MEMORANDUM

To: John Cotton
New Hampshire Department of Environmental Services
Groundwater Protection Bureau

From: Paul M. Sanborn
Sanborn, Head & Associates, Inc.

Date: October 27, 1994

File No.: 1049: North Country Environmental Services Landfill

Re: Viability of Bromide (Br) as a Tracer

In accordance with our recent discussions concerning use of bromide as a tracer in landfill leachate to distinguish a possible release from a double-lined landfill from groundwater already containing leachate constituents from a former (now removed) unlined landfill, we offer the following supplemental information in support of the use of bromide for this circumstance.

According to reviewed literature, bromide is one of the most common ions used as a natural groundwater tracer. It is generally found to have low background concentrations (< 1mg/l in aquifers containing potable water), is biologically stable, and is not lost by precipitation, absorption, or adsorption (Davis et.al. 1985).

Due to its conservative nature bromide has been used in many tracer tests involving contaminated aquifers. A brief description of a few relevant studies is provided.

- A biodegradation study by Roberts et.al. (1990) involved the co-injection of bromide, trichloroethane (TCE) trans-1,2 dichloroethene (trans-DCE), CIS - 1,2 dichloroethene (CIS-DCE), and vinyl chloride (VC) to assess the effects of biostimulation. The bromide tracer was used to provide information on 1) fluid residence times, 2) the degree of breakthrough at the observation location, 3) dispersion, and 4) the extent to which the injected fluid was captured by the extraction well. Numerous bromide tracer tests were completed during this 3-year field study. All the tests showed reproducible results with almost total bromide recovery in the extraction well. The authors attributed any apparent loss of bromide to dilution via the natural groundwater.

- A similar study by Freyberg (1986) involved the use of a bromide tracer co-injected with organic solutes; namely, bromoform, carbon tetrachloride, tetrachloroethane, 1,2-dichlorobenzene, and hexachloroethane. The goal of the study was to

investigate natural gradient transport of solutes in groundwater. The tracer tests were performed in an unconfined sand aquifer underlying an inactive sand quarry at the Canadian Forces Base, Borden, Ontario. Chloride and bromide were chosen as tracers due to their conservative nature. A leachate plume with elevated chloride concentrations emanated from the Borden landfill upgradient of the test site. The authors successfully used the ratio of bromide to chloride to determine if the experimental and leachate plumes intersected.

- LeBlanc et.al (1991) completed a large scale tracer test between July 1985 and July 1988 in an abandoned gravel pit on western Cape Cod near Otis Air Base. The objective of the tests was to examine the transport and dispersion of solutes in a sand and gravel aquifer. The disposal of treated sewage to the aquifer at Otis Air Base created a plume that was approximately 23 meters wide and 3 kilometers long at the time of this study. The plume contained elevated concentrations of many inorganic and organic constituents. Water in the plume contained little or no dissolved oxygen and had a specific conductance as high as 350 ms/cm (microsiemens per centimeter at 25° C) (LeBlanc et.al. 1991). The tracer test was conducted partly in the uncontaminated zone above the plume and partly in the underlying plume. Bromide was chosen as the non-reactive tracer. Background levels of bromide averaged 0.05 mg/l. For 14 of the 16 sampling rounds in which the bromide cloud was monitored, the calculated mass of bromide exceeded 90% of the injected mass. Also, there was no trend of increasing or decreasing bromide mass with time.

In addition to the studies cited above, bromide has been used as a non-reactive tracer in studies by Davis et.al. 1991a, 1991b; Anderson et.al. 1991; and Kent et.al. 1991.

Finally, SHA contacted Mr. Robert Landreth at the U.S. Environmental Protection Agency, Environmental Research Laboratory in Cincinnati, Ohio. Mr. Landreth had been referred to us as an expert by his colleagues at EPA Headquarters in Washington, D.C. and research associates at EPA's Cincinnati Research Laboratory. We explained to Mr. Landreth our proposed methodology to use bromide as an ionic tracer at the NCES (landfill in Bethlehem. Mr. Landreth indicated that, given its conservative nature, bromide is suitable for this application. (R. Landreth, pers. comm. with P. Sanborn, 1994)

Based upon our initial review, John, supported by this additional information, we remain fully confident that bromide is a suitable tracer for the proposed leak detection monitoring program at NCES.

References reviewed for the information contained in this letter include:

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cc: John Regan, NHDES, GPB
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