M E M O R A N D U M

To: Interested Parties

From: WDEQ, Solid Waste Permitting and Corrective Action Program

Date: November 13, 2006

Re: Minimum requirements for monitoring networks at municipal solid waste landfills

Introduction

In the past it was believed that Wyoming's climate was generally dry enough to prevent impacts to groundwater from buried wastes in unlined landfills. Many assumed that very little leachate would be generated and this leachate would not migrate to groundwater. However, over time, it has become evident that the assumption of "no potential for migration" is incorrect. Recent data indicates that currently operating landfills in Wyoming and other arid western states generate a sufficient quantity of leachate to pose a threat to groundwater quality. There is also evidence that landfill gas migration from both lined and unlined landfills in arid Western states can result in adverse impacts to groundwater. In Wyoming, groundwater contamination has been detected at more than twenty-one (21) municipal landfills.

This growing body of information indicates that municipal solid waste (MSW) can threaten human health, the environment and Wyoming's groundwater resources. Therefore, the Wyoming Department of Environmental Quality (DEQ), Solid and Hazardous Waste Division (SHWD) has evaluated the adequacy of groundwater monitoring networks at permitted and unpermitted MSW landfills within the state. This evaluation has focused on the adequacy of existing groundwater monitoring networks to detect a release of contaminants to shallow groundwater. In addition, the potential for adverse impacts (including contamination of groundwater) by landfill gas migration needs to be evaluated at Wyoming MSW facilities. The facilities that require additional groundwater characterization include current operating lined and unlined landfills, and previously closed and/or abandoned unlined landfills.

Current monitoring requirements for owners and operators of MSW landfills are promulgated under Chapter 2, Section 6 of the Wyoming Solid Waste Rules and Regulations. Monitoring systems must consist of a sufficient number of wells to monitor water from the uppermost aquifer which may be affected by leakage from the facility. The system must be capable of monitoring background and downgradient water quality. Well locations must be approved by the administrator and downgradient wells shall be placed as close as possible, but in no case greater than 150 meters (492 feet) from the disposal facility waste boundary on land owned, leased, or otherwise controlled by the operator.

Installing monitoring systems to determine if there is contamination at municipal landfills will pose a significant financial challenge to local government entities. Fortunately, the Wyoming

legislature recently authorized funding for a municipal solid waste landfill planning and monitoring program which provides partial reimbursement for the cost of assessing the nature and extent of groundwater contamination at MSW landfills (Enrolled Act No. SEA0043; Bill No. SF0038 [see http://legisweb.state.wy.us/2006/Enroll/SF0038.pdf]; effective July 1, 2006). The legislation provides reimbursements, for up to 50% or 75% of the cost to local government entities responsible for any municipal solid waste landfill, for groundwater investigation projects where a work plan has been submitted to the department for work performed or initiated after July 1, 2005.

The purpose of this memorandum is to provide guidance on the installation of adequate groundwater monitoring networks to detect contamination at MSW landfills under the MSW landfill monitoring program ("the program"). A brief summary of well installation costs is provided to assist local municipalities with the estimation of costs for these services. Additional references to regulatory guidance and other resources are also provided to assist operators needing to upgrade landfill monitoring networks. The information in this document should be taken into consideration when developing proposals for monitoring network upgrades. Proposals for alternate approaches will be considered by SHWD on a case-by-case basis.

Minimum Requirements for Groundwater Monitoring Networks

As described in the applicable regulations (Chapter 2, Section 6.b), an adequate monitoring network must include a sufficient number of wells to monitor groundwater from the uppermost aquifer that may be affected by leakage from the facility. Both background (upgradient) and downgradient groundwater must be assessed. Site-specific geological and hydrogeological information must be considered in the design of the monitoring system.

All work must be performed by qualified persons, drilling contractors, and analytical laboratories. Upon request, DEQ can provide lists of drillers and laboratories.

Based on SHWD's review of available monitoring data from Wyoming MSW landfills, the following comments and observations should be addressed in the implementation of future groundwater monitoring networks under the program:

- *Number of Wells Needed* – At some landfills, there may not be a sufficient number of existing upgradient and downgradient wells to provide site-specific data for leak detection and groundwater monitoring. It would not be unreasonable to expect the number of wells in an adequate monitoring network to range from 4 to 8 wells for small (<1 to 5 acres) landfills, and from 12 to 16 wells or more for larger (>15 acres) landfills. However, these quantities should not be considered as a prescriptive minimum or maximum SHWD requirement. Instead, a site-specific evaluation of local geological conditions is required. Geologic factors such as lithology of the subsurface, depositional or erosional environment, depth to groundwater, climatological and geographical influences should be considered. The facility's operational conditions should also be considered.

- *Iterative or Phased Well Installation* - Groundwater studies are typically conducted in a phased or iterative approach. It is rare for a single drilling program with a constrained

scope of work to provide sufficient data to completely define and characterize the groundwater system. Instead, the installation of each additional monitoring device typically provides additional information on site-specific conditions, such as groundwater flow direction(s). Therefore, MSW owners and operators should generally anticipate conducting more than one phase of well installation activities to develop an adequate monitoring network. Alternative methods, such as geophysical studies, may be used to select monitoring locations.

- *Groundwater Well Screen Interval* – During its review of existing monitoring data, SHWD has frequently noted that the upper screened interval of landfill monitoring wells may be set at an elevation that is well below the top of the potentiometric surface (groundwater level) of the uppermost aquifer. SHWD considers a shallow monitoring well construction to be deficient unless the well is screened across the top water table.

- *Confined versus unconfined groundwater* – In some cases, a well may be screened below the water table, but reportedly screened across the water bearing zone in a confined or semi-confined aquifer. However, this situation can also commonly occur by "missing" the first water bearing zone during drilling. Fine grained (clay and silt) formations may provide little or no indication of the presence of groundwater during drilling. In general, confined or semi-confined conditions will not be adequately demonstrated unless "nested" or multiple-level well pairs are installed. The observation that the water level rose after drilling is not in and of itself adequate to identify confined groundwater. Supporting evidence (relative head in well pairs, presence of confining layers, orientation and dip of beds, pump tests, etc.) will be required prior to SHWD concurrence that confining conditions exist.

- *Geologic Boring Logs* – Continuous sampling or coring of all borings is desired and strongly advised to provide more direct field observations of subsurface conditions. Continuous core barrel techniques are available for hollow stem auger drill rigs (and other drilling methods), and typically are similar in cost to split-spoon sampling. Borehole logging from hollow stem auger or solid stem auger cuttings will not be accepted. Cores should be archived and stored for future reference.

- *Log Descriptions* – The Uniform Soil Classification System shall be used to identify the material from cores. It is important to include information on the, shape, size, grading (sorting), and color of lithologies drilled, the presence and orientation of bedding planes, joints and/or fractures, the degree of weathering, and any oxidation coatings or mineralization along joints, fractures, bedding planes, macropores and micropores, or other characteristics which may indicate water movement. Also, the presence of thin clay layers or sand stringers may be important and should be documented. Subtle changes in subsurface conditions may be indicative of features that could significantly influence groundwater flow and contaminant migration.

- *Landfill Gas Monitoring* – Landfill gas monitoring is beyond the scope of activities eligible for funding at this time. However, landfill gas is a known source of groundwater contamination. If corrective action for groundwater contamination is required at a site in the future, it will be important to determine if landfill gas is the source or a contributing

factor to the contamination detected. Therefore, landfill gas monitoring may be needed in the future. In many cases, a groundwater monitoring well that has been screened across the water table can also be used to sample landfill gas.

- *Well Development* – A well development procedure should be provided in the work plan for SHWD approval, and development activities should be documented in the field and reported. One major goal of well development is to allow for collection of low turbidity, representative groundwater samples. The focus of well development should be on the removal of fines from the well, establishing good hydraulic communication between the monitoring well and the formation, and reducing the turbidity of groundwater samples. A surge block is the development method preferred by SHWD, but other methods would be considered. The use of air injection and water jetting should be avoided due to potential impacts on water quality. Periodic turbidity analyses should be conducted and recorded as wells are developed. Technical guidance on well development is provided in the references listed below, including EPA, 1992b and 1991.

- *Well Construction* - Minimum well construction requirements have been previously described in the WDEQ Water Quality Division (2001 and 2002) guidance documents, and should also be followed for MSW landfill monitoring well networks. For detection monitoring or initial investigations, wells must be screened across the uppermost water bearing zone. Wells screened below the water table may be appropriate or necessary during subsequent phases of investigation.

- *Other Subsurface Information* – The scope of the grant program was not intended to include extensive site characterization. However, the DEQ believes that a limited amount of information could be helpful. Work plans should include hydraulic conductivity testing of a well from each hydrogeological regime. Either slug tests or pumping tests are considered adequate, depending on site-specific conditions. In addition, an undisturbed permeability test should be conducted for each major lithologic unit encountered.

- *Analytical Parameters and Frequencies* - Please refer to the attached memorandum titled "Groundwater monitoring frequency and constituents at facilities determined to have inadequate groundwater monitoring systems" for information regarding necessary analyses and sampling frequencies. These analytical guidelines reflect industry and DEQ's recognition that groundwater quality may be affected by leachate or landfill gas, and that the nature of impacts may differ depending on a leachate and/or landfill gas source.

- *Surveying* - Well locations (longitude and latitude, or northing and easting) and elevations (top of casing/measuring point, and ground surface) must be surveyed using standard coordinate systems. Use of relative information (such as distance from structures or other site features) is not acceptable. Top of casing (measuring point) elevations must be surveyed within a minimum accuracy of +/- 0.01 foot to support mapping of groundwater surface elevations. Water level measurements should always be made from the same measuring point on each well.

Minimum Work Plan and Reporting Requirements

MSW landfill owners and operators that modify or upgrade their monitoring well network are required to submit a work plan and obtain written SHWD approval prior to conducting any field work. **Prior written SHWD approval is also necessary if the work is to qualify for reimbursement under W.S. § 35-11-521.** The following are minimum requirements for the work plan submittal:

- Include a brief summary of existing groundwater and landfill gas monitoring results, and identify data needs. Provide supporting documents such as landfill plan/development maps indicating waste disposal areas and potentiometric surface information when possible.

- Describe any proposed use of geophysical techniques. Provide technical information about the technique, information regarding the pros and cons for selection and use of the technique, and a cost-benefit analysis comparing the use of the geophysical technique to other available options.

- Provide a site map showing all existing and proposed well locations.

- Describe the proposed well installation and sampling activities including procedures for well drilling and construction, well development, well purging and sampling. Also include proposals for hydraulic conductivity and permeability testing.

- Describe the proposed analyses to be performed, including the wells to be sampled, the sampling constituents, and the sampling frequency.

- Provide an estimate of the cost to complete the proposed work

- Provide a project schedule.

The following should be considered as minimum items to be provided in a report for the monitoring well system upgrades:

- Narrative of when, where and how the work was done.

- A topographic site map showing well locations, landfill boundaries, past and future disposal areas, roads, and other site features as appropriate.

- A potentiometric surface map for each sampling event and each water-bearing zone identified, showing the direction(s) of groundwater flow.

- Boring logs and well construction details, with descriptions of soil or consolidated rock type, structure (such as bedding), thicknesses, and fracture patterns (including inclination from horizontal, coatings on fractures, etc.) (see SW Chapter 2, Section 2.b.iii.IX).

- Geological cross section showing the landfill location (depicting known or estimated waste depths), subsurface lithologies, and the potentiometric surface for each water bearing zone identified.

- Summary analytical data and copies of laboratory data sheets. Document exceedances of groundwater protection standards and other relevant criteria.

- Summary water level and survey data.

Well Installation Costs

Owner/operators and consultants performing work under the program should also critically evaluate project costs associated with monitoring network upgrades. The Department, working in conjunction with the Water and Waste Advisory Board, will evaluate reasonable and customary costs for the work performed as one factor in consideration of reimbursement for work performed. Standard procurement procedures need to be followed to ensure the fair cost and value of services received under the program. DEQ strongly urges that a competitive selection process be used as a cost containment measure. Please refer to the process outlined in the Wyoming Professional Services Procurement Act, W.S. 9-2-1027 through 9-2-1033. A copy of this Act may be found online at the following location: http://legisweb.state.wy.us/statutes/statutes.aspx?file=titles/Title9/Title9.htm.

For guidance, summary information regarding the costs of monitoring well installation has been reported below for reference by owners/operators and consultants. These costs should not be considered as a maximum cost standard; however, SHWD believes that this information will be useful for selection of vendor services.

The SHWD Storage Tank Program (STP) has previously contracted for monitoring well installation services to support the assessment of tank sites. These wells were installed using hollow stem auger techniques and 2-inch diameter polyvinyl chloride (PVC) casing and screen. Based on 120 wells installed at an average depth of 20 feet, the average installation cost was less than $1,000 per well.

Additional cost data was solicited from private vendors based on a more realistic scenario for a Wyoming landfill site. For a total of 12 wells with an average depth of 50 feet, the resulting average cost was approximately $3,070 per well. Average costs for wells installed using continuous core methods was $3,160 per well, while split spoon sampling at every 5 feet was only slightly less costly at $3,030 per well.

Applicable References

The following references provide additional information that may be helpful in the development of upgraded groundwater monitoring networks for MSW landfills.

Barcelona, M.J.; J.P. Gibb; J.A. Helfrich; and E.E. Garske. 1985. Practical Guide for Ground-Water Sampling. SWS Contract Report 374, Illinois State Water Survey, Department of Energy and Natural Resources. Prepared in cooperation with the Robert S. Kerr Environmental Research Laboratory and the Environmental Monitoring Systems Laboratory, USEPA. November.

Driscoll, F.G. 1986. Groundwater and Wells. 2nd Edition, Johnson Filtration Systems. St. Paul, Minnesota. 1089 p.

Kansas Department of Health and Environment. 2002. *Kansas Solid Waste Statutes and Solid Waste Regulations*. Available online at: http://www.kdhe.state.ks.us/waste/download/sw_laws_aug2002.pdf

Lowman, S.W. 1979. Groundwater Hydraulics. United States Geological Survey (USGS) Professional Paper 708. 70 p.

Missouri Department of Natural Resources. Guidelines for Conducting a Detailed Geological Site Assessment. Available online: http://www.dnr.mo.gov/geology/geosrv/envgeo/swmpapp1.htm

Montana State Department of Environmental Quality. *Administrative Rules, Solid Waste Management, Sub-Chapter 7, Ground Water Monitoring*. Available online at: http://www.deq.state.mt.us/dir/legal/Chapters/CH50-07.pdf

Nielsen, D. M. (Editor). 1991. Practical Handbook of Ground-Water Monitoring. Lewis Publishers, Chelsea, Michigan.

North Dakota Department of Health, Division of Waste Management. 2002. Guideline 3 - Hydrogeologic Investigations, Groundwater Monitoring Networks, and Groundwater Sampling for Solid Waste Management Facilities. Available online: http://www.health.state.nd.us/wm/pdf/guide3.pdf

Oklahoma Department of Environmental Quality. *Chapter 515: Management of Solid Waste.* Available online: http://www.deq.state.ok.us/rules/515.pdf

Oregon Department of Environmental Quality, 1992. Groundwater Monitoring Well Drilling, Construction, and Decommissioning. Available online: http://www.deq.state.or.us/wmc/tank/documents/monwell.pdf

Reilly, T.E.; O.L. Franke, H.T. Buxton, and G.D. Bennett. 1987. A Conceptual Framework for Ground-Water solute-Transport Studies with Emphasis on Physical Mechanisms of Solute Movement. United States Geological Survey (USGS) Water Resources Investigation Report 87-4191. 44 p.

United States Environmental Protection Agency (USEPA). 1996. Superfund Remedial Design and Remedial Action Guidance. Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0-4A. June.

United States Environmental Protection Agency (USEPA). 1993. Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide. EPA/625/R-93/003a and b. May.

United States Environmental Protection Agency (USEPA). 1992a. Guide to Site and Soil Description for Hazardous Waste Site Characterization, Volume 1: Metals. Office of Research and Development, EPA/600/4-91/029. March.

United States Environmental Protection Agency (USEPA). 1992b. RCRA Ground-Water Monitoring: Draft Technical Guidance. Office of Solid Waste, EPA 530R-93-001. November.

United States Environmental Protection Agency (USEPA). 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. Environmental Monitoring Systems Laboratory, Office of Research and Development, ISAPI. EPA 600/4-89/034. March.

United States Environmental Protection Agency (USEPA). 1988. Guidance for Conducting Remedial Investigations/ Feasibility Studies Under CERCLA. Interim Final. Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01. October.

United States Environmental Protection Agency (USEPA). 1985. Practical Guide for Ground-water Sampling. Robert S. Kerr Environmental Research Laboratory, EPA 600/2-85/104. September.

Washington Department of Ecology Solid Waste Rules. Criteria for Municipal Solid Waste Rules. Chapter 173-351 WAC. Available online: http://www.ecy.wa.gov/laws-rules/ecywac.html

Williams, D.E. 1985. Modern Techniques in Well Design. Journal of the American Water Works Association. September.

Wyoming Department of Environmental Quality (WDEQ), Water Quality Division (WQD). 2002. Site Characterization Work Plans. Guideline #2, Version 3.0. October. Available online: http://deq.state.wy.us/wqd/groundwater/downloads/Corrective%20Action%20Guidelines/Guide2.pdf

Wyoming Department of Environmental Quality (WDEQ), Water Quality Division (WQD). 2001. Permit-By-Rule: Requirements and Recommendations for the Design, Construction and Installation of Monitoring Wells, Piezometers, Boreholes, Test Pits and Other Sub-surface Investigation Facilities at Sites Where Pollution Has Not Been Identified. Guideline #1, Version 2.1. February. Available online: http://deq.state.wy.us/wqd/groundwater/downloads/Corrective%20Action%20Guidelines/guide1.pdf