Effectiveness of the Los Angeles County Sanitation Districts' Groundwater Barriers in Preventing Puente Hills Landfill Leachate from Polluting San Gabriel Basin Groundwater Aquifer System

G. Fred Lee, Ph.D., D.E.E.
G. Fred Lee & Associates
El Macero, CA 95618

Submitted to Los Angeles County Board of Supervisors
June 21, 1993

Introduction

The Los Angeles County Sanitation Districts (Districts) and the Regional Water Quality Control Board (Regional Board) have attempted to use what are referred to as "groundwater barriers" to prevent the leachate/landfill-gas-contaminated groundwaters that exist under the Puente Hills Landfill from migrating to the San Gabriel Basin aquifer system. The so-called barriers are either clay or cement/bentonite slurry walls placed across the mouth of canyons.

The Districts have experienced failure of the clay slurry wall system at the Puente Hills Landfill site; contaminated groundwaters have been found on the downgradient side of the slurry walls. In an attempt to address this problem, the Regional Board has required that the Districts construct a cement/bentonite slurry wall downgradient of one of the existing, failed clay slurry walls. While a cement/bentonite slurry wall can, to some extent, slow the rate and amount of migration of leachate-polluted groundwater, it will not prevent leachate-polluted groundwater beneath the Puente Hills Landfill from reaching the San Gabriel Basin aquifer system in sufficient amounts to render waters in the Basin aquifer unusable for domestic purposes. An understanding of the physical and chemical properties of slurry walls made of clay or cement/bentonite shows that they do not provide a reliable barrier to transport of leachate-contaminated groundwater; such groundwater can travel through and/or around them. Further, while the slurry walls are keyed into the fractured bedrock, from the geological information available for the Puente Hills Landfill area it is clear that the extent to which this keying occurs is not sufficient to cause interception of all fractures that could transport leachate-contaminated groundwaters from under the landfill to the San Gabriel Basin aquifer system.

Efficacy of Slurry Wall Groundwater Barriers

Slurry walls can serve to retard/retain large-scale movement of groundwaters in certain gross application such as construction site dewatering. However, they are significantly deficient in preventing migration of leachate-contaminated groundwater where the purpose is to prevent contamination of downgradient groundwater otherwise suitable for domestic water supply, with the myriad hazardous and otherwise deleterious components of landfill leachate. It is well-known that small amounts of municipal landfill leachate can pollute large amounts of groundwater to render it unsuitable for domestic water supply (Jones-Lee and Lee, 1993).

It is also well-known that slurry walls have relatively high permeabilities compared to what is needed to be a significant barrier to transport of leachate-contaminated groundwater through them. Slurry walls, such as those made of cement/bentonite, typically have permeabilities on the order of 10^{-6} cm/sec (Millett *et al*., 1992; Khera and Tirumala, 1992). This means that even if the slurry wall were free of cracks and other anomalous areas of higher permeability, within a few years leachate-contaminated groundwater will pass through the slurry wall. Further, especially in fractured rock systems, leachate-contaminated groundwater can pass around a slurry wall to pollute downgradient groundwater. The report of Stetson Engineers (1993), as well as Williams (1993), discussed pathways for the transport of leachate-contaminated groundwater through the fractured rock geology of the Puente Hills site, around the slurry wall.

The American Society for Testing and Materials (ASTM) published the proceedings of a conference entitled, *"Slurry Walls: Design, Construction and Quality Control,"* (Paul *et al.,* 1992). The proceedings contain two papers (Grube, 1992, and Khera and Tirumala, 1992) that provide information directly pertinent to understanding the ability of slurry walls of the type the Districts have constructed and are continuing to construct, for the purpose of preventing gas-contaminated and leachate-contaminated groundwaters under the Puente Hills Landfill from migrating to the San Gabriel Basin aquifer system. Grube (1992) discussed the experience with and expected performance of clay-based slurry walls. He pointed out that the hydraulic effectiveness of slurry walls used to try to prevent contaminant migration must be of a substantially higher quality than that applied for conventional geotechnical purposes where groundwater cutoff is necessary for routine construction site dewatering. He also discussed the use of Portland cement-enriched backfills, pointing out that such materials are susceptible to cracking which leaves preferential pathways for contaminated waterflow.

In commenting on the lack of field performance data on the effectiveness of slurry walls, Dr. Grube (who at the time was Research Project Manager in the area of landfill liners and slurry walls, US EPA, Cincinnati) stated (Grube, 1992),

> *"Published data from these installations are not uniform in approach, field methods, parameters tested, or data analysis. This is because of the lack of standardized performance assessment methods. At the present time, there is little Agency* [US EPA] *interest in supporting development of standard methods to evaluate groundwater cut-off structure performance* [slurry walls]. ***This is because of the expected relatively short performance lifetime of a cut-off wall in environmental applications,*** *the stigma of a slurry trench as a simple containment structure (with its corresponding least preference as a waste management option), and dedication of scarce resources to waste minimization and related efforts."* (emphasis added).

It can be concluded from Dr. Grube's summary of the US EPA's position that slurry walls of the type that the Districts have constructed and are constructing at the Puente Hills Landfill in an attempt to prevent leachate-pollution of the San Gabriel Basin aquifer system, will not be effective for that purpose. Such approaches are not considered effective for long-term prevention of pollution downgradient of the "barrier."

In a study of slurry walls made of soil/sodium bentonite mixtures, Khera and Tirumala (1992) found that a number of chemicals caused the permeability of slurry walls to increase significantly. Of particular concern in this regard was water containing high levels of calcium relative to sodium. That condition can cause shrinkage of the bentonite clays that can greatly increase permeability of a slurry wall. They also pointed out that the lime that is associated with cement in a cement/bentonite slurry can cause that type of increased permeability because of its high calcium content. It is clear that there is a wide variety of factors that can cause slurry walls of various types to fail to be effective barriers to the transport of leachate-contaminated groundwater thorough them.

Gray and his associates at the University of Michigan have done extensive research on behalf of the US EPA on the expected performance of slurry walls used as barriers to the transport of contaminated groundwater. They, too, have found that slurry walls are not effective barriers to contaminant transport. Gray (1988) summarized information on the transport of contaminants through slurry walls, pointing out that in addition to advective transport, diffusional transport can be a very important mechanism contributing to failure of slurry walls. Gray (1988) illustrated the significance of diffusional contaminant transport through slurry walls with an example of a 3-ft-thick clay slurry wall that has an advective transport permeability of 10^{-7} cm/sec (i.e., 1000-times less-permeable than the slurry walls of the type being used by the Sanitation Districts at the Puente Hills Landfill) and an counter hydraulic gradient for advective transport of -0.5. For such a system, breakthrough of contaminants would occur in less than 10 years despite the counter hydraulic gradient for advective transport. He pointed out that typically those who try to use slurry walls to control transport of polluted groundwater have not given adequate consideration to the impact of diffusional transport on the leakage of slurry walls placed for containment of contaminated groundwater.

The Los Angeles County Sanitation District no. 2 provided general information on the characteristics of the "subsurface cement-bentonite barrier" ("Barrier no. 3") being placed to replace an existing subsurface compacted clay barrier at the Puente Hills Landfill site (County Sanitation District no. 2, 1992). That information stated,

"The proposed subsurface barrier is designed to physically prevent the lateral migration of canyon waters offsite; it is a 2-foot thick, 850-foot long and 60-foot deep wall made of cement and bentonite (a highly impermeable clay) with a design permeability of less than 10^{-4}cm/sec. The barrier will extend from the ground surface to a minimum of 5 feet into 'competent' bedrock."

The "fact sheet" provided by the County Sanitation Districts on the construction of the Puente Hills Landfill subsurface "Barrier no. 3" stated,

*"The work consists of the construction of an underground dam composed of cement and bentonite-clay materials that work together to make an **impermeable barrier**."* (emphasis added).

As discussed above, and contrary to the claim of the Sanitation Districts, cement-bentonite slurry walls are not "impermeable." They allow passage of appreciable amounts of water through them. As noted above, the slurry wall being developed by the Districts for the Puente Hills Landfill, for the purpose of containment of leachate-contaminated groundwater, has an allowed maximum permeability of 10^{-4} cm/sec. That is 100-times more permeable than what can be achieved with slurry walls of this type. This means that the Districts' Barrier no. 3 slurry wall currently under construction at the Puente Hills Landfill can allow transmission of large amounts of leachate-contaminated groundwater through it. Further, the slurry wall under construction will certainly not intercept all fractures in the "competent" bedrock that could transmit leachate-contaminated groundwater around the slurry wall. Therefore, the new "Barrier no. 3" will not prevent transport of leachate-contaminated groundwater from under the landfill to the San Gabriel Basin aquifer system.

Conclusions and Recommendations

The overall conclusion is that the various types of slurry walls that the Districts and the Regional Board have attempted to use at the Puente Hills Landfill will not be effective in preventing the transport of leachate-contaminated groundwaters from under the landfill to the San Gabriel Basin aquifer. It is important to emphasize that the existing Puente Hills Landfill and the proposed Puente Hills Landfill expansion (if permitted) will be threats to groundwater quality in the San Gabriel Basin forever. Because of the longer-term ineffectiveness of slurry walls in serving as an effective barrier to migration of leachate-contaminated groundwater through and around them, the Districts should not be allowed to expand the Puente Hills Landfill and should be required to immediately undertake much more effective efforts to detect leachate- and gas-contaminated groundwater beneath and near the landfill and to start an effective, perpetual groundwater remediation program to minimize the pollution of groundwater in the San Gabriel Basin aquifer system.

As discussed by Stetson Engineers (1993) and independently found by the author, since the Regional Board does not have adequate staff to properly supervise and police the operations of the Districts with respect to groundwater quality investigation and protection at the Puente Hills Landfill, and since based on past and current performance the Districts cannot be relied on to self-police its operations, it will be necessary to appoint a third-party, independent oversight panel that has its objective the protection of groundwater quality in the San Gabriel Basin from pollution by the Puente Hills Landfill. That oversight panel should have a staff with adequate funds to inspect the Districts' day-to-day operations pertinent to groundwater quality protection at the Puente Hills Landfill. It should report to the Main San Gabriel Basin Watermaster and the Upper San Gabriel Basin Municipal Water District. The Sanitation Districts should have no veto power or other control over the panel's operations. They should fund that panel at a sufficient level to enable its staff to conduct independent sampling and analysis, and to carry out other activities to ensure with a high degree of reliability, that the groundwater pollution by the Puente Hills Landfill will be reliably identified and remediated, *ad infinitum*.

References

County Sanitation District no. 2, Notice of Exemption, to Los Angeles County Clerk, Los Angeles, CA, July 16 (1992).

Gray, D., "Diffusion as a Transport Process in Fine-Grained Barrier Materials," Geotechnical News 6(2) (1988).

Grube, W., Jr., "Slurry Trench Cut-Off Walls for Environmental Pollution Control," IN: Slurry Walls: Design, Construction, and Quality Control, STP 1129, ASTM, Philadelphia, pp. 69-77 (1992).

Jones-Lee, A., and Lee, G. F., "Groundwater Pollution by Municipal Landfills: Leachate Composition, Detection, and Water Quality Significance," Proceedings of Sardinia '93 IV International Landfill Symposium, Sardinia, Italy, October (1993).

Khera, R., and Tirumala, R., "Materials for Slurry Walls in Waste Chemicals," IN: Slurry Walls: Design, Construction, and Quality Control, STP 1129, ASTM, Philadelphia, pp. 172-180 (1992).

Millett, R., Perez, J., and Davidson, R., "USA Practice Slurry Wall Specifications 10 Years Later," IN: Slurry Walls: Design, Construction, and Quality Control, STP 1129, ASTM, Philadelphia, pp. 42-66 (1992).

Paul, D., Davidson, R., and Cavalli, N. (eds), Slurry Walls: Design, Construction, and Quality Control, STP 1129, ASTM, Philadelphia (1992).

Stetson Engineers, "Puente Hills Landfill Investigation," Report prepared for Upper San Gabriel Valley Municipal Water District, Stetson Engineers, West Covina, CA, June (1993).

Williams, D., Testimony before Los Angeles County Regional Planning Commission on proposed Puente Hills Landfill expansion, March (1993).