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Brenda E. Keith

April 24, 2009

Karlee Kenison, P.G.
Department of Environmental Services
Solid Waste Management Division
29 Hazen Drive, P.O. Box 95
Concord, NH 03302-0095

Via E-mail

Re: February 2009 Groundwater Performance Standards Submittal Review
North Country Environmental Services, Inc.'s Landfill
Bethlehem, New Hampshire
NHDES: Site 198704033

Dear Ms. Kenison:

Attached is Aries Engineering's technical analysis of NCES' February 20, 2009 and April 6, 2009 groundwater performance standards submittals. We submit this on behalf of the Town of Bethlehem.

Please do not hesitate to contact me if you have any questions.

Sincerely,

Brenda E. Keith

Enc. (Review of Aries Engineering, Inc.)

c. Clients (U.S. Post)
Wayne Wheeler (email)
Bryan Gould (U.S. Post)
File

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April 24, 2009
File No. 2002-015

Brenda E. Keith, Esq.
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Londonderry, NH 03053

Re: February 2009 Groundwater Performance Standards Submittal Review
North Country Environmental Services Landfill
Bethlehem, New Hampshire
NHDES: Site 198704033

Dear Brenda:

Aries Engineering, Inc., (Aries) is pleased to provide to the Town of Bethlehem (Town) the following technical analysis (analysis) of the February 20, 2009, Groundwater Performance Standards submittal (submittal) prepared by North Country Environmental Services, Inc. (NCES) for the NCES landfill (site) located in Bethlehem, New Hampshire.

NCES prepared their February 20, 2009 submittal in response to New Hampshire Department of Environmental Services' (Department's) December 23, 2008 correspondence that denied approval of the performance monitoring standards proposed by NCES as part of a site Corrective Action Plan (CAP). In correspondence dated October 13, 2008, NCES proposed a CAP target groundwater bromide concentration of 0.4 milligrams per liter (mg/l) to represent site background bromide concentrations. The Department responded that the final groundwater performance standards for the site groundwater release detection wells must be defined as background concentrations.

In addition, the Department also required that both soil and groundwater data were needed to identify the source of each observed exceedance of background concentrations for volatile organic compounds (VOCs) and bromide, and to confirm that the site source (or sources) of the exceedances had been effectively remediated by the CAP. The Department stated that if the proposed activities in the CAP did not achieve the performance standards (background conditions for VOCs and bromide), then further site work would be required in accordance with Env-Or 703.15 (a). The Department requested that the revised groundwater performance standards be incorporated into a comprehensive work plan.

The February 20, 2009 NCES submittal also indicated that, "the scientific evidence demonstrates beyond a serious question that there has been no release from the containment system of the landfill". It appears that NCES' assertion was based, in part, on NCES' prior comment response letter dated October 13, 2008, which provided a liner leakage analysis, prepared by CMA Engineers, Inc. (CMA) of Portsmouth, New Hampshire, and a hydrogeologic analysis, prepared by Sanborn, Head & Associates, Inc. (SHA) of Concord, New Hampshire. CMA's and SHA's analyses produced leakage and groundwater transport estimates based on models, assumptions and limited site data. In their October 13, 2008 correspondence, NCES concluded that observed site groundwater contamination in the area of monitoring wells MW-402U and MW-403L could not be the result of a leak in the landfill containment system.

In preparing this analysis, Aries evaluated the following documents:

1. February 20, 2009, NCES correspondence regarding: *North Country Environmental Services, Inc. Landfill Facility - Bethlehem, New Hampshire, Groundwater Performance Standards* (February 2009 NCES correspondence);
2. April 6, 2009, NCES correspondence regarding: *North Country Environmental Services, Inc. Landfill Facility - Bethlehem, New Hampshire, First Quarter 2009 Progress Report for NCES Projects* (April 2009 NCES correspondence);
3. December 23, 2008, Department correspondence regarding*: Response to September 10, 2008 NHDES Comment Letter, prepared by North Country Environmental Services, Inc., dated October 13, 2008* (December 2008 Department correspondence);
4. October 17, 2008, SHA memorandum regarding: Analysis of Site Hydrogeologic Conditions Relative to VOC Detections in Groundwater Sample from Well MW-402U (October 2008 SHA Hydrogeologic Analysis);
5. October 14, 2008, CMA report regarding: *Liner Leakage Analysis, North Country Environmental Services, Bethlehem, New Hampshire* (October 2008 CMA Liner Leakage Analysis);
6. October 13, 2008, NCES correspondence regarding: *North Country Environmental Services, Inc. Landfill Facility - Bethlehem, New Hampshire, Response to September 10, 2008 NHDES Comment Letter* (October 2008 NCES correspondence);
7. September 10, 2008, Department correspondence regarding*: Type 1B and II Permit Modification Application, North Country Environmental Services Landfill, Stage IV Phase II, 581 Trudeau Road, Bethlehem, New Hampshire/Permit #DES-SW-SP-03-002* (September 2008 Department correspondence); and
8. September 2008, *2008 Summary of Water Quality Monitoring, North Country Environmental Services (NCES) Landfill, Bethlehem, New Hampshire,* prepared by Sanborn, Head & Associates, Inc. (SHA) of Concord, New Hampshire (September 2008 SHA Annual Monitoring Report).

OBJECTIVES

Aries' analysis objectives are to:

1. Evaluate conditions that likely represent "background" for the observed VOC and bromide groundwater contamination located hydraulically downgradient of the NCES landfill; and
2. Evaluate whether observed VOC and bromide groundwater contamination is likely due, in whole or in part, to leakage of landfill leachate through the landfill liner.

Following is Aries' analysis.

BACKGROUND CONCENTRATION ANALYSIS

Groundwater Flow Directions

According to the September 2008 SHA Annual Monitoring Report, the site groundwater flow direction is generally to the north and northeast toward the Ammonoosuc River. Therefore, site monitoring wells located to the south and hydraulically upgradient of the landfill should represent background conditions for site groundwater flowing across the site. Based on the SHA July 2008 Water Table Contour Plan, groundwater samples collected from site monitoring wells MW-401, B-901U, B-901L, B-902U and B-902L would, therefore, likely represent site background groundwater conditions. In general, SHA's groundwater bromide concentration data (dating back to November 1995 for groundwater samples from monitoring well MW-401, and November 2000 for groundwater samples from the B-series monitoring wells) sporadically (17 out of 99 samples, or approximately 17% of the time) detected bromide at concentrations above the lower analytical detection limit of 0.1 mg/l. Based on the low incidence of detectable bromide in the samples, Aries concludes that site background bromide concentrations are likely less than the analytical detection limit of 0.1 mg/l.

However, groundwater flow directions beneath the landfill are not well defined. Site groundwater flow directions are generally inferred from observed groundwater elevations at the margins of the landfill. Therefore, groundwater elevations beneath the landfill footprint are inferred from groundwater elevation data collected more than 1,000 feet apart, which could mask groundwater flow patterns beneath the landfill such as potential groundwater mounding and radial flow.

Uncertainty of the groundwater flow direction beneath the landfill creates uncertainty in which monitoring wells are upgradient of the landfill. Therefore, if there is mounding of the groundwater beneath the landfill, groundwater flow may be toward, and not away from, assumed site background monitoring well locations. Such conditions could result in the detection of bromide and VOCs in apparent upgradient monitoring wells, as may be the case for the occasional detection of bromide in the apparent background monitoring wells MW-401, B-901U, B-901L, and B-902U.

Bromide as a Conservative Tracer

As a condition[1] of NCES's site Groundwater Management and Release Detection Permit, the Department required that a bromide tracer compound be disposed along with the landfill municipal solid waste (MSW) and that site groundwater be monitored for the presence of bromide. The intent of the bromide tracer was to provide a direct means to detect landfill waste leachate releases from the lined portion of the landfill. Thus, if bromide was subsequently detected in groundwater samples, landfill leachate would be assumed to have potential escaped from the lined landfill system or the leachate management system.

The bromide ion is an inorganic tracer that is widely used in groundwater studies[2] to assess contaminant fate and transport characteristics. Because the bromide ion is considered to be conservative, or not susceptible to sorption and degradation, movement of bromide in groundwater is controlled by advection and dispersion processes[3]. Temporal bromide concentration trends for a given groundwater monitoring point can be used to deduce groundwater transport velocities, as well as the nature and occurrence of the tracer release to groundwater based on the pattern of the groundwater tracer concentration trend.

For example, if the bromide tracer were released to groundwater during a singular event (such as a leachate spill), the resultant groundwater tracer concentration trend would typically result in the "slug flow" of bromide in groundwater at the rate of the average site groundwater (advective) flow. In this case, a slug of bromide tracer would travel with groundwater downgradient past a monitoring point, with a concentration profile indicating a characteristic groundwater bromide concentration increase followed by a distinct decrease as the bromide slug passed the monitoring point. For example the groundwater bromide concentration trend observed in groundwater samples collected from monitoring well B-921U likely represent a "slug flow" signature based on the relatively rapid increase and decrease in bromide concentrations observed in samples from this location as depicted in the following Chart 1.

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[1] Bethlehem - North Country Environmental Services, Inc. Revised Groundwater Management and Release Detection Permit No. GWP-870433-B-002, Conditions 13 and 17, issued by the Department on April 18, 1995.

[2] J. A. Davis, K. M. Hess, J. A. Coston, D. B. Kent, J. L. Joye, P. Brienen and K. W. Campo, March 2001, Multispecies Reactive Tracer Test in a Sand and Gravel Aquifer, Cape Cod, Massachusetts - Part 1 - Experimental Design and Transport of Bromide and Nickel-EDTA Tracers, U.S. Environmental Protection Agency Document: EPA/600/R-01/007a.

[3] Ibid.

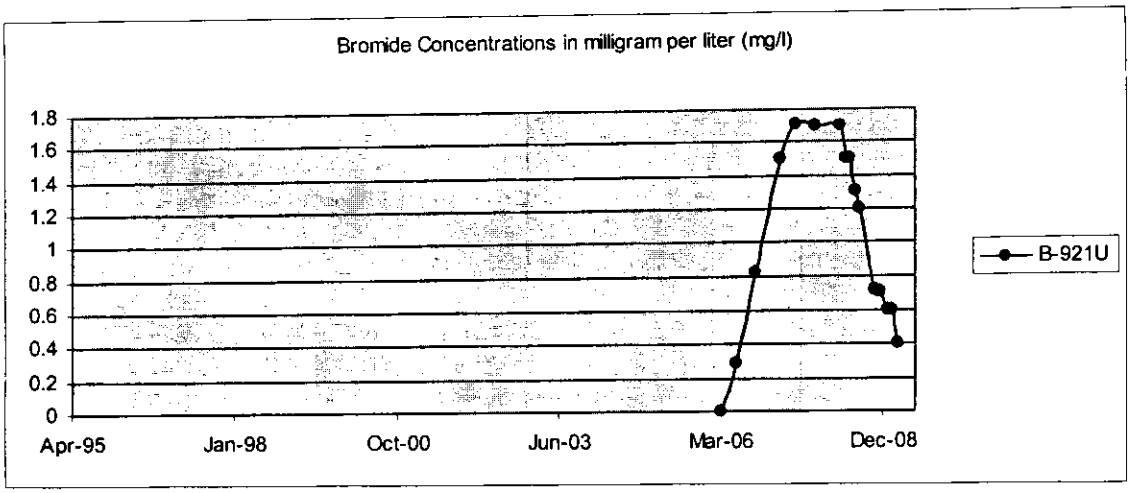

Chart 1 - "Slug Flow" Groundwater Bromide Concentration Trend in Monitoring Well B-921U

Conversely, persistent, long-term observation of bromide in compliance monitoring samples would suggest a continuing source or sources of bromide released to the groundwater. Long-term attenuation of a bromide plume may also suggest continuing source depletion, rather than attenuation of a plume caused by a singular (slug flow) leachate release.

Aries compared these potential bromide tracer signatures to site historical groundwater bromide concentration trends[4,5] using available site data. Based on these comparisons, Aries concludes that available site bromide concentration data are generally consistent with a persistent and long-term bromide concentration signature, rather than a "slug flow" bromide concentration signature. These persistent and long-term bromide concentration signatures are apparent in groundwater samples collected from the following site monitoring wells:

1. B-304UR - with frequent detection of bromide and a generally increasing bromide concentration trend;
2. MW-402U - with the highest annual bromide concentrations generally observed in April, although a high bromide concentration was also observed in November 2006;
3. MW-802 - with the highest annual bromide concentrations generally observed in April, likely due to seasonal groundwater flow direction variations that result in an apparent pulsed (detected and non-detected) bromide concentration trend;
4. MW-803 - with generally persistent detection of bromide concentrations since approximately November 2001;

[4] 2008 Summary of Water Quality Monitoring, North Country Environmental Services (NCES) Landfill, Bethlehem, New Hampshire, prepared by Sanborn, Head & Associates, Inc. (SHA) of Concord, New Hampshire, September 2008.

[5] April 2009 NCES correspondence.

5. B-901L - with continued groundwater bromide detections between 2003 and 2008 at low levels; and
6. B-913M - with increasing bromide concentrations observed during 2006, 2007 and 2008 (Higher bromide concentrations were observed in samples from the deeper monitoring well B-913M, rather than is the shallow monitoring well B-913U, possibly indicating migration from a distant source).

The following Chart 2 depicts site groundwater bromide concentrations for samples collected from the above-referenced monitoring wells over an approximate 13-year period. The chart illustrates the apparent long-term, bromide concentrations trends observed in groundwater samples collected from the above-referenced monitoring wells, which are all likely located downgradient of the site landfill. Spikes in the observed bromide concentrations may indicate "slug flow" bromide signatures superimposed on a persistent bromide concentration signature.

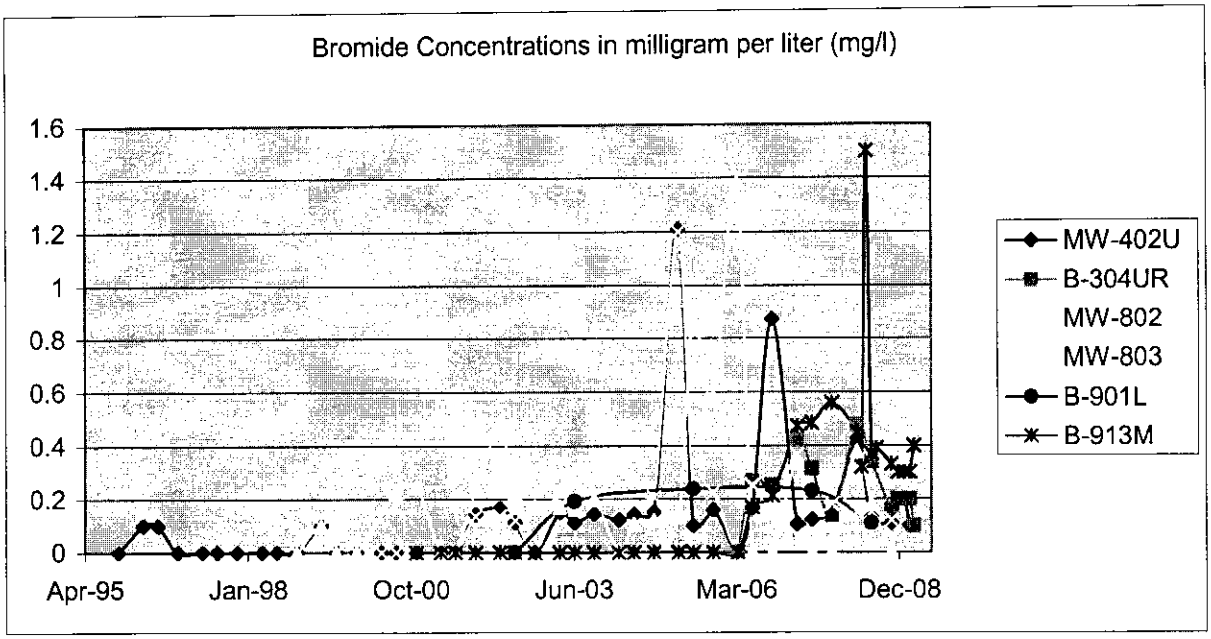

Chart 2 - Long-Term, Persistent Bromide Concentrations in Selected Site Monitoring Wells

Based on the available site data, Aries concluded that the observed groundwater bromide concentration trends are consistent with a persistent, long-term bromide concentration signature and, therefore, consistent with an on-going bromide source.

Further, it is Aries' opinion that the bromide data do not clearly indicate only incidental or singular leachate spills and leaks, such as from the site leachate management system, at these locations, although such incidental release signatures may be superimposed on the persistent, long-term bromide concentration signature. The data indicate that the source of these observed bromide concentration trends may be from leaks from the landfill liner system, repeated discharges from the site leachate

management system, or a combination of both. Additional groundwater monitoring data or groundwater data from beneath the landfill would be required to further assess the source (or sources) of the persistent, long-term bromide concentrations observed in site groundwater.

Additional Specific Comments

Page 2, Paragraph 5: NCES proposed a total VOC background concentration of less than or equal to ≤ 10 milligrams per liter (mg/l). Based on reported total VOC concentrations in the Table 3 of the September 2008 SHA Annual Monitoring Report, Aries assumes that NCES actually proposed a total VOC background concentration of less than or equal to ≤ 10 micrograms per liter (µg/l). As the VOCs detected in site groundwater are generally not naturally occurring, Aries concludes that non-detection of any VOC should be the proposed background total VOC concentration. Additionally, compliance of groundwater contaminants should be measured relative to the Department's Ambient Groundwater Quality Standards (AGQSs).

Page 4, Paragraph 6: NCES proposed a background bromide concentration of 0.2 mg/l for groundwater samples collected from monitoring well B-304UR, which is located approximately 450 feet downgradient from the Stage IV landfill area. However, Aries concludes that site groundwater background bromide concentrations are below the lower analytical detection limit of 0.1 mg/l.

Available site groundwater bromide concentration data for site monitoring well B-304UR, although apparently limited to the years 2006, 2007 and 2008, generally indicated cyclical seasonal variation, with the highest observed annual concentrations detected in the April sampling rounds. Comparison of the April or July bromide concentrations for the three available years indicates increasing bromide concentrations as follows: April 2006 to April 2008 (<0.1 mg/l, 0.42 mg/l, 0.48 mg/l); and July 2006 to July 2008 (0.269 mg/l, 0.313 mg/l, 0.34 mg/l). Observed increasing seasonal bromide concentration trends suggest the presence of a persistent, long-term bromide source upgradient of this location.

CONCLUSIONS

Based on our review of the NCES submittal and recent site groundwater water quality data, Aries concluded the following:

1. Site background bromide concentrations should be less than the analytical detection limit, which Aries understands is currently 0.1 mg/l.
2. Site background VOC concentrations should be less than applicable AGQSs for each individual detected compound and less than 10 µg/l for total VOCs.
3. Site groundwater elevations and flow directions beneath the landfill are not well defined which may lead to erroneous conclusions regarding background concentrations.

4. Observed groundwater bromide concentration trends are consistent with an on-going source or sources of bromide released to groundwater. Potential bromide release sources include leachate leaks from the landfill liner system, discharges from the site leachate management system due to leachate mismanagment, or a combination of both.
5. Observed groundwater bromide concentration trends do not clearly indicate that incidental or singular leachate spills or leaks from the leachate management system are the only source of observed site groundwater bromide, as concluded by NCES.

RECOMMENDATIONS

Aries recommends continued groundwater monitoring for the presence of bromide and VOCs to assess whether the source (or sources) of observed groundwater bromide and VOC concentrations are the result of leachate leakage from the landfill liner and containment system, releases due to leachate mismanagement, or a combination of both leachate release mechanisms. These additional groundwater monitoring data, and observations and data from NCES's leachate management improvement project and Corrective Action Plan will be necessary to assess, and correct, the source (or sources) of bromide and VOCs in site groundwater.

If you have any additional comments or questions, please do not hesitate to contact me at 603-228-0008.

Sincerely,
Aries Engineering, Inc.

George C. Holt, P.G.
Senior Hydrogeologist

Thomas E. Roy, P.E./P.G.
Principal Engineer/Geologist

GCH:sgc