Groundwater Quality Protection: A Suggested Approach for Water Utilities

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Many water utilities, especially in California, have all or parts of their domestic water supply based on groundwater sources. Some communities, even though they have all of their normal domestic supply provided by surface water sources, have installed stand-by well(s) as an emergency supply during drought or other conditions which would interrupt the surface supply source. The recent drought has emphasized the importance of a highly developed, coordinated conjunctive use program in the state where during wet years, surplus surface water is recharged into groundwater basins. This recharged water would then be available for use during future droughts. The recent drought has also pointed to the extreme importance of protecting groundwater and groundwater aquifer quality. For many years, the state of California has had regulations which prohibit many of the activities that can lead to groundwater pollution. It has been found, however, that over the years, including today, these regulations are not necessarily being adequately implemented with the result that groundwater pollution is still occurring at landfills and other sources of wastes, agricultural and industrial chemicals, at significant rates in various parts of the state. Further, during the past nine years landfills have been constructed in the state with liner systems that only postpone groundwater pollution by landfill leachate.

In some areas, such as those associated with municipal and some industrial solid waste disposal by land burial, the groundwater pollution is not only destroying the use of the water for domestic and some other purposes, but is also destroying the use of parts of the aquifer for conjunctive use storage. It is therefore important that steps be taken to protect groundwater aquifer systems from pollution in order to maintain aquifer quality.

One of the most potentially significant sources of groundwater pollution for waters that could be used for domestic water supply purposes is by municipal landfill leachate. US EPA estimates that there are on the order of 55,000 landfills in the US with over 75% of them polluting groundwaters at this time. In California, the state Water Resources Control Board and the regional boards, as part of their Solid Waste Assessment Test annual report to the legislature, concluded that of the approximately 300 landfills in the state investigated thus far, over 80% of them are polluting groundwaters. While existing groundwater pollution by municipal and industrial landfills is occurring from unlined landfills, the clay and plastic sheeting lined landfills of the type being constructed today ("dry tombs") are widely recognized as simply postponing the problems of groundwater pollution by landfill leachate. Ultimately, the landfill cover will fail to keep moisture out of the landfill and the landfill liners will fail to keep leachate from polluting groundwaters.

Table 1 presents information on the typical composition of municipal landfill leachate for the common contaminants. Typically municipal landfill leachate must be diluted at least a thousand, or more commonly, over ten-thousand-fold before groundwaters contaminated by such leachate would be considered to comply with drinking water standards (MCL's) from known leachate constituents. Since very limited dilution of contaminants occurs in groundwater, it is evident that municipal landfill leachate represents a highly significant threat to domestic water supply water quality.

The US EPA (1988) has determined that when a groundwater well is contaminated by municipal landfill leachate that it is appropriate to assume that the well has to be abandoned and a new well be constructed in a different aquifer or at a sufficiently distant location so that it will not intercept any groundwaters contaminated by leachate. While in many parts of the country construction of new wells to replace those that have been contaminated by leachate is feasible, in the more arid areas and ultimately everywhere, this approach cannot be followed since there is a finite amount of groundwater available that can be used for domestic water supply purposes.

It is important to understand the difference between the pollution of domestic water supply groundwaters by VOC's, such as TCE, and by municipal landfill leachate. While it is possible, through pump and treat for aqueous dissolved VOC's, to eventually remove many of the VOC's from contaminated groundwaters and produce a water that is considered suitable for domestic consumption, it is extremely difficult if not impossible to treat a groundwater contaminated by municipal landfill leachate to the degree necessary so that it would be considered appropriate for domestic water supply use. Municipal landfill leachate contains a wide variety of contaminants which are highly difficult to remove. Further, because of the large amounts of uncharacterized-unknown, non-conventional contaminants in landfill leachate, using treated groundwaters for domestic water supplies that have been contaminated by municipal landfill leachate will always be a threat to public health since it will never be possible to be certain that the treatment has removed all hazardous chemicals.

Another consequence of contaminating groundwaters by municipal landfill leachate which is of major significance to some water utilities is the loss of aquifer storage capacity as part of conjunctive use of surface and groundwaters. Those parts of aquifers that have been contaminated by municipal landfill leachate cannot be used for domestic water supply conjunctive use even though attempts are made to try to flush out the residual contaminants in the aquifer. It is therefore apparent that domestic water supply utilities and, for that matter, individual homeowners who depend on groundwaters near a municipal landfill must be highly concerned about the potential for groundwater contamination by landfill leachate.

Suggested Approach for Improving Groundwater Quality Protection from Pollution by Landfill Leachate and Other Sources

Presented below is a suggested set of actions that municipal water agencies, water districts and others should take to protect the quality of existing and potential

groundwater water supply sources from landfill contamination. Basically the same approach can be used to prevent the pollution of groundwaters from other sources of contaminants such as enhanced and incidental recharge of surface water associated contaminants, agricultural and industrial activities such as use of fertilizers, pesticides, herbicides, etc.

1. Determine if existing and previously closed sanitary landfills or other waste management units are contaminating groundwaters.

Any groundwater contamination by municipal landfill leachate, independent of whether it causes a drinking water standard to be exceeded, should be considered to be a serious threat to public health and domestic water supply water quality. Generally, state water pollution control agencies are requiring that all landfill owner/operators establish groundwater monitoring programs for active as well as closed landfills. Water utilities should periodically review the state and/or local agency files to determine the adequacy of the groundwater monitoring programs that have been established for the landfills located in their aquifer recharge area. This should be done by an individual on the utility's staff or a consultant who is highly familiar with groundwater quality monitoring near landfills.

Typically, the groundwater monitoring programs that are being required by state agencies for existing, much less previously closed, landfills are inadequate to define with a high degree of certainty whether pollution of groundwater is occurring and the degree and extent of pollution. It may be necessary for the utility to request and, if necessary, take legal action to require that the state and/or local agency responsible for groundwater quality protection will require that the owner/operator of existing as well as previously closed landfills establish an adequate groundwater monitoring program for each landfill that could contaminate the utility's aquifer.

It is suggested that the groundwater monitoring programs be designed so that they would have at least a 95% probability of detecting incipient groundwater pollution by landfill leachate. As discussed by Jones-Lee and Lee (1993) and Lee and Jones-Lee (1993), this will require a much more extensive groundwater monitoring program than is typically being developed today for landfills.

2. If contamination of an aquifer that is or could be used for domestic water supply purposes has occurred, require that the owner/operator of the landfill define the areal extent and degree of groundwater contamination by the landfill.

The determination of the extent and degree of groundwater contamination by a landfill will require that an extensive set of monitoring wells, typically nested to sample water at various depths at various locations, be used. These wells should be sampled at no less than quarterly intervals over one year to define the degree and extent of contamination that has occurred. Normally, such a sampling program has to be conducted in phases where at the end of the first phase, when it becomes clear that insufficient information is

available to fully define the extent and degree of contamination, that additional monitoring wells will have to be constructed and sampled.

3. Require that the landfill owner/operator initiate comprehensive groundwater quality remediation programs to try to remove all contamination from the groundwater and the aquifer.

Work on remediation of Superfund sites is now showing that groundwater remediation from simple contamination, such as from VOC's, is difficult to achieve. It is clear now that typically it will take many tens of years of continuous pumping of the contaminated water in order to stop the spread of the contamination and to reduce the degree of contamination to the maximum extent possible. It is becoming recognized that for some types of contaminants it may not be possible to achieve background concentrations. The owner/operator of the landfill, however, should be required to aggressively pursue a remediation program to achieve background concentrations of contaminants to the maximum extent possible.

4. If the owner/operator of an active landfill cannot prevent further contamination from the landfill, the owner/operator should stop accepting wastes and close the landfill.

If closure does not stop groundwater contamination, require that the waste be exhumed and properly treated, and the residues be deposited at a suitable location where groundwater pollution will not occur.

It has become clear that in many instances the only way to truly protect a domestic groundwater supply from municipal landfill leachate contamination is to exhume the wastes. This will be especially true for those landfills that are located in areas where moisture can enter the landfill from groundwaters. In situations where the only source of moisture for leachate generation is through the cover, it may be possible to stop further groundwater pollution by leachate generated in the landfill by construction of a cover that will, in fact, prevent moisture from entering the landfill. Such covers will require highly expensive *ad infinitum* cover maintenance. It is important to note that the typical landfill covers that are being constructed today are inadequate to prevent leachate generation within the landfill and will not achieve this objective. Further, the owner/operator of a landfill that is covered as a means of attempting to prevent groundwater contamination must be required to maintain the cover forever in order to prevent moisture from entering the landfill. Any owner/operator that fails to provide this type of maintenance of the cover should be required to exhume the wastes.

5. For all landfills that could effect a domestic groundwater supply, the water utility should require that all groundwater quality monitoring data on the landfill be sent to the utility at the time that it is submitted by the landfill owner/operator to the regulatory agency review and comment.

For existing as well as closed landfills, water utilities should take a pro-active approach to groundwater quality protection where they have specific staff members or consultants who will review all routine groundwater monitoring data as it is submitted to the agency by the owner/operator of the landfill. There are situations where the regulatory agency personnel do not have time or do not appreciate the significance of the potential damage that municipal landfill leachate can cause to a groundwater based domestic water supply. They also may not understand the importance of detecting, at the earliest possible time, leakage from a landfill. It is therefore imperative that the water utilities conduct their own independent data review developed in the groundwater quality monitoring program at all active as well as closed landfills that could contaminate the aquifer.

6. Water utilities should require that all owner/operators of landfills that could impact existing or potential domestic water supplies operate the leachate removal system, the groundwater monitoring system, maintain the cover, the landfill cover, and all groundwater diversion systems FOREVER.

Water utilities should review the post-closure care financial assurance instruments that are submitted by owner/operators of landfills that are designed to provide for post-closure monitoring and maintenance of the landfill. In California, the financial instruments and the amount of funding to be provided by the instrument used by owner/operators of landfills for post-closure care funding are frequently inadequate to provide the amount of funds necessary to provide for required post-closure care activities that will prevent the landfill from polluting groundwaters at any time in the future. Water utilities should work toward requiring that the owner/operator of the landfill and the regulatory agencies establish a dedicated trust fund that will ensure that adequate funds are available to carry out these activities for as long as the wastes represent a threat, which should be considered to be **FOREVER**.

For active landfills, the trust fund can be developed from disposal fees. For previously closed municipal landfills that could contaminate a domestic water supply, the utilities should work through the state and local agencies and, if necessary, the courts to require the principle responsible parties who owned/operated the landfill, as well as the public that contributed waste to the landfill, to develop a trust fund of sufficient magnitude to ensure that the landfill will be properly closed and maintained **FOREVER**. The magnitude of the trust fund should be sufficient to cover not only the post-closure monitoring and maintenance but also the costs to exhume the wastes, properly treat them, and rebury the non-recyclable, non-reusable residues at an appropriate location that will not contaminate groundwaters in the future.

7. Water utilities should aggressively pursue developing approaches for the management of solid waste in their groundwater supply watersheds that will minimize the potential for groundwater quality problems to occur at any time in the future. They should work toward elimination of the use of the "dry tomb" approach for municipal solid waste management in areas where domestic water supplies could be contaminated because of the high probability that that approach will ultimately lead to groundwater contamination.

It is suggested that it would be appropriate for water utilities to require that the owner/operator of existing as well as proposed landfills conduct a detailed review of the plausible worst case scenarios that could occur at the landfill that could lead to groundwater pollution. The reports made by consulting firms working on behalf of governmental agencies and/or landfill owner/operators in the environmental impact statements (EIS's) or in California environmental impact reports (EIR's) typically do not properly assess the potential for groundwater pollution by landfills. It is frequently observed that consulting firms working on behalf of the applicant for a landfill make such statements as "since the landfill is lined, there can be no water pollution." Another example is that "any leakage of leachate from the landfill will be detected by the groundwater monitoring system." Such statements are not an appropriate assessment of the current understanding of the ability of landfill liners to prevent groundwater pollution and groundwater monitoring systems to detect it once it has occurred.

As part of evaluating the plausible worst case scenario(s) for groundwater pollution by a landfill, the owner/operator of a landfill should be required to provide detailed discussion of how they will prevent groundwater pollution at a particular landfill based on worst case scenario conditions. They should also provide detailed discussions with associated cost estimates of what remediation steps they will take to remediate the groundwaters that are polluted by landfill leachate. This discussion should include specific delineation of the source of the funds for this remediation. The worst case scenario should consider that the proposed groundwater monitoring program will fail to detect groundwater pollution. It should be assumed that a pollution plume has occurred for considerable distances downgradient where it is detected in production wells used for domestic water supply or other purposes.

One of the best ways for water utilities to protect their groundwater supplies from pollution by new landfills is to develop a aggressive program for work toward developing alternative methods of managing municipal solid and industrial wastes so that they are not buried in "dry tombs" where they can ultimately pollute groundwater. It is clear that the "dry tomb" approach is not a viable approach for municipal solid waste management in most parts of the US. Alternative approaches are available. While initially somewhat more expensive, compared to what the public has become used to paying for municipal solid waste disposal, in the long-term they will be less expensive and provide for true long-term groundwater quality protection.

While the focus of this groundwater quality protection program is municipal landfills, similar kinds of programs should be directed toward all waste management units, such as hazardous waste landfills including those that receive so-called treated wastes, industrial non-hazardous landfills, wastewater lagoons and areas which receive wastewater sludges and compost. Further, utilities with groundwater supplies near saline waters, such as along the coast, should be determining whether salt water intrusion is occurring to a significant extent that could ultimately pollute the groundwaters of the region.

Groundwater Recharge

Inadequate attention is being given to the potential for groundwater contamination by chemicals in surface waters that are deliberately recharged or incidentally recharge aquifers. Water utilities should be conducting intensive monitoring programs of all enhanced and incidental recharged waters to insure that such waters do not contain contaminants that will pollute the aquifer.

Agricultural Use of Fertilizers

An area of particular concern in California as well as in many other areas is the use of nitrogen fertilizers in farming practices where more nitrogen is applied to the soil than is needed for the crops. This can result in nitrate pollution of groundwaters. In California, there are no regulations governing the application of nitrogen fertilizers to land which can be used to control excessive applications that lead to groundwater pollution. Water utilities should work toward developing regulations that can be used to prevent groundwater pollution by nitrogen fertilizers applied to farmlands. Further, it is suggested that a tax should be placed on nitrogen fertilizers that can be used to fund regulatory programs, including groundwater monitoring, to determine whether excessive nitrogen is being applied to the lands that will lead to groundwater pollution by nitrate.

Use of Pesticides and Herbicides

At this time the state of California does not have adequate regulations to protect the state's groundwaters from pollution by pesticides and herbicides. Agriculture and industry can use pesticides and herbicides in an area without first evaluating whether such use could lead to groundwater pollution. Water utilities should work toward developing regulations that would require that before a pesticide or herbicide is used in an area that a site specific evaluation is made by the proposed user to determine whether such use could lead to groundwater pollution. A plausible worst case scenario evaluation approach of the proposed use should be required. Further, associated with any use, should be the development of a reliable monitoring program to determine the fate of the pesticide or herbicide and its transformation products as well as whether any of these could cause surface of groundwater pollution.

References

CH2M Hill, "Sanitary Landfill Database," (1989).

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

Lee, G. F. and Jones, R. A., "Groundwater Quality Monitoring at Lined Landfills: Adequacy of Subtitle D Approaches," Report G. Fred Lee & Associates, El Macero, CA (1993).

Lee, G. F., Jones, R. A. and Ray, C., "Sanitary Landfill Leachate Recycle," Biocyle 27:36-38 (1986).

US EPA, "Draft Regulatory Impact Analysis of Proposed Revisions to Subtitle D Criteria for Municipal Solid Waste Landfills," prepared for the Economic Analysis Staff, Office of Solid Waste, Washington, DC, August (1988).

References as:"Lee, G. F. and Jones-Lee, A., 'Groundwater Quality Protection: A Suggested Approach for Water Utilities,' Report to the CA/NV AWWA Section Source Water Quality Committee, 8pp, August (1993)."