required to characterize the hydrogeology of the landfill's area sufficiently well so that reliable estimates of the direction, rate and degree of pollution of adjacent and nearby properties' groundwaters can be made once the liner system has failed to collect all the leachate generated in the landfill. This information is essential to developing an appropriate groundwater monitoring system to detect when the leachate-polluted groundwater first reaches the point of compliance for groundwater monitoring down groundwater gradient from the landfill.

S. Hubbard (2006) senior scientist at the Lawrence Berkeley National Laboratory presentation, "Toward X-Ray Vision: Geophysical Signatures of Complex Subsurface Processes" provides information on the kind of studies that are needed to adequately characterize the hydrogeology of landfill and hazardous chemical sites. Information on this presentation is available at, http://esd.lbl.gov/about/staff/susanhubbard/2010_birdsall_dreiss.html. Her report covering this presentation is available as Hubbard and Rubin (2006); other papers/reports of Dr. Hubbard's are available at http://esd.lbl.gov/about/staff/susanhubbard/publications.html.

The landfill permitting agency(s), as part of consideration of permitting a landfill, should require that a comprehensive hydrogeological investigation be conducted at the landfill site so that there is a reasonable degree of scientific certainty in predicting the potential pathways by which leachate-polluted groundwaters that occur at any location under the landfill liner can trespass under adjacent properties.

The hydrogeological investigation should also provide a plausible worst-case estimate of the concentrations of selected leachate chemicals that could occur at adjacent property lines and how fast leachate-polluted groundwater would reach the adjacent property lines when the liner system fails to collect all leachate generated in the landfill. Requiring this degree of hydrogeological characterization is in accord with most landfill permitting agencies' mission of public health and groundwater resource protection.

A proposed landfill should not be permitted until the additional hydrogeological information is made available and independently reviewed for its technical adequacy and reliability. This information on the

- pathways for leachate-polluted groundwaters to move from under the landfill to offsite properties,

- when pollution of offsite groundwaters is expected to occur, and
- the potential concentrations that will occur under adjacent properties of various types of pollutants that are present in the expected leachate

is needed to determine whether a proposed landfill should be permitted. If it is permitted, then with this information the potentially impacted public, regulatory agencies and others would have a better understanding of the threat that the landfill represents to the groundwater resources under their property and the surface water resources of the area.

Offsite Groundwater, Water Supply Well, and Surface Water Monitoring. In addition to greatly improving the information on the hydrogeology of a proposed landfill site and the surrounding area, there is need to require that the landfill owner establish comprehensive offsite groundwater monitoring of all water supply wells within the sphere of influence of the proposed landfill. This sphere should be considered to be several miles in any direction from the landfills, dependent upon the hydrogeological conditions that exist in the area. The purpose of this monitoring program would be to detect incipient pollution of existing water supply wells located on nearby properties. This approach is justified as part of providing improved public health and groundwater resource protection and assurance to the potentially impacted public that the landfill has not yet polluted their groundwater. It would provide a means of verifying the reliability of the predicted pollution of offsite groundwater.

In addition to the landfill compliance monitoring wells at the point of compliance for groundwater monitoring, additional groundwater monitoring wells should be developed along the most probable pathways for leachate-polluted groundwaters to move toward offsite properties. If leachate-polluted groundwater is detected in any compliance monitoring wells and/or the pathway monitoring wells, then the landfill owner should be required to begin groundwater remediation, likely through pump and treat of the leachate-polluted groundwaters. This remediation would be designed to stop further offsite movement of leachate-polluted groundwaters. This is important because, as discussed by Rowe (1991), MSW leachate-polluted aquifers can never be remediated to a sufficient extent to enable the use of groundwater that has come in contact with the polluted but "remediated" part of the aquifer to be a reliable, safe source of domestic and animal water supply.

This monitoring program should be conducted quarterly for a broad range of parameters until a sufficient database has been developed so that the concentrations of the monitored parameters can be reliably predicted for the next quarterly monitoring. After one year of reliably predicting the results of the quarterly monitoring, the frequency of monitoring of offsite potentially impacted wells can be reduced to semiannually.

In order to protect surface water quality from pollution by landfill leachate, comprehensive monitoring of all springs and streams within several miles of the landfill should be required for those hydrogeological situations where polluted groundwaters could discharge to surface waters.

This monitoring would provide an early warning of pollution of surface waters by landfill leachate. The pollution of surface waters can affect both domestic water supply water quality as well as aquatic life-related beneficial uses of a waterbody. For many constituents, the water quality criterion for protection of aquatic life is one or more orders of magnitude lower than the

drinking water MCL.

This monitoring program should be funded by the landfill owner but carried out by third-party consultants that report the results to a Monitoring Committee consisting of the regulatory agencies, property owners and the landfill owner. This monitoring program should be conducted forever – i.e., as long as the landfill has the potential to generate leachate that can pollute groundwaters underlying the landfill.

The offsite well monitoring would be for all existing and any new water supply wells that are developed in the future. This approach is justified since those who own properties adjacent to and near the landfill are entitled to continuing to have groundwaters under their property that are free of landfill leachate.

Monitoring of the characteristics of the leachate generated in a landfill should include a broad range of potential pollutants that can be expected to be generated based on the characteristics of the wastes accepted at the landfill. The monitoring of groundwaters and surface waters should include a broad range of potential pollutants and potential transformation products. An expert panel would advise the Monitoring Committee on the parameters that should be included in the monitoring. The required monitoring parameters should be reviewed each year by the panel to determine if there are any new potential pollutants that should be added to the list of parameters.

Lee and Jones-Lee (2006) have provided guidance to public groups and agencies on issues that need to be considered in selection of an independent consultant to assist in evaluation of the potential impacts of a proposed landfill. The key to this selection is to find someone knowledgeable on landfill containment/pollution issues who has not and does not expect to work for landfill developers. As they discuss those who work for landfill developers cannot expect to do further work on behalf of landfill developers if they discuss the full potential impacts of a proposed landfill. Lee and Jones-Lee (2007) have provided guidance on the issues that typically need to be considered in evaluating the potential impacts of proposed landfill and landfill expansions that conform to Subtitle D regulations. Lee and Jones-Lee (2005) have developed a summary of issues on developing Municipal Solid Waste Landfills – Water Quality Issues, in the *Water Encyclopedia: Water Quality and Resource Development*.

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