Connecticut Valley
Environmental Services, Inc.

Town of Dalton Selectboard
& Conservation Commission
756 Dalton Road
Dalton, NH 03574

via email: selectmen@townofdalton.com
conservationchair@townofdaltonnh.gov

November 14, 2024

re: *Water Quality Monitoring Results, North Country Environmental Services, Inc.* Landfill in Bethlehem, New Hampshire; implications for *Granite State Landfill* in Dalton and Bethlehem, New Hampshire

Dear Dalton Selectboard and Conservation Commissioners Members,

On October 3, 2024, you requested that our firm, Connecticut Valley Environmental Services, Inc. ("CVES"), review the water quality monitoring results at the North Country Environmental Services, Inc. Landfill ("NCES Landfill") in Bethlehem and comment on the implications of those results to the proposed Granite State Landfill LLC ("GS Landfill") in Dalton. We are pleased to offer the following analysis and comments on those reports.

The proposed GS Landfill site in Dalton is less than seven miles away from the existing NCES Landfill in Bethlehem (see Landfill Locations attached), and the NCES Landfill is storing a significant volume of toxic compounds (e.g., polyfluoroalkyl substances (PFAS) and manganese) harmful to human health and the natural environment.[1] The reports below demonstrate that the NCES Landfill has inadvertently released some of these toxic compounds into groundwater and surface waters near the Ammonoosuc River. The GS Landfill is of similar design, will store similar solid waste, and will likely release the same toxic compounds. In our opinion, some of these toxic compounds can be expected to be released – whether because of human errors, geologic vulnerability, and/or climate events – resulting in contamination of the Ammonoosuc and Connecticut Rivers.

The proposed location of the GS Landfill, within the same reach of the Ammonoosuc River as the NCES Landfill, creates a disproportionate and unacceptable risk from the toxic waste that will be generated by several New England States, then transported to and stored within the watersheds of the Ammonoosuc and Connecticut Rivers. The probable cumulative release of toxic compounds from the NCES Landfill and the GS Landfill will cause irreparable harm to these watersheds. Consequently, siting the GS Landfill near the NCES Landfill cannot comport

[1] https://img1.wsimg.com/blobby/go/3a99e672-2796-498c-8250-9aae47365deb/downloads/a9d59459-7c23-4edd-ac92-

with environmental justice objectives, meet the "public benefit" standard[2], nor represent the environmentally preferable alternative[3] as required by the National Environmental Policy Act.

This conclusion is based on review of the following documents:

- *Sanco Landfill Hydrogeologic Analysis, Bethlehem, New Hampshire, October 26, 1984 (attached)*
- *Calex Environmental, LLC (Calex) March 22, 2024-letter pertaining to solid waste landfills in Bethlehem (attached)*
- *Sanborn Head & Associates, Inc. (SHA) July 2024 Tri-Annual 2024 Annual Water Quality Monitoring Results, North Country Environmental Services, Inc. (NCES),* dated *September 3, 2024*[4]
- *NCES September 6, 2024-incident report*[5] *on the penetration of the landfill overliner by drilling for landfill gas wells*

I. SUMMARY AND COMMENTS ON REPORTS

Sanco Landfill October 26, 1984-Hydrogeologic Analysis

This analysis, prepared by Kimbal Chase Company, Inc. and Caswell, Eichler & Hill and submitted to the New Hampshire Bureau of Solid Waste Management, describes the geologic setting and presents 1984-water quality monitoring data at the Sanco Landfill in Bethlehem, a precursor of the NCES Landfill and a successor of a landfill operated there since September 2, 1976.

The underlying sediments are described as well-drained glacial outwash that are "extremely complex and laterally discontinuous." The water table is deep. Depths to ground water range from approximately 16 feet to 44 feet below the surface. Groundwater flow is generally to the north-northeast (NNE) but is variable.

Analyses of water quality data indicate the landfill adversely impacts groundwater quality offsite of the Sanco property. Data from a well upgradient of the landfill and a seep on the Ammonoosuc River bank show excellent background water quality. Nevertheless, elevated concentrations of leachate indicators near the site boundary prove the landfill is generating leachate and creating reducing conditions under the landfill (evidenced by iron and manganese concentrations), which violate secondary drinking water standards. It also documents that volatile organic compounds (VOCs) are present in elevated quantities.

Our Comment*:* These data clearly show the NCES Landfill generates concentrations of organic and inorganic chemicals that are harmful to human health and violate drinking water standards. The organic compounds are biodegradable, whereas, per- and polyfluoroalkyl substances (PFAS), which were not monitored at the time, are not known to degrade. These "forever

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[2] for approval according to NH RSA 149-M:11

[3] https://www.federalregister.gov/documents/2024/05/01/2024-08792/national-environmental-policy-act-implementing-regulations-revisions-phase-2

[4] https://img1.wsimg.com/blobby/go/3a99e672-2796-498c-8250-9aae47365deb/downloads/a9d59459-7c23-4edd-ac92-3d0f4b825686/9%203%202024%20NCES%20SHA%20July%202024%20GW%20Report.pdf?ver=1727018295657

[5] https://www4.des.state.nh.us/DocViewer/?ContentId=5238441

chemicals" dissolve in water, don't easily break down over time, and are linked to numerous health problems.[6]

To manage the Sanco leachate, the waste from the Sanco landfill was later transferred to a double-lined cell within the NCES Landfill next to the Sanco site. To protect water quality the New Hampshire Department of Environmental Services (NHDES) has required groundwater testing at the NCES Landfill for PFAS starting in 2017 and surface water testing starting in 2023.

Calex Environmental, LLC, (Calex) March 22, 2024-Letter ("Calex Letter")

Calex was asked by the North Country Alliance for Balanced Change to determine whether the PFAS detected in July 2023 in groundwater wells and surface water seeps are from residual leachate releases from the decommissioned unlined Sanco landfill, were released when the Sanco waste was transferred to the lined NCES Landfill, or were more recently released from the active NCES Landfill. Based on review of the landfills' history and July 2023-water quality monitoring data, Calex concluded the following in its March 22, 2024 letter to the Alliance:

1) the unlined Sanco landfill generated leachate indicators in ground water;
2) a spike in leachate indicators occurred when Sanco waste was transferred to the NCES Landfill;
3) elevated concentrations of both PFAS and bromide[7] indicate leachate releases occurred after 1996;
4) a second spike of leachate indicators occurred from the mid 2000's to about 2012 which was attributable to operational errors at the landfill (e.g., inadequate leachate storage and handling);
5) PFAS, as well as other regulated compounds, have migrated beyond the historical and current landfill footprints and are moving downgradient in groundwater;
6) contamination is "located less than 50 feet from the edge of the [Ammonoosuc] River;" and,
7) discharges of contaminated groundwater and surface water are likely entering the Ammonoosuc River.

Our Comment*:* The evidence cited in the Calex Letter support all of its conclusions above. The recent high concentrations of leachate indicators in groundwater and surface water correlate to, and are likely to be primarily caused by, accidental spills at the NCES landfill (documented in the 2009 NCES Corrective Action Plan; see pgs. 4-5 of Calex Letter).

In 1996, Sodium bromide, a "leachate tracer", was added to waste deposited in Stages II and III of the NCES lined-landfill. Detections of PFAS coincident with bromide at monitoring locations indicate leachate has been released since 1996 and that it is from the NCES Landfill waste rather than from the residual Sanco waste. The "regulatory record shows that these landfill releases were clearly from current operations (e.g., leachate spills, sumps, tanks, force mains, caps, and liners) which impacted downgradient groundwater conditions" (Calex Letter, pgs. 1-2).

These observations and Calex's projection "that the GSL will generate leachate contamination for the better part of 100 years"[8] indicate the risks created by the landfills are ongoing and will

[6] https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas
[7] Bromide was added to NCES waste from 1996 to about 2006 to detect leachate releases.
[8] Carex Environmental Consulting, February 12, 2024-letter, p. 1.

persist long after they are closed. Consequently, it is our opinion that its reasonably likely that the GS Landfill will have **adverse effects on human health and the natural environment[9] which could persist for more than a century (the "foreseeable future") and occur well beyond the footprint of the landfill.**

The current NCES Landfill – which did not appear to have any wetlands or surface waters within the project footprint – did not require wetland fills to meet required separation distances to groundwater and surface waters. Conversely, the proposed GS Landfill requires numerous wetland fills to meet the required separation distances to both groundwater and surface waters. Due to the proximity of groundwater and surface waters to the GS Landfill, leachate releases at the GS Landfill are more likely to contaminate waters of the State than those which have occurred at the NCES Landfill.

NCES Water Quality Monitoring Results July 2024

The most recent tri-annual water quality monitoring at the NCES Landfill took place between July 22 and 24, 2024. The report by Sanborn Head & Associates (SHA), Inc., is comprehensive and responsive to New Hampshire Department of Environmental Service's (NHDES) requests for groundwater and surface water testing. The monitoring locations include 43 groundwater samples and/or water levels, five surface water spring/seep samples, and three Ammonoosuc River samples.

Consistent with Calex's report, these results confirm toxic compounds (e.g., PFAS and manganese) continue to be present in groundwater and surface water in concentrations that exceed background values, violate ambient groundwater quality standards (AGQS), and show a trend of increasing concentrations at several locations.

Groundwater PFAS. Thirty groundwater locations were sampled in July 2024 for analysis of per- and polyfluoroalkyl substances (PFAS). Perfluorooctanoic acid (PFOA) was detected above background concentrations at 17 locations, exceeded the ambient groundwater quality standard at eight locations, and was present in record maximum concentrations at three locations.

Notably, the July 2024 PFOA concentration (44.6 ng/L) at release detection well B-926U is significantly above the background concentration (<1.5-<2.5 ng/L). This is "the first sampling event for PFAS at this location" and SHA surmises that ***"[g]iven the general absence of other potential leachate indicators, the data are not consistent with a new release*** [emphasis and italics added]" (SHA, pg. 4).

The July 2024-bromide concentration at B-926U was 0.12 mg/l, <u>the only</u> July 2024-sampling location where bromide concentration exceeded background concentration. In April 2024 bromide concentration at this location was below the reporting concentration limit (0.1 mg/l) whereas the July 2024 bromide exceedance was above the background concentration (0.1 mg/l).

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[9] The GSL will put at risk critical components of New Hampshire's natural environment including the Ammonoosuc River, highest ranked habitats in New Hampshire, 11.5 acres of wetlands, five vernal pools, perennial and intermittent streams, cold water fisheries, and possibly exemplary natural communities and rare, threatened and endangered species. Connecticut Valley Environmental Services, Inc. (CVES) February 20, 2024-letter to Town of Dalton Selectboard & Conservation Commission

In addition to PFAS and bromide spikes at location B-926U, the July 2024-values, relative to background values, of specific conductance, pH, chloride, chemical oxygen demand and manganese at this same location are indicative of a leachate release.

Groundwater and Surface Water Manganese. In July 2024, manganese concentrations exceeded background concentrations (0.072 mg/l) and ambient groundwater quality standards (0.3 mg/l) at eight groundwater locations. The exceedances were recorded at wells near or downgradient from the former unlined Sanco landfill, but also occur at two locations (MW-701 and B-926U) west-northwest of the landfill, purportedly upgradient of the former unlined landfill.

Of the five surface-water seep sampling locations, total manganese concentrations exceeded the human health water and fish criteria (0.05 mg/l) at four locations, the human health fish only criterion (0.1 mg/l) at three locations, and the AGQS (0.3 mg/l) at one location.

<u>Our Comment</u>: It is our interpretation that the July 2024 exceedance of bromide (the leachate-tracer) coincident with a significant PFOA concentration and five other leachate indicators (listed above) at B-926U indicate leachate was released from the NCES Landfill waste. It may represent either a new release, between April 2024 and July 2024 (as evidenced by the spike in bromide concentration), or an ongoing release. (Data for PFAS prior to July 2024 were not taken at this location.) It is our opinion that the PFOA detected at B-926U may be from a leak in the leachate storage system and/or accidental spills during handling and transport.

It is evident that current leachate indicator exceedances at sampling locations in the vicinity of the NCES Landfill can be attributed to both residual releases from the Sanco waste and releases from the NCES Landfill waste, either due to accidental operational releases or to failure of the containment system. However, regardless of the source of the leachate and how it was released, **it is unequivocable that the NCES Landfill, even with diligent NHDES oversight of its design and operation, continues to be a source of toxic compounds that contaminate groundwater and surface water.**

NCES Solid Waste Facility Incident Report, September 6, 2024

This incident report, prepared by NCES Landfill employees and submitted to NHDES on September 6, 2024, documents that both liners of the overliner system, which are necessary to enhance leachate travel time, were inadvertently punctured. Eleven gas wells drilled to extract landfill gas, between September 9, 2014 and June 27, 2024, resulted in increased leachate flows in the base liner system that necessitated corrective actions. The report states "***NCES's on-site manager and its overseeing company engineer mistakenly concluded*** [emphasis and italics added] … the existing overliner could be treated as decommissioned."

<u>Our Comment</u>: The punctures of the liner system, previous incidents in which landfill releases were reported in the *2009 NCES Corrective Action Plan* (see Calex Letter, pgs. 4-5), and two recent significant accidental discharges of landfill leachate (Bethlehem, New Hampshire[10] and

[10] https://www.nhpr.org/climate-change/2021-05-20/leachate-spill-under-investigation-at-bethlehem-landfill-could-be-largest-in-n-h

Coventry, Vermont[11]) demonstrate the likelihood of human error in the oversight of landfill operations and failure to prevent accidental leachate releases.

II. DISCUSSION

The National Environmental Policy Act (NEPA) requires that all impacts on public interest factors are considered in a determination of "effects" before a decision is rendered to issue a permit.[12] The definition of "effects" includes "direct, indirect, and cumulative effects."[13]

In our opinion, the **cumulative discharge of toxic substances into the watersheds of the Ammonoosuc and Connecticut Rivers by the GS Landfill and the NCES Landfill as a result of probable operational accidents, undersized storm water control structures (discussed below), and potential natural disasters must be assessed and given adequate weight in the decision-making process.** Specifically:

1. The cumulative effects of discharges of toxic substances into the watersheds of the Ammonoosuc and Connecticut Rivers from the GS Landfill and the NCES Landfill (e.g., PFASs, VOCs, discussed above), roadway runoff (e.g., salt, heavy metals) from widened roadways and increased traffic (particularly trucks hauling leachate) necessary to serve the GS Landfill, and other sources over the foreseeable future (i.e., the next 100 years) need to be addressed.

   Toxic discharges can be expected to occur from increased impervious road surfaces and leachate transport within the protected shoreline of the Ammonoosuc River. Shoreline improvements to construct a truck turn lane will directly impact a perennial stream, an intermittent stream and wetlands (NHDES Wetland Application 6.1, pg. 5). Moreover, toxic runoff from accidental spills and use of the roadway will directly discharge to the Ammonoosuc River (which would feed into the Connecticut River).

2. Additionally, adverse effects on water quality will likely result from the undersized stormwater management system. The GS Landfill storm water control structures are currently designed for 50-year precipitation events. This design standard ignores precipitation events of more intense storms (i.e., those associated with 100-year events and greater). The current design is grossly inadequate as the frequency and intensity of storms have recently increased due to climate change and are predicted to increase even further in the future. The Connecticut River Valley has experienced multiple 100-year and 500-year storms within the last twenty years. Over the expected life of the landfill, the site will likely see numerous storms[14] that the proposed constructed ponds will be

[11] https://www.vermontpublic.org/local-news/2024-03-08/spill-of-landfill-leachate-into-stormwater-pond-leaves-coventry-locals-concerned

[12] In this instance, it is particularly relevant to the pending wetland permit application before the U.S. Army Corps of Engineers

[13] https://www.ecfr.gov/current/title-40/chapter-V/subchapter-A/part-1508/section-1508.1.

[14] Intense storms have become more frequent and are projected to become even more common due to climate change. Precipitation in the Northeast has increased in all seasons, and extreme precipitation events (defined as events with the top 1% of daily precipitation accumulations) have increased by about 60% in the region–the largest

unable to detain and infiltrate. It is difficult to define the impact these more intense storms will have on the structural integrity of the landfill and downstream aquatic resources. Particularly since the data for the NCES Landfill show that even though there is greater separation between solid waste cells and groundwater and surface water at the NCES Landfill than at the GS Landfill, the distances are still inadequate to protect water quality.

3. Natural disasters and human errors, such as embankment failures, landslides, flooding triggered by extreme precipitation events, earthquakes, operational mishaps and even the possibility of domestic terrorism can all result in the transport of toxic substances by groundwater and surface waters to the watersheds of the Ammonoosuc and Connecticut Rivers.

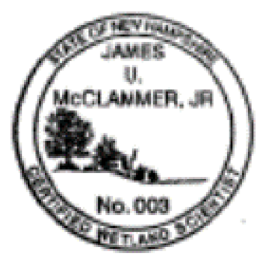
III. CONCLUSION

Based on the well-documented record at the NCES Landfill of ongoing leachate releases to groundwater and surface water, and the persistence of toxic leachate compounds in groundwater at levels exceeding background concentrations and ambient groundwater quality standards, as well as undersized stormwater control structures at the proposed GS Landfill and its close proximity to both groundwater and surface waters, it is our opinion that **the GS Landfill should not be located anywhere in the watersheds of the Ammonoosuc and Connecticut Rivers**.

The State of New Hampshire is compelled to protect our rivers, which are public trust resources. New Hampshire's Solid Waste Management Act[15] clearly states that "[f]acilities …. must be **designed** and **operated** [emphasis added] in a manner which will protect the public health and the state's natural environment."

Respectfully Submitted,

Jim McClammer
Environmental Scientist &
NH Certified Wetland Scientist #003
Connecticut Valley Environmental Services, Inc.
Charlestown, NH 03603



Attachments:
Landfill Locations
Sanco Landfill Hydrogeologic Analysis
Calex Environmental, LLC March 22, 2024-letter

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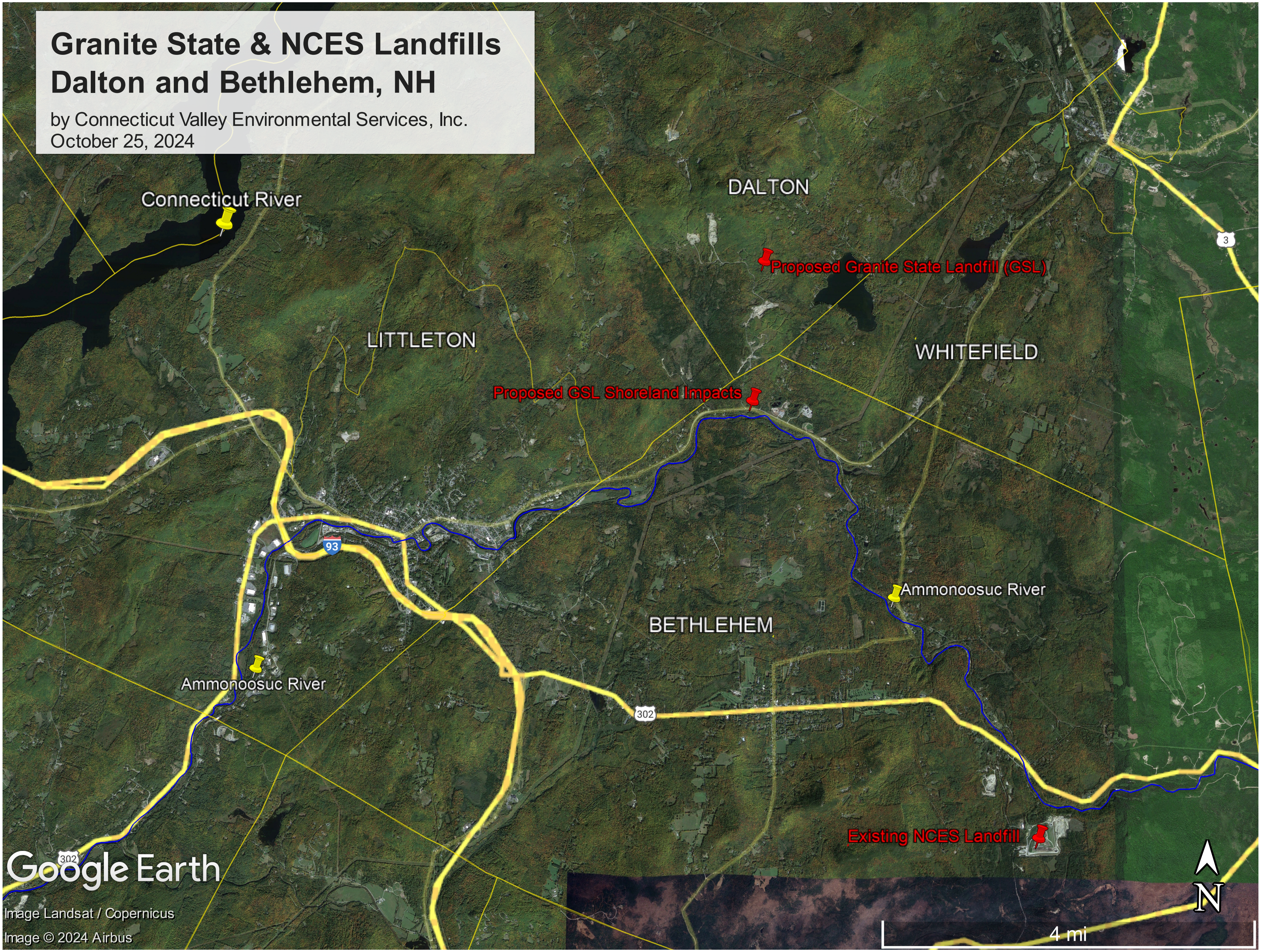
increase in the US. USGCRP, 2023: Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023. November 2023. Figure 2.8.

[15] https://gencourt.state.nh.us/rsa/html/X/149-M/149-M-11.htm


Granite State & NCES Landfills
Dalton and Bethlehem, NH
by Connecticut Valley Environmental Services, Inc.
October 25, 2024
Connecticut River
DALTON
Proposed Granite State Landfill (GSL)
LITTLETON
WHITEFIELD
Proposed GSL Shoreland Impacts
93
Ammonoosuc River
BETHLEHEM
Ammonoosuc River
302
302
3
Existing NCES Landfill
Google Earth
Image Landsat / Copernicus
Image © 2024 Airbus
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KIMBALL CHASE
company, inc.
Civil
Environmental
Engineers
40 Bridge Street
Portsmouth
New Hampshire 03801
603-431-2520

October 26, 1984

Mr. Thomas Sweeney
Bureau of Solid Waste Management
Department of Health and Welfare
Hazen Drive
Concord, New Hampshire 03301

Re: Final Report, Sanco Landfill Hydrogeologic Analysis, Bethlehem, NH 84-608

Dear Mr. Sweeney:

Transmitted herewith are three copies of the final report on the installation of groundwater monitoring wells and hydrogeologic evaluation at the Sanco Landfill in Bethlehem, New Hampshire. This final report reflects those items discussed with you as well as Mike Sills and Walter Carlson of the Water Supply and Pollution Control Commission at our meeting in Concord on October 17.

The report prepared by Caswell, Eichler and Hill has been clarified to include the confirmed elevation of the seep below Muchmore Road, details of finished well construction, sieve analysis of soil samples, and documentation of public water use status of the residences on Muchmore Road. The report also includes several recommendations regarding continued sampling and analysis and general landfill operation.

It is our understanding that Sanco intends to continue specific engineering and financial evaluations with the goal of constructing and operating a new landfill expansion on approximately 10 acres immediately adjacent to the existing permitted site. This new expansion will require positive leachate control systems in accordance with the current requirements for new landfill facilities in the State. Accordingly, the new landfill expansion, if constructed, may potentially accommodate leachate management capability for leachate which may be generated in the future at the existing permitted site.

With this concept, we make the following specific recommendations regarding continued operation at the existing site:

1. Generally construct and develop the landfill to permitted limits in such a way as to coordinate with the anticipated expansion.

2. To minimize further infiltration of surface water into the existing landfilled refuse, and hence minimize further production of leachate and potential contamination;

   a. Place an intermediate soil cover layer over all areas of existing landfill. The cover should have the minimum practical in place permeability possible, and have a minimum compacted thickness of 12". Native soils as available or as conditioned with ammendments should be placed such that a permeability in the range of 10^{-7} cm/sec is achieved. The intermediate cover should be graded such that any future leachate which may encounter the layer will flow laterally and be collectable for handling and disposal.

b. Place, compact, and cover refuse in the further development of the landfill such that moisture addition to refuse is minimized with the goal of not exceeding the moisture holding capacity of the fill. This may include techniques of maximizing the ratio of vertical development to active area prior to future intermediate covers, control of surface grades of successive lifts, maximizing compaction, and choice and placement of cover material.

3. Develop an engineering plan for the operation and successive development of the permitted fill to address the above objectives as well as efficient use of space and cover material.

4. Proceed with evaluation of planned new landfill expansion to determine site specific technical requirements and costs such that the facility may be further pursued.

We appreciate the attention of the Bureau of Solid Waste Managaement and Water Supply and Pollution Control Commission in the preparation and review of this report. If you have any questions or comments, please do not hesitate to call.

Very truly yours,

KIMBALL CHASE COMPANY, INC.

Bill Straub

William A. Straub, P.E.
Project Engineer

WAS/br

cc: Roy Sanborn
Barry Hager
David Hill

INSTALLATION OF MONITORING WELLS

AT THE

SANCO LANDFILL
BETHLEHEM, NEW HAMPSHIRE

Prepared for:

KIMBALL CHASE CO., INC.
42 Bridge Street
Portsmouth, NH 03801

Prepared by:

CASWELL, EICHLER & HILL, INC.
P.O. Box 4696
Portsmouth, NH 03801

OCTOBER 1984

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APPENDICES

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ACKNOWLEDGEMENTS

This project was performed for Kimball Chase Company Inc. under funding provided by SANCO, Inc. Caswell, Eichler and Hill would like to acknowledge the support and assistance of Kimball Chase, especially project manager William A. Straub; and SANCO, through the help of Roy Sanborn. We also wish to thank the State agencies and their officials who cooperated in supplying necessary data and regulatory assistance. These include Mr. Thomas Sweeney of the Bureau of Solid Waste Management and Mr. Walter Carlson of the Water Supply and Pollution Control Commission. Laboratory services and consultation were performed by Mr. Russell D. Foster of Resource Analysts, Inc.

This report was prepared by Mr. David Hill with review and technical assistance from W.B. Caswell, Jr. and Matthew F. Eichler III, all of CEH.

INSTALLATION OF MONITORING WELLS AT THE SANCO LANDFILL

BETHLEHEM, NEW HAMPSHIRE

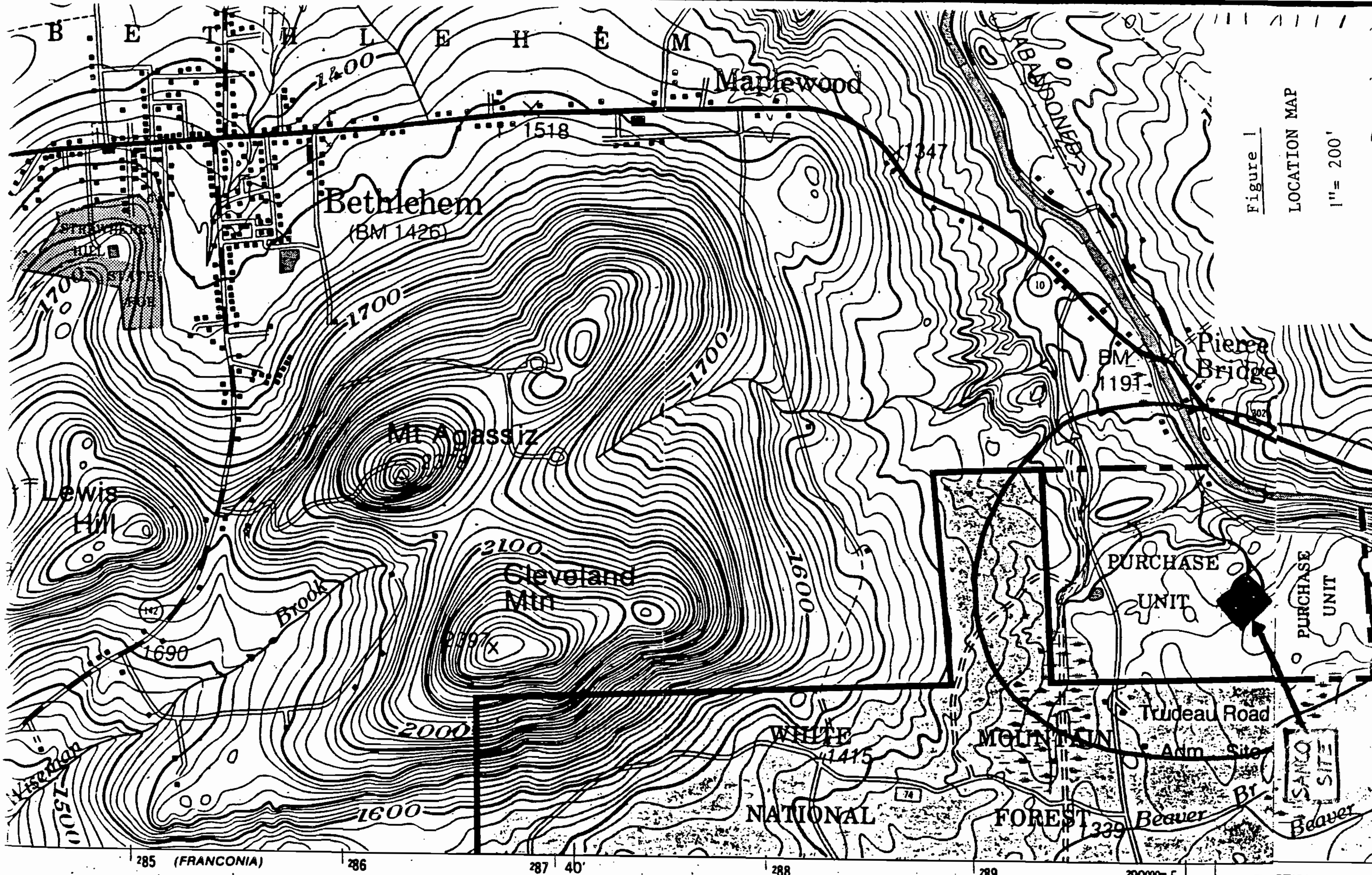
INTRODUCTION

The privately owned landfill in Bethlehem, N.H., has been owned and operated by SANCO, Inc. since April 1, 1983. Prior to that time the landfill was owned and operated by Mr. Harold Brown since September 2, 1976. The site was formerly used as a borrow pit by Mr. Brown before being used as a landfill. In late 1983, SANCO applied to the New Hampshire Bureau of Solid Waste Management (BSWM) for a permit to extend the vertical limits of waste placement to an elevation of 1370 feet MSL, or about thirty feet above the current contours. In a letter dated November 29, 1983, the BSWM approved this application subject to the installation and subsequent monitoring of three downgradient and one upgradient monitoring wells.

In order to comply with the State mandate, SANCO retained The Kimball Chase Company Inc. (KCCI) of Portsmouth, NH to perform the necessary investigations and pursue the necessary approvals. KCCI retained Caswell, Eichler and Hill, Inc. (CEH) of Portsmouth, NH to complete the necessary hydrogeologic analysis and to oversee the installation of the monitoring wells. In a letter dated June 8, 1984, KCCI forwarded a proposed scope of work to SANCO which was approved.

In keeping with its contractual arrangement, CEH performed a preliminary hydrogeologic analysis of the SANCO landfill site. This work included review and analysis of existing data, reconnaissance geologic mapping, determination of ground water flow directions, and preparation of a detailed scope of work for submission to the appropriate State agencies. The results of that analysis were reported in the CEH letter of July 17, 1984 which is attached in Appendix I. The salient points of the report were two-fold. First, that the site was underlain, not universally by the coarse-grained terrace materials exposed at the surface, but rather by a wide variety of grain sizes ranging from clay to boulders with no apparent area-wide lateral continuity. Second, the apparent ground water flow direction was determined to be to the north or northeast (see Figure 1).

This information along with the detailed scope of work was forwarded to the BSWM and the New Hampshire Water Supply and Pollution Control Commission (WSPCC) with the Kimball Chase letter of July 20, 1984 (App. I). On August 15, 1984, a CEH geologist met at the SANCO site with representatives of KCCI (William Straub), SANCO (Roy Sanborn and Barry Hager), BSWM (Tom Sweeney), and WSPCC (Walter Carlson). At this time, the site was toured and the proposed scope of work discussed. Both BSWM and WSPCC gave verbal approvals of the proposed scope at that time and indicated that written confirmation would be forthcoming. As of this writing, this approval has not been received. However, the project did proceed forward based on a September 5, 1984 telephone conversation between Bill Straub and Walter Carlson verifying his approval of the scope with minor modifications. These modifications included additional well construction specifications and a change in one well location. These were incorporated into the project. Also mentioned were two seeps



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1 MILE
0 1000 2000 3000 4000 5000 6000 7000 FEET
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CONTOUR INTERVAL 20 FEET
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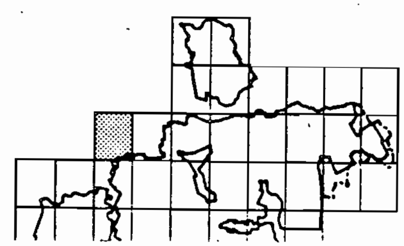
LEGEND



Copies of this Map are available for purchase at
Forest Supervisor's Headquarters
White Mountain National Forest
Federal Bldg 719 Main
Laconia, New Hampshire 03246

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WHITEFIELD SW, N.H.

located downgradient of the landfill on the north side of Muchmore Road above the Ammonoosuc River which were detected by Carlson during the site visit (Figure 2). Since one of the seeps appeared to be very iron-rich based on a large area of iron precipitate, it was suggested that the seeps be included in future sampling runs.

Based on this background, the work described below was completed.

WORK PERFORMED

The scope of work proposed by CEH and amended by the State included the following tasks:

1) Site inspection with State personnel
2) Sampling of the Muchmore Road seep (Seep 1)
3) The observation and installation of four test wells
4) The geologic sampling and permeability testing of the four wells
5) The construction of secure monitoring wells within the four test wells
6) The horizontal and vertical survey of the test wells
7) Measurement of stabilized water levels within the wells
8) Sampling and analysis of water extracted from the stabilized wells

The site inspection with the State has been discussed in the Introduction section above. The Muchmore Road seep (Seep 1) was sampled on August 22, 1984 using sample bottles supplied by Resource Analysts, Inc. (RAI) of Hampton, NH. The conductivity of Seep 1 as well as an adjacent seep (Seep 2) and others were taken. The samples were chilled and delivered to RAI.

The four test wells were drilled by Maine Test Borings, Inc., during September 1984. A CEH geologist was also on-site to supervise the drilling. The location of these wells is shown on Figure 3. The wells were constructed using drill-and-drive-techniques. Wash water for drilling was obtained from the Bethlehem municipal supply. Split-spoon samples were taken at 5-foot intervals and at any noticable change in sub-surface materials. The samples were visually inspected by the driller and on-site geologist at the time of extraction, and retained for further analysis. The driller prepared well logs based on his observations. These logs have been annotated and are attached as Appendix II. One of the retained samples from each well was subsequently sieved to determine the actual grain-size distribution of the sediments. These analyses are attached as Appendix III.

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Organic Chemical Analysis

SAMPLE NO.: 47034
OWNERS NAME: SANCO LANDFILL
OWNERS ADDRESS: TRUDEAU ROAD
CITY OR TOWN BETHLEHEM
DATE SAMPLED: 09-12-85
PERSON SAMPLING: WALTER CARLSON
DATE SUBMITTED: 09-13-85,08:09
DATE COMPLETED: 10-07-85

Comments:
SANCO LANDFILL
MW-104
SPEC COND 32 UMHOS

Test Name	Result (ug/l)	Test Name	Result (ug/l)
Dichloromethane	ND	Trichlorofluoromethane	ND
Dichlorobromomethane	ND		
Tetrachloromethane	ND	Acetone	ND
Chlorodibromomethane	ND	Tetrahydrofuran	ND
Chloroethane		Diethyl ether	ND
1,1-Dichloroethane	ND	Methyl Ethyl Ketone	ND
1,2-Dichloroethane	ND	Methyl Isobutyl Keton	ND
1,1,1-Trichloroethane	ND	1,3-Dichloropropane	ND
1,1,2-Trichloroethane	ND	Trichlorotrifluoroeth	ND
Tetrachloroethane	ND		
1,1-Dichloroethylene	ND	Tribromomethane	ND
Dichloroethylene (c+t)	ND	Trichloromethane	ND
Trichloroethylene	ND	t-1,2-Dichloroethylene	
Tetrachloroethylene	ND		
1,2-Dichloropropane	ND		
1,3-Dichloropropene	ND		
Benzene	ND		
Chlorobenzene	ND		
Dichlorobenzene	ND		
Ethylbenzene	ND		
Toluene	ND		
Xylene, meta isomer	ND		
Xylenes, (ortho&para)	ND		
Vinyl chloride			
Bromomethane			
Chloromethane			

ug/l = micrograms per liter
> = greater than
< = less than

ND = none detected
PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Inorganic Chemical Analysis

Sample No.:	47034
Owners Name:	SANCO LANDFILL
Address:	TRUDEAU ROAD
City or Town:	BETHLEHEM
Date sampled:	09-12-85
Person sampling:	WALTER CARLSON
Date Submitted:	09-13-85,08:09
Date Completed:	10-07-85

Comments:
SANCO LANDFILL
MW-104
SPEC COND 32 UMHOS

Test Name	MCL		Result (mg/l)	Test Name	MCL		Result (mg/l)
Primary Standards				**Secondary Standards**			
Arsenic	(0.05)			Chloride, Cl	(250)		
Barium	(1.0)			Copper, Cu	(1.0)		
Cadmium	(0.010)	<	.0050	Iron, Fe	(0.30		.1000
Chromium	(0.05)	<	.0300	Manganese, Mn	(0.05	<	.0300
Lead	(0.05)		.0810	Sulfate, SO4	(250)		
Mercury	(0.002)			Sodium, Na	(20-250		
Selenium	(0.01)			Turbidity	(N.T.U.		
Silver	(0.05)			Specific Conductance	(mhos		
Nitrate/Nitrite	(10.0)			pH	(units		
Fluoride, F	(2.4)			Total Hardness as	CaCO3		
Coliform Bact./100 ml				Calcium Hardness as	CaCO3		
Non-Coliform Bact.				Total Alkalinity as	CaCO3		
Iron Bacteria				TDS (tot. Dis. Sol.)	(500)		
Coliform, Tot. MPN/100				C.O.D.		<	10.0000
Other Heavy Metal							
				T.K.N.			
Aluminum, Al				NO2+NO3			
Antimony, Sb				Total Solids			
Molybdenum, Mo				T.O.C.			
Vanadium, Va				Total P			
Zinc, Zn				Sulfide			

mg/l = milligrams per liter - (otherwise noted)
\> = greater than * < = less than
ND = none detected * PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Organic Chemical Analysis

SAMPLE NO.: 47035
OWNERS NAME: SANCO LANDFILL
OWNERS ADDRESS: TRUDEAU ROAD
CITY OR TOWN BETHLEHEM
DATE SAMPLED: 09-12-85
PERSON SAMPLING: WALTER CARLSON
DATE SUBMITTED: 09-13-85,08:15
DATE COMPLETED: 10-07-85

Comments:
SANCO LANDFILL
MW-101

Test Name	Result (ug/l)	Test Name	Result (ug/l)
Dichloromethane	ND	Trichlorofluoromethane	PR
Dichlorobromomethane	ND		
Tetrachloromethane	ND	Acetone	ND
Chlorodibromomethane	ND	Tetrahydrofuran	ND
Chloroethane		Diethyl ether	ND
1,1-Dichloroethane	ND	Methyl Ethyl Ketone	ND
1,2-Dichloroethane	ND	Methyl Isobutyl Keton	ND
1,1,1-Trichloroethane	ND	1,3-Dichloropropane	ND
1,1,2-Trichloroethane	ND	Trichlorotrifluoroeth	ND
Tetrachloroethane	ND		
1,1-Dichloroethylene	ND	Tribromomethane	ND
Dichloroethylene (c+t)	ND	Trichloromethane	ND
Trichloroethylene	ND	t-1,2-Dichloroethylene	
Tetrachloroethylene	ND		
1,2-Dichloropropane	ND		
1,3-Dichloropropene	ND		
Benzene	ND		
Chlorobenzene	ND		
Dichlorobenzene	ND		
Ethylbenzene	ND		
Toluene	ND		
Xylene, meta isomer	ND		
Xylenes, (ortho&para)	ND		
Vinyl chloride			
Bromomethane			
Chloromethane			

ug/l = micrograms per liter
> = greater than
< = less than

ND = none detected
PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Inorganic Chemical Analysis

Sample No.:	47035
Owners Name:	SANCO LANDFILL
Address:	TRUDEAU ROAD
City or Town:	BETHLEHEM
Date sampled:	09-12-85
Person sampling:	WALTER CARLSON
Date Submitted:	09-13-85,08:15
Date Completed:	10-07-85

Comments:
SANCO LANDFILL
MW-101

Test Name	MCL		Result (mg/l)	Test Name	MCL	Result (mg/l)
Primary Standards				**Secondary Standards**		
Arsenic	(0.05)			Chloride, Cl	(250)	
Barium	(1.0)			Copper, Cu	(1.0)	
Cadmium	(0.010)	<	.0050	Iron, Fe	(0.30	.1000
Chromium	(0.05)	<	.0300	Manganese, Mn	(0.05	3.8500
Lead	(0.05)		.0380	Sulfate, SO4	(250)	
Mercury	(0.002)			Sodium, Na	(20-250	
Selenium	(0.01)			Turbidity	(N.T.U.	
Silver	(0.05)			Specific Conductance	(mhos	
Nitrate/Nitrite	(10.0)			pH	(units	
Fluoride, F	(2.4)			Total Hardness as	CaCO3	
Coliform Bact./100 ml				Calcium Hardness as	CaCO3	
Non-Coliform Bact.				Total Alkalinity as	CaCO3	
Iron Bacteria				TDS (tot. Dis. Sol.)	(500)	
Coliform, Tot. MPN/100				C.O.D.		24.0000
Other Heavy Metal						
				T.K.N.		
Aluminum, Al				NO2+NO3		
Antimony, Sb				Total Solids		
Molybdenum, Mo				T.O.C.		
Vanadium, Va				Total P		
Zinc, Zn				Sulfide		

mg/l = milligrams per liter - (otherwise noted)
\> = greater than * < = less than
ND = none detected * PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Organic Chemical Analysis

SAMPLE NO.: 47036
OWNERS NAME: SANCO LANDFILL
OWNERS ADDRESS: TRUDEAU ROAD
CITY OR TOWN BETHLEHEM
DATE SAMPLED: 09-12-85
PERSON SAMPLING: WALTER CARLSON
DATE SUBMITTED: 09-13-85,08:16
DATE COMPLETED: 10-07-85

Comments:
SANCO LANDFILL
MW-103
SPEC COND 460 UMHOS

Test Name		Result (ug/l)	Test Name		Result (ug/l)
Dichloromethane	ND		Trichlorofluoromethane	PR	
Dichlorobromomethane	ND				
Tetrachloromethane	ND		Acetone		11.6000
Chlorodibromomethane	ND		Tetrahydrofuran	ND	
Chloroethane			Diethyl ether		18.0000
1,1-Dichloroethane		5.4000	Methyl Ethyl Ketone		500.0000
1,2-Dichloroethane	ND		Methyl Isobutyl Keton	<	5.0000
1,1,1-Trichloroethane	<	5.0000	1,3-Dichloropropane	ND	
1,1,2-Trichloroethane	ND		Trichlorotrifluoroeth	ND	
Tetrachloroethane	ND				
1,1-Dichloroethylene	ND		Tribromomethane	ND	
Dichloroethylene (c+t)	ND		Trichloromethane	ND	
Trichloroethylene	ND		t-1,2-Dichloroethylene		
Tetrachloroethylene	<	5.0000			
1,2-Dichloropropane	ND				
1,3-Dichloropropene	ND				
Benzene	<	5.0000			
Chlorobenzene	ND				
Dichlorobenzene	ND				
Ethylbenzene	<	5.0000			
Toluene		15.3000			
Xylene, meta isomer		5.6000			
Xylenes, (ortho&para)	<	5.0000			
Vinyl chloride					
Bromomethane					
Chloromethane					

ug/l = micrograms per liter * ND = none detected
> = greater than * PR = present
< = less than *

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Inorganic Chemical Analysis

Sample No.: 47036
Owners Name: SANCO LANDFILL
Address: TRUDEAU ROAD
City or Town: BETHLEHEM
Date sampled: 09-12-85
Person sampling: WALTER CARLSON
Date Submitted: 09-13-85,08:16
Date Completed: 10-07-85

Comments:
SANCO LANDFILL
MW-103
SPEC COND 460 UMHOS

Test Name	MCL		Result (mg/l)	Test Name	MCL	Result (mg/l)
Primary Standards				**Secondary Standards**		
Arsenic	(0.05)			Chloride, Cl	(250)	
Barium	(1.0)			Copper, Cu	(1.0)	
Cadmium	(0.010)	<	.0050	Iron, Fe	(0.30	100.0000
Chromium	(0.05)	<	.0300	Manganese, Mn	(0.05	17.8000
Lead	(0.05)		.0390	Sulfate, SO4	(250)	
Mercury	(0.002)			Sodium, Na	(20-250	
Selenium	(0.01)			Turbidity	(N.T.U.	
Silver	(0.05)			Specific Conductance	(mhos	
Nitrate/Nitrite	(10.0)			pH	(units	
Fluoride, F	(2.4)			Total Hardness as	CaCO3	
Coliform Bact./100 ml				Calcium Hardness as	CaCO3	
Non-Coliform Bact.				Total Alkalinity as	CaCO3	
Iron Bacteria				TDS (tot. Dis. Sol.)	(500)	
Coliform, Tot. MPN/100				C.O.D.		38.0000
Other Heavy Metal						
				T.K.N.		
Aluminum, Al				NO2+NO3		
Antimony, Sb				Total Solids		
Molybdenum, Mo				T.O.C.		
Vanadium, Va				Total P		
Zinc, Zn				Sulfide		

mg/l = milligrams per liter - (otherwise noted)
> = greater than * < = less than
ND = none detected * PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Organic Chemical Analysis

SAMPLE NO.: 47037
OWNERS NAME: SANCO LANDFILL
OWNERS ADDRESS: TRUDEAU ROAD
CITY OR TOWN BETHLEHEM
DATE SAMPLED: 09-12-85
PERSON SAMPLING: WALTER CARLSON
DATE SUBMITTED: 09-13-85,08:17
DATE COMPLETED: 10-07-85

Comments:
SANCO LANDFILL
MW-102
SPEC COND 250 UMHOS

Test Name	Result (ug/l)	Test Name	Result (ug/l)
Dichloromethane	ND	Trichlorofluoromethane	ND
Dichlorobromomethane	ND		
Tetrachloromethane	ND	Acetone	11.4000
Chlorodibromomethane	ND	Tetrahydrofuran	ND
Chloroethane		Diethyl ether	< 5.0000
1,1-Dichloroethane	< 5.0000	Methyl Ethyl Ketone	300.0000
1,2-Dichloroethane	ND	Methyl Isobutyl Keton	ND
1,1,1-Trichloroethane	ND	1,3-Dichloropropane	ND
1,1,2-Trichloroethane	ND	Trichlorotrifluoroeth	ND
Tetrachloroethane	ND		
1,1-Dichloroethylene	ND	Tribromomethane	ND
Dichloroethylene (c+t)	ND	Trichloromethane	ND
Trichloroethylene	ND	t-1,2-Dichloroethylene	
Tetrachloroethylene	ND		
1,2-Dichloropropane	ND		
1,3-Dichloropropene	ND		
Benzene	ND		
Chlorobenzene	ND		
Dichlorobenzene	ND		
Ethylbenzene	ND		
Toluene	67.6000		
Xylene, meta isomer	< 5.0000		
Xylenes, (ortho&para)	ND		
Vinyl chloride			
Bromomethane			
Chloromethane			

ug/l = micrograms per liter
\> = greater than
< = less than

ND = none detected
PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Inorganic Chemical Analysis

Sample No.: 47037
Owners Name: SANCO LANDFILL
Address: TRUDEAU ROAD
City or Town: BETHLEHEM
Date sampled: 09-12-85
Person sampling: WALTER CARLSON
Date Submitted: 09-13-85,08:17
Date Completed: 10-07-85

Comments:
SANCO LANDFILL
MW-102
SPEC COND 250 UMHOS

Test Name	MCL		Result (mg/l)	*	Test Name	MCL	Result (mg/l)
Primary Standards				*	Secondary Standards		
Arsenic	(0.05)			*	Chloride, Cl	(250)	
Barium	(1.0)			*	Copper, Cu	(1.0)	
Cadmium	(0.010)	<	.0050	*	Iron, Fe	(0.30	108.0000
Chromium	(0.05)	<	.0300	*	Manganese, Mn	(0.05	123.0000
Lead	(0.05)		.0440	*	Sulfate, SO4	(250)	
Mercury	(0.002)			*	Sodium, Na	(20-250	
Selenium	(0.01)			*	Turbidity	(N.T.U.	
Silver	(0.05)			*	Specific Conductance	(mhos	
Nitrate/Nitrite	(10.0)			*	pH	(units	
Fluoride, F	(2.4)			*	Total Hardness as	CaCO3	
Coliform Bact./100 ml				*	Calcium Hardness as	CaCO3	
Non-Coliform Bact.				*	Total Alkalinity as	CaCO3	
Iron Bacteria				*	TDS (tot. Dis. Sol.)	(500)	
Coliform, Tot. MPN/100				*	C.O.D.		140.0000
Other Heavy Metal				*			
				*	T.K.N.		
Aluminum, Al				*	NO2+NO3		
Antimony, Sb				*	Total Solids		
Molybdenum, Mo				*	T.O.C.		
Vanadium, Va				*	Total P		
Zinc, Zn				*	Sulfide		

mg/l = milligrams per liter - (otherwise noted)
> = greater than * < = less than
ND = none detected * PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Organic Chemical Analysis

SAMPLE NO.: 47038
OWNERS NAME: SANCO LANDFILL
OWNERS ADDRESS: TRUDEAU ROAD
CITY OR TOWN BETHLEHEM
DATE SAMPLED: 09-12-85
PERSON SAMPLING: WALTER CARLSON
DATE SUBMITTED: 09-13-85,08:20
DATE COMPLETED: 10-07-85

Comments:
SANCO LANDFILL
SEEP UNDER MUCHMORE ROAD
UPSTREAM END
SPEC COND 175 UMHOS

Test Name		Result (ug/l)	*	Test Name		Result (ug/l)
Dichloromethane	ND		*	Trichlorofluoromethane	ND	
Dichlorobromomethane	ND		*			
Tetrachloromethane	ND		*	Acetone		5.9000
Chlorodibromomethane	ND		*	Tetrahydrofuran	ND	
Chloroethane			*	Diethyl ether	<	5.0000
1,1-Dichloroethane	<	5.0000	*	Methyl Ethyl Ketone		100.0000
1,2-Dichloroethane	ND		*	Methyl Isobutyl Keton	ND	
1,1,1-Trichloroethane	ND		*	1,3-Dichloropropane	ND	
1,1,2-Trichloroethane	ND		*	Trichlorotrifluoroeth	ND	
Tetrachloroethane	ND		*			
1,1-Dichloroethylene	ND		*	Tribromomethane	ND	
Dichloroethylene (c+t)	ND		*	Trichloromethane	ND	
Trichloroethylene	ND		*	t-1,2-Dichloroethylene		
Tetrachloroethylene	ND		*			
1,2-Dichloropropane	ND		*			
1,3-Dichloropropene	ND		*			
Benzene	ND		*			
Chlorobenzene	ND		*			
Dichlorobenzene	ND		*			
Ethylbenzene	ND		*			
Toluene		26.8000	*			
Xylene, meta isomer	ND		*			
Xylenes, (ortho&para)	ND		*			
Vinyl chloride			*			
Bromomethane			*			
Chloromethane			*			

ug/l = micrograms per liter * ND = none detected
> = greater than * PR = present
< = less than *

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Inorganic Chemical Analysis

Sample No.: 47038
Owners Name: SANCO LANDFILL
Address: TRUDEAU ROAD
City or Town: BETHLEHEM
Date sampled: 09-12-85
Person sampling: WALTER CARLSON
Date Submitted: 09-13-85,08:20
Date Completed: 10-07-85

Comments:
SANCO LANDFILL
SEEP UNDER MUCHMORE ROAD
UPSTREAM END
SPEC COND 175 UMHOS

Test Name	MCL		Result (mg/l)	Test Name	MCL	Result (mg/l)
Primary Standards				**Secondary Standards**		
Arsenic	(0.05)			Chloride, Cl	(250)	
Barium	(1.0)			Copper, Cu	(1.0)	
Cadmium	(0.010)	<	.0050	Iron, Fe	(0.30	36.0000
Chromium	(0.05)	<	.0300	Manganese, Mn	(0.05	5.3000
Lead	(0.05)		.0420	Sulfate, SO4	(250)	
Mercury	(0.002)			Sodium, Na	(20-250	
Selenium	(0.01)			Turbidity	(N.T.U.	
Silver	(0.05)			Specific Conductance	(mhos	
Nitrate/Nitrite	(10.0)			pH	(units	
Fluoride, F	(2.4)			Total Hardness as	CaCO3	
Coliform Bact./100 ml				Calcium Hardness as	CaCO3	
Non-Coliform Bact.				Total Alkalinity as	CaCO3	
Iron Bacteria				TDS (tot. Dis. Sol.)	(500)	
Coliform, Tot. MPN/100				C.O.D.		66.0000
Other Heavy Metal						
				T.K.N.		
Aluminum, Al				NO2+NO3		
Antimony, Sb				Total Solids		
Molybdenum, Mo				T.O.C.		
Vanadium, Va				Total P		
Zinc, Zn				Sulfide		

mg/l = milligrams per liter - (otherwise noted)
\> = greater than * < = less than
ND = none detected * PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Organic Chemical Analysis

SAMPLE NO.: 47039
OWNERS NAME: SANCO LANDFILL
OWNERS ADDRESS: TRUDEAU ROAD
CITY OR TOWN BETHLEHEM
DATE SAMPLED: 09-12-85
PERSON SAMPLING: WALTER CARLSON
DATE SUBMITTED: 09-13-85,08:23
DATE COMPLETED: 10-07-85

Comments:
SANCO LANDFILL
SEEP UNDER MUCHMORE ROAD
DOWNSTREAM END BY AMMONOSUC RIVER
SPEC COND 140 UMHOS

Test Name	Result (ug/l)	Test Name	Result (ug/l)
Dichloromethane	ND	Trichlorofluoromethane	ND
Dichlorobromomethane	ND		
Tetrachloromethane	ND	Acetone	ND
Chlorodibromomethane	ND	Tetrahydrofuran	ND
Chloroethane		Diethyl ether	ND
1,1-Dichloroethane	ND	Methyl Ethyl Ketone	ND
1,2-Dichloroethane	ND	Methyl Isobutyl Keton	ND
1,1,1-Trichloroethane	ND	1,3-Dichloropropane	ND
1,1,2-Trichloroethane	ND	Trichlorotrifluoroeth	ND
Tetrachloroethane	ND		
1,1-Dichloroethylene	ND	Tribromomethane	ND
Dichloroethylene (c+t)	ND	Trichloromethane	ND
Trichloroethylene	ND	t-1,2-Dichloroethylene	
Tetrachloroethylene	ND		
1,2-Dichloropropane	ND		
1,3-Dichloropropene	ND		
Benzene	ND		
Chlorobenzene	ND		
Dichlorobenzene	ND		
Ethylbenzene	ND		
Toluene	ND		
Xylene, meta isomer	ND		
Xylenes, (ortho&para)	ND		
Vinyl chloride			
Bromomethane			
Chloromethane			

ug/l = micrograms per liter
> = greater than
< = less than

ND = none detected
PR = present

State of New Hampshire
WATER SUPPLY AND POLLUTION CONTROL COMMISSION
HAZARDOUS WASTE AND GROUNDWATER PROTECTION DIVISION
Inorganic Chemical Analysis

Sample No.: 47039
Owners Name: SANCO LANDFILL
Address: TRUDEAU ROAD
City or Town: BETHLEHEM
Date sampled: 09-12-85
Person sampling: WALTER CARLSON
Date Submitted: 09-13-85,08:23
Date Completed: 10-07-85

Comments:
SANCO LANDFILL
SEEP UNDER MUCHMORE ROAD
DOWNSTREAM END BY AMMONOSUC RIVER
SPEC COND 140 UMHOS

Test Name	MCL		Result (mg/l)	Test Name	MCL	Result (mg/l)
Primary Standards				**Secondary Standards**		
Arsenic	(0.05)			Chloride, Cl	(250)	
Barium	(1.0)			Copper, Cu	(1.0)	
Cadmium	(0.010)	<	.0050	Iron, Fe	(0.30	14.0000
Chromium	(0.05)	<	.0300	Manganese, Mn	(0.05	3.4000
Lead	(0.05)		.0420	Sulfate, SO4	(250)	
Mercury	(0.002)			Sodium, Na	(20-250	
Selenium	(0.01)			Turbidity	(N.T.U.	
Silver	(0.05)			Specific Conductance	(mhos	
Nitrate/Nitrite	(10.0)			pH	(units	
Fluoride, F	(2.4)			Total Hardness as	CaCO3	
Coliform Bact./100 ml				Calcium Hardness as	CaCO3	
Non-Coliform Bact.				Total Alkalinity as	CaCO3	
Iron Bacteria				TDS (tot. Dis. Sol.)	(500)	
Coliform, Tot. MPN/100				C.O.D.		52.0000
Other Heavy Metal						
				T.K.N.		
Aluminum, Al				NO2+NO3		
Antimony, Sb				Total Solids		
Molybdenum, Mo				T.O.C.		
Vanadium, Va				Total P		
Zinc, Zn				Sulfide		

mg/l = milligrams per liter - (otherwise noted)
> = greater than * < = less than
ND = none detected * PR = present

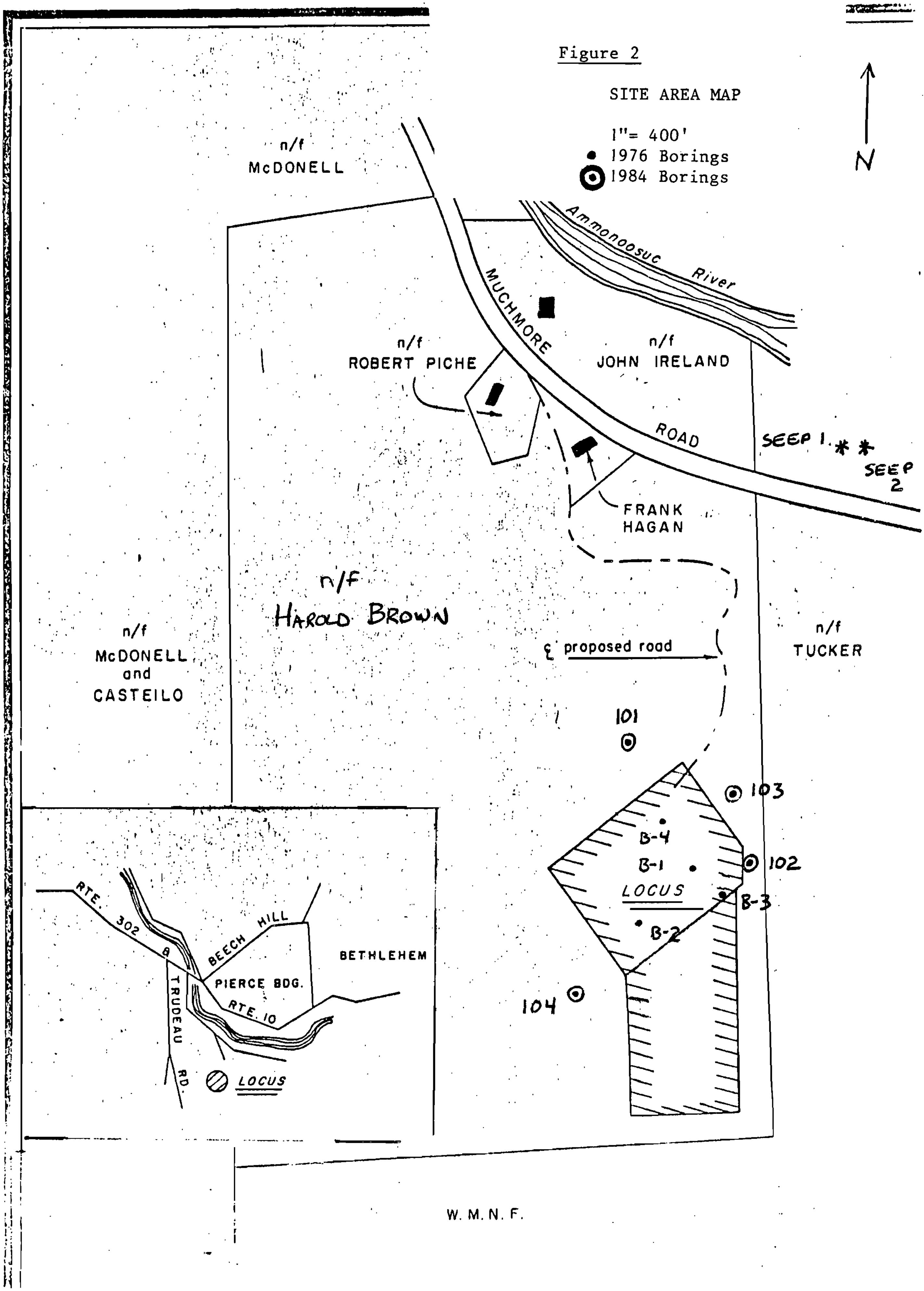


Figure 2
SITE AREA MAP
1"= 400'
1976 Borings
1984 Borings
N
n/f
McDONELL
Ammonoosuc River
MUCHMORE ROAD
n/f
ROBERT PICHE
n/f
JOHN IRELAND
SEEP 1.
SEEP 2
FRANK HAGAN
n/f
HAROLD BROWN
n/f
McDONELL
and
CASTEILO
proposed road
n/f
TUCKER
101
103
102
B-4
B-1
LOCUS
B-3
B-2
104
RTE. 302
BEECH HILL
BETHLEHEM
PIERCE BDG.
RTE. 10
TRUDEAU RD.
LOCUS
W. M. N. F.

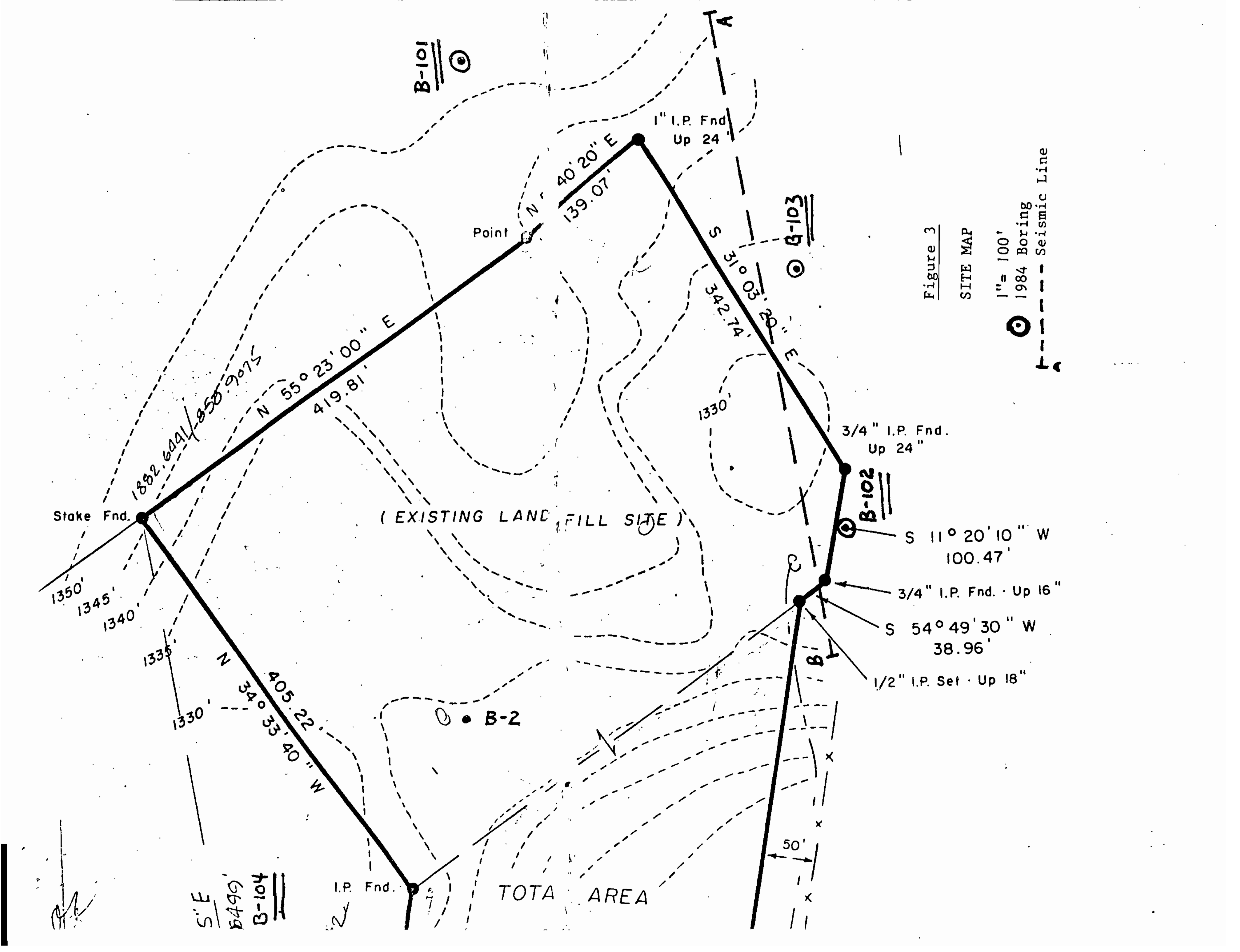


Figure 3

SITE MAP

At four separate locations in the various borings, falling-head permeability tests were performed to determine the approximate hydraulic conductivity of the underlying saturated sediments. These were accomplished by washing the boring flush with the bottom of the three-inch drive pipe at the selected depth and filling the pipe with clean water to a point three to six feet above ground surface. The rate of decline in the water level was then observed and recorded. In some cases, the rate of drop was so slight that the tests were continued overnight. These data were then analyzed by the Horslev method. The results are presented in a later section of the report.

Once the borings were completed and flushed with clean water, monitoring wells were constructed within the holes. This was accomplished by setting 1½-inch slotted (.010 in.) flush-joing PVC pipe within the boring from a position near the water table to the bottom of the hole.

The annulus around the pipe was backfilled with clean sand. A solid PVC riser pipe was installed from the screen to a convenient point above the surface. A bentonite seal was placed just above the screen to prohibit the direct inflow of surface waters. A 3-inch locking steel riser pipe was then grouted over the protruding PVC riser for security against accident and vandalism. Construction detail for these monitoring wells is shwon in Appendix II. At the completion of construction, the wells were flushed with clean water until they flowed free of fines.

Once the wells were completed, the tops of the steel risers were surveyed for both horizontal (± 1 foot) and vertical (± .01 foot) control. This was performed by SANCO. These data are discussed later in the report to correlate water levels between the wells.

After waiting one week for the clean water placed within the wells to equilibrate with the surrounding waters, both from the viewpoint of potentiometric level and quality, a water level/water quality round of observations were taken. On September 19 and then again on September 26, 1984, a CEH geologist travelled to the site to measure water levels and collect water samples. Water levels were measured from the top of the steel protector pipes using a fiberglass tape with bobber.

Water samples were collected by two methods. Three of the wells, B-101, 102, and 103 have water levels over one atmosphere of lift from the surface, therefore precluding the use of a peristaltic pump on these wells. In its place, a 1¼-inch by four feet galvanized baler was used. Water was baled from the wells until three volumes of the well had been displaced. The baler was then used to extract the sample volume which was placed in containers provided by RAI. Although not required the baler was also used at the upgradient well, B-104, to minimize the bias which might have resulted from using different sampling techniques. This was especially important in that the baling technique creates a surging motion in the well bore which introduced a significant volume of fine sediments into the sample even in these well developed wells.

The seeps were sampled using the peristaltic pump with the sample being taken only after flushing the pump with over ten liters of seep water. Care was taken to minimize intoduction of organic or inorganic debris into the sample. All samples were chilled and delivered to RAI within twenty-four hours.

At RAI, the samples were tested for iron, manganese, potassium, sodium, chloride, sulfate, chemical oxygen demand (COD), total organic carbon (TOC), pH, and volitile organics (by GCMS). In the first sampling run, only totals were taken. When the bias shown by the suspended sediments was observed, both total and dissolved constituents were determined on the second round. The results of these analyses are discussed in a later section and are presented in full in Appendix IV.

SITE HYDROGEOLOGY

The landfill is situated on a very deep glacial terrace to the south of, and approximately 180 feet above, the Ammonoosuc River in Bethlehem, N.H. There is no bedrock exposed on or directly adjacent to the site. None of the borings (up to 71 feet deep) encountered documented bedrock. For this reason, a seismic refraction profile was completed along the access road to the site to the north-east of the monitoring wells (Figure 3). The seismic data shows bedrock to be 200 feet below land surface at the A end of the line and over 160 feet at the B end or about 20 feet below river level. The type of bedrock which occurs at this depth is unknown but will be assumed to be inconsequential based on the nature and extent of the overburden.

Due to its upland nature, its well-drained soils, and deep water table, there is no surface drainage on or about the site. A small brook 2000 feet to the northwest drains the bogs in the Trudeau Road area to the west while numerous seeps along the Ammonoosuc bank give rise to a number of rivulets along the bank 1200 feet or more to the northeast.

The overburden, as observed in both on - and off - site pits as well as the test borings covers a wide variety of grain sizes from clay to boulders. The surface material is predominantly a dense, brown, silty fine sand with cobbles (Figure 4). Coarser surface materials may have existed previously but have been mined for their economic value. The thickness of this unit varies from 8-15 feet on the southern half of the site to as much as 40 feet to the north. Beneath this unit lies a slightly coarser, dense silty brown fine-to-coarse sand with gravel. In general, the water table occurs in this horizon. Its thickness varies from 20-30 feet. Beneath this level, at approximately elevation 1290 MSL, a very dense grey-brown sandy silt was encountered. No boring penetrated through this material which exhibits a <u>minimum</u> thickness of <u>over</u> 15 feet. A permeability test was conducted in this strata at B-102 and based on those results, the layer was assumed to be an aquiclude or at least an aquitard beneath the site.

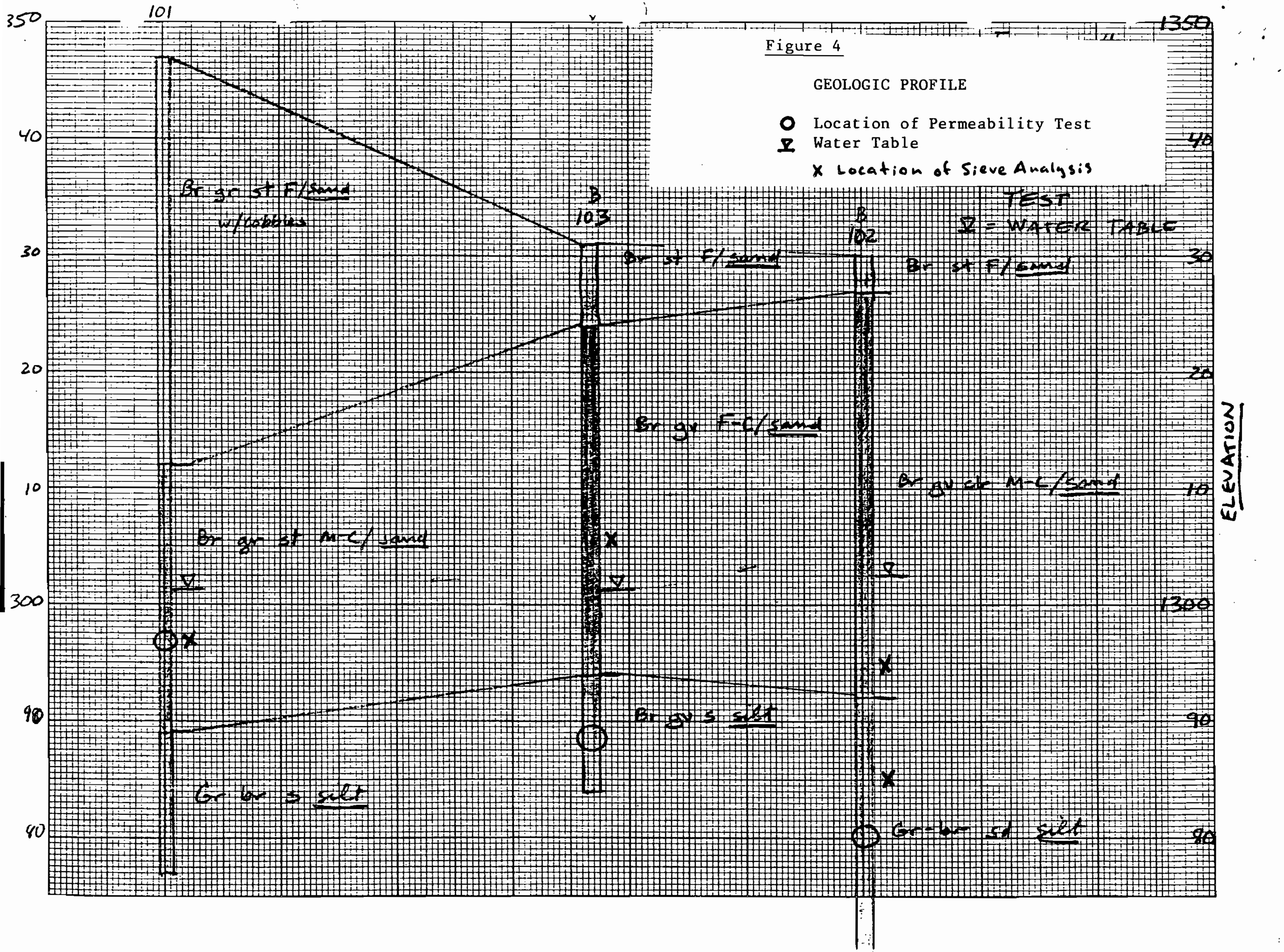


Figure 4

GEOLOGIC PROFILE

It must be stressed that these units described above are only generalizations of an extremely complex and laterally discontinuous distribution of sediments. The genisis of these sediments is not clear but it appear certain that their terrace-like appearance is destructional rather than constructional, that is, it appears that the Ammonoosuc is cutting down through previously deposited sediments. The dense and compact nature of the sediments are perhaps indicative of glacial outwash which was subsequently overridden by glacial ice causing its compacted condition.

As mentioned above, one of the split-spoon samples from each of the wells and covering each of the generalized geologic units was selected for sieve analysis. As the graphs and tables show, there is a variability in the grain-size distribution from unit-to-unit and depth-to-depth which demonstrates the heterogeneity and anisotrophy of the subsurface sediments. This is important as this variability in subsurface sediments leads to variability in ground water flow.

These analyses are included as Appendix III and summarized below in Table I.

TABLE I - GRAIN SIZE DISTRIBUTION

Borings	Depth	Unit	D10 (mm)	D50 (mm)
101	50 - 51.5	Medium sand	.140	.750
102	35 - 36.5	Medium sand	7.063	.240
102	45 - 46.5	Sandy silt	7.063	.140
103	25 - 26.5	Medium sand	.150	.297
104	20 - 21.5	Fine sand	.149	.841

The depth to water table, as determined by the four new test wells at the site (and one 1976 test boring, B-2) are shown in Table II.

Table II   Stabilized Water Levels (9-17-84)

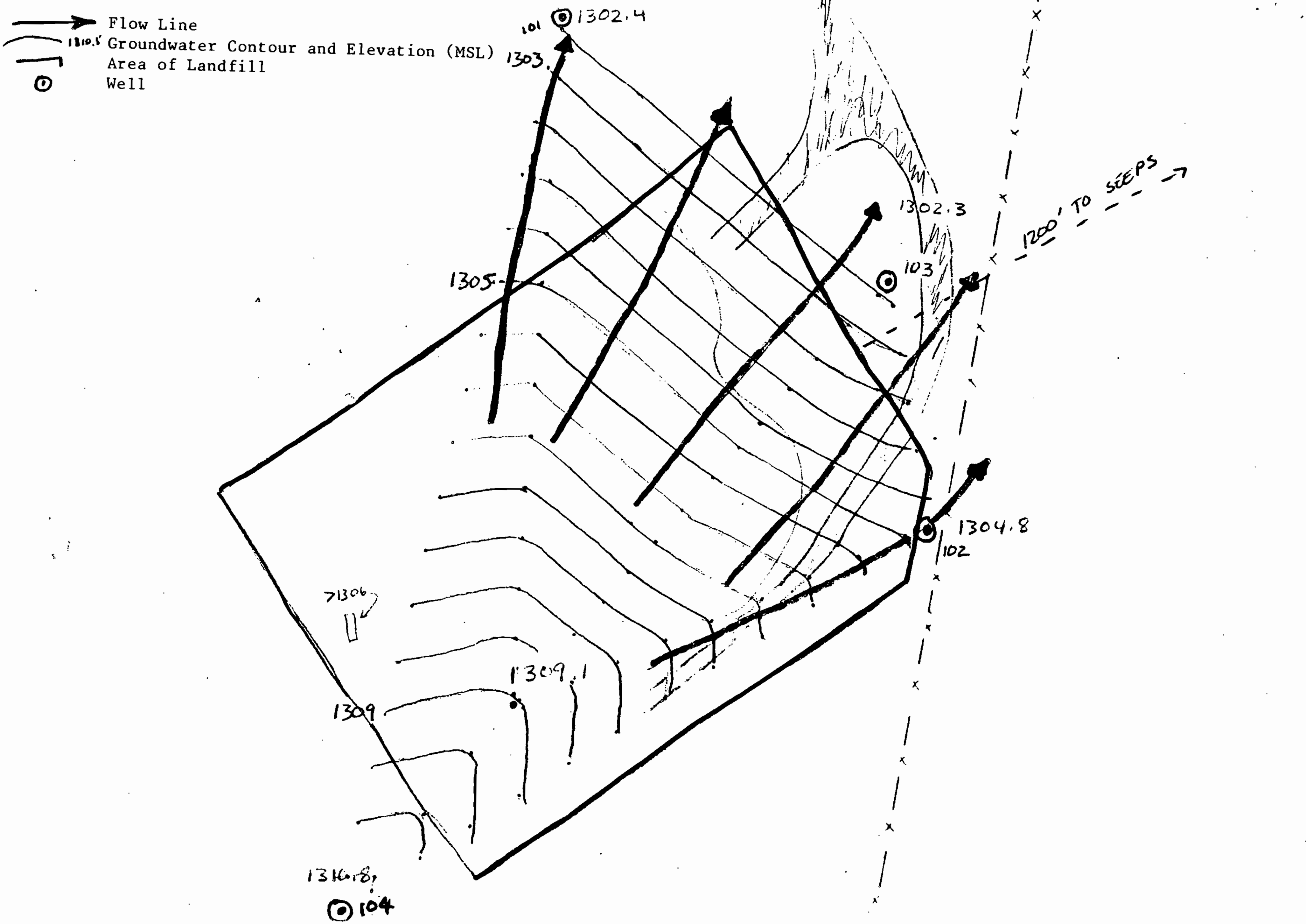
Well	Depth Below Measuring Point[1] (Ft)	Measuring Point Elevation (Ft) (MSL)	Water Table Elevation (Ft) (MSL)
101	48.40	1350.80	1302.40
102	30.25	1335.11	1304.36
103	33.25	1335.57	1302.32
104	19.35	1330.14	1310.79
B-2	28.80	1337.91	1309.11

[1]Measuring Point is top of Steel Riser Pipe, 3-4 feet above land surface.

As can bee seen, ground water is quite deep all around the site. Actual water table depth beneath the waste cannot be determined without placing test wells directly through the waste. B-2 is surrounded by waste and probably shows a slightly elevated water level because of it. This is "mounding" which occurs almost universally under landfills of this type. Mounding is a raising of the water table due to the increased infiltration of rainfall through the waste, which is generally more permeable than the soil. As B-2 shows (see Figure 5), some mounding is occurring beneath the fill which has deflected the otherwise straight flow line. Had our data point at B-2 been more central in the fill, the flow would probably be even more radial than shown in Figure 5.

URE 5)

Figure 5
PRELIMINARY WATER TABLE MAP
9/17/84 LEVELS



Cursory review of the shallow horizontal flownet (Figure 5) indicates a very low hydraulic gradient across the site. It can be seen that there exists an 8.5 foot drop in water level over the 800+ foot run from B-104 to B-103. This gives rise to a hydraulic gradient of .011, or just over 1%. This figure is important in that it, along with hydraulic conductivity, dictates the seepage, velocity of any water-borne contaminants.

The flownet also shows that the primary direction of ground water flow beneath the site is to the NNE as originally supposed. The likely discharge points for water flowing beneath the site are a series of seeps and springs which occur all along the bank of the Ammonoosuc River, to the north of Muchmore Road. The highest of these occur at an elevation of roughly 1270 MSL approximately 1200 feet from the SANCO site. This leads to a gradient of about two percent.

As mentioned above, hydraulic conductivity (permeability) tests were conducted in each of the new borings. Attempts were made to run the tests just below the water table, however, due to the slowly permeable nature of the sediments and the amount of water used during drilling, placement of these tests was not always accurate. In fact, when the stabilized levels were taken it was discovered that one test, at B-104, was performed above the water table and had to be discarded. Results of the remaining tests are shown graphically in Table III and their locations are shown back in Figure 4.

Table III
Results of Falling Head Permeability Tests

Well Number	Depth (A)	Strata	Hydraulic Conductivity (cm/sec)
101	50	Silty coarse sand	2.75×10^{-6}
102	50	Sandy silt	4.4×10^{-6}
103	40	Sandy silt	3.8×10^{-6}
104	15	Unsaturated	Discarded

The results of these tests show that the sandy silt is very slowly permeable as would be expected from observing the split-spoon samples or the sieve analyses. However, it is surprising that a test in the silty coarse sand unit should yield such a low value. This sub-strata within this unit must have been much siltier than those on either side which only points out the hazard of lumped geologic units. It seems apparent from on-site observation of drilling and subsequent re-insepction of the samples, that regardless of the denseness of these silty sands, their buld permeability most likely exceeds the 10^{-6} cm/sec value measured at the single isolated point.

This belief is supported by the water quality data presented below. One monitoring well, B-102, shows a clear impact from the landfill in terms of COD, TOC and metals concentration. The nearest upgradient waste to this well is approximately 200 feet away and was placed approximately five years ago. The minimum average seepage velocity of water borne contaminants from this waste (and therefor the average ground water flow velocity) can be used to back-figure the permeability using the following relationship:

$$\bar{v} = Ki/n_e$$

where; $\bar{v}$ = average seepage velocity (L/T)

K = hydraulic conductivity (L/T)

i = hydraulic gradient (unitless)

n_e = effective porosity (unitless)

The $\bar{v}$ estimated from the above (200 feet divided by five years) can be inserted in the rearranged equation to solve for K using the observed hydraulic gradient of .01 and an estimated effective porosity of .15. This gives rise to a hydraulic conductivity of 5.7×10^{-4} cm/sec which is much more in keeping with reasonable estimates based on visual inspection of the split spoon samples.

It is apparent, then, that the hydraulic conductivity of the subsurface sediments at the SANCO site range from 5×10^{-4} cm/sec to 3×10^{-6} cm/sec depending on the specific substratum. The silts appear to be roughly 4×10^{-6} cm/sec, or almost 100 times slower than the more permeable sands. Experience has shown that ground water flow is preferential towards the coarser more permeable sediments; therefore, any calculations towards future potential impacts of the landfill should use the more liberal, higher estimate of the hydraulic conductivity.

SITE WATER QUALITY

As stated earlier, two sampling runs were made to the SANCO landfill during September, 1984. Samples were delivered to RAI and subsequently analyzed. The results of these analyses are attached as Appendix D. They are also presented graphically in Figures 6-9 and some of the key constituents are summarized below in Table IV.

TABLE IV Water Quality Summary

Constituent*	Seep 1	Seep 2	101	102	103	104
Iron	8.6	0.01	6.1	73	0.02	0.12
Manganese	1.7	0.02	1.2	21	16	0.11
Chloride	17	12	37	19	32	6
Acetone	0	0	0	140	90	0
MEK	0	0	0	310	200	0
TOC	21	7	10	130	24	10

* All values represent dissolved concentrations in parts per million except Acetone and MEK in parts per billion.

The "upgradient" well, B-104, shows excellent background water quality as does Seep 2 located along the Ammonoosuc bank roughly 100 feet east of Seep 1. Seep 1 shows elevated iron concentrations as might be expected upon viewing the precipitate below the seep as does B-101. Neither of these two sampling points, however, show excessive levels of other leachate indicators. In contrast, elevated levels of most indicators do occur at wells B-102 and B-103, especially at B-102. Review of Figures 6-9 show the elevated concentrations in the vicinity of B-102 for all plotted constituents except chloride.

This observed bias of these constituents towards B-102 conflicts with the flownet prepared using the water table data collected (Figure 5) which indicates ground water flow moving predominantly to the NNE rather than due east to B-102. There appears to be only two explanations for this phenomenon. One possibility is that a lens of slowly permeable sediments underlies the landfill between the waste and the water table. (Lowest placement of waste reported to be elevation 1320 MSL). It is possible that such a layer would deflect the flow of the leachate generated by the fill to the south or east before reaching the water table and following the normal flow regime. However, based on earlier observations of the lack of lateral continuity to the substrata, this remains speculation.

Another possibility is that B-102 is the closest to the oldest placed waste and that the water borne contaminants derived from that waste appeared there first, leading to the apparent bias. The contours in Figures 6-9 are drawn using classical methods with no subjective interpretation regarding source area which also contributes to the asymmetric interpretation. This, along with the presence of coarser surface sediments in the area of B-102, is probably the more likely interpretation. It should be pointed out that the possible mounding described earlier would bend even more the contours in Figure 5 and result in more flowlines from the waste towards B-102.

Figure 6 and Table IV document the high iron observed at Seep 1. Unusual in this observation is the lack of elevated concentrations of other leachate indicators at Seep 1. Cursory analysis of the sub-surface samples and the extremely large difference between the "total" and "dissolved" ion concentrations (Appendix D) show the iron-rich nature of the local sediments. However, background dissolved iron concentrations at B-104 and nearby Seep 2 are extremely low (Table IV). It is possible that the reducing environment beneath the SANCO landfill may be responsible for mobilizing the sediment-bound iron for ground water transport to Seep 1. However, the proximity of "clean" Seep 2 (100 feet) at a distance 1200± feet downgradient from the landfill is difficult to explain. Additionally, sediments capable of transmitting water borne contaminants at the 300 feet/year rate necessary were not observed on-site, though off-site conditions may differ.

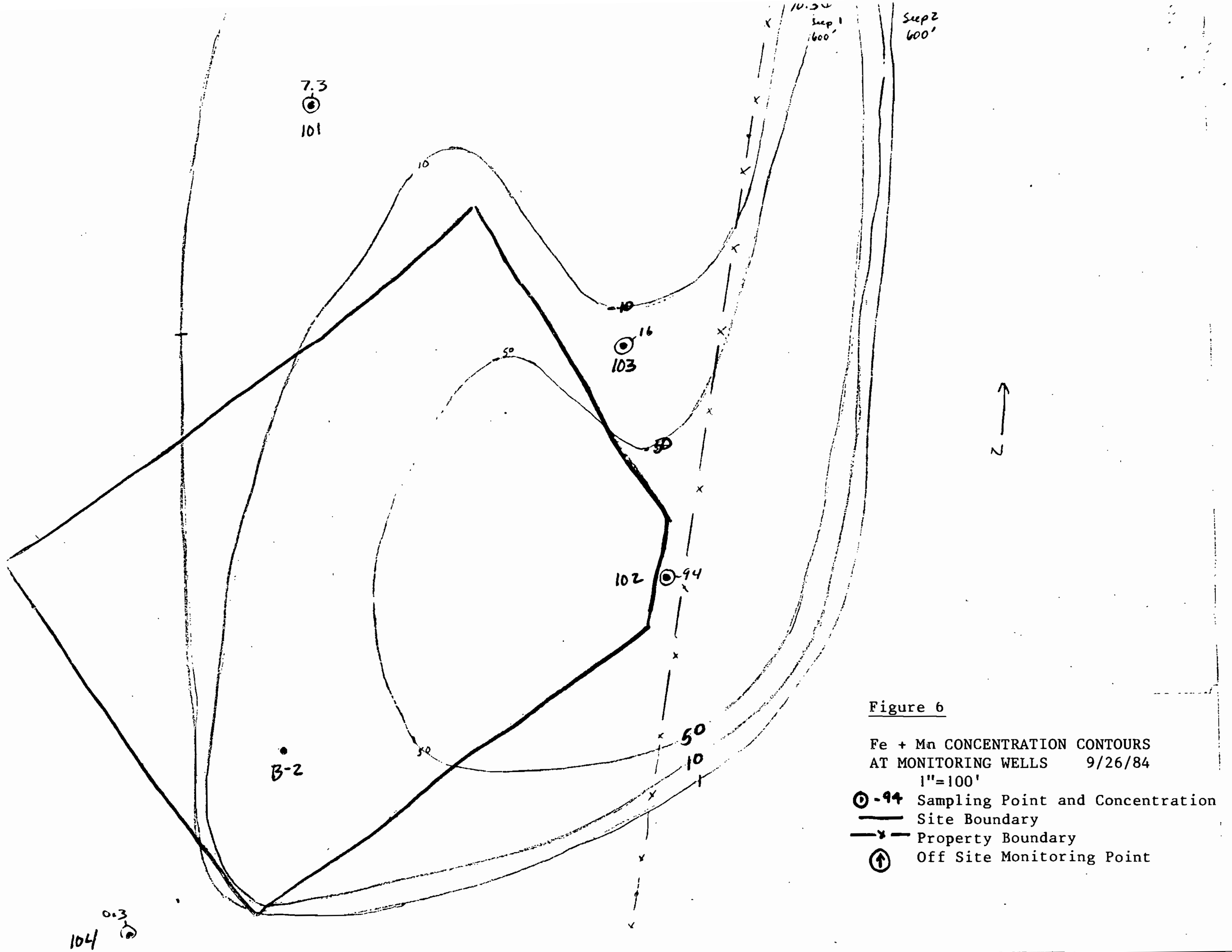


Figure 6

Fe + Mn CONCENTRATION CONTOURS
AT MONITORING WELLS 9/26/84
1"=100'

-94 Sampling Point and Concentration
Site Boundary
Property Boundary
Off Site Monitoring Point

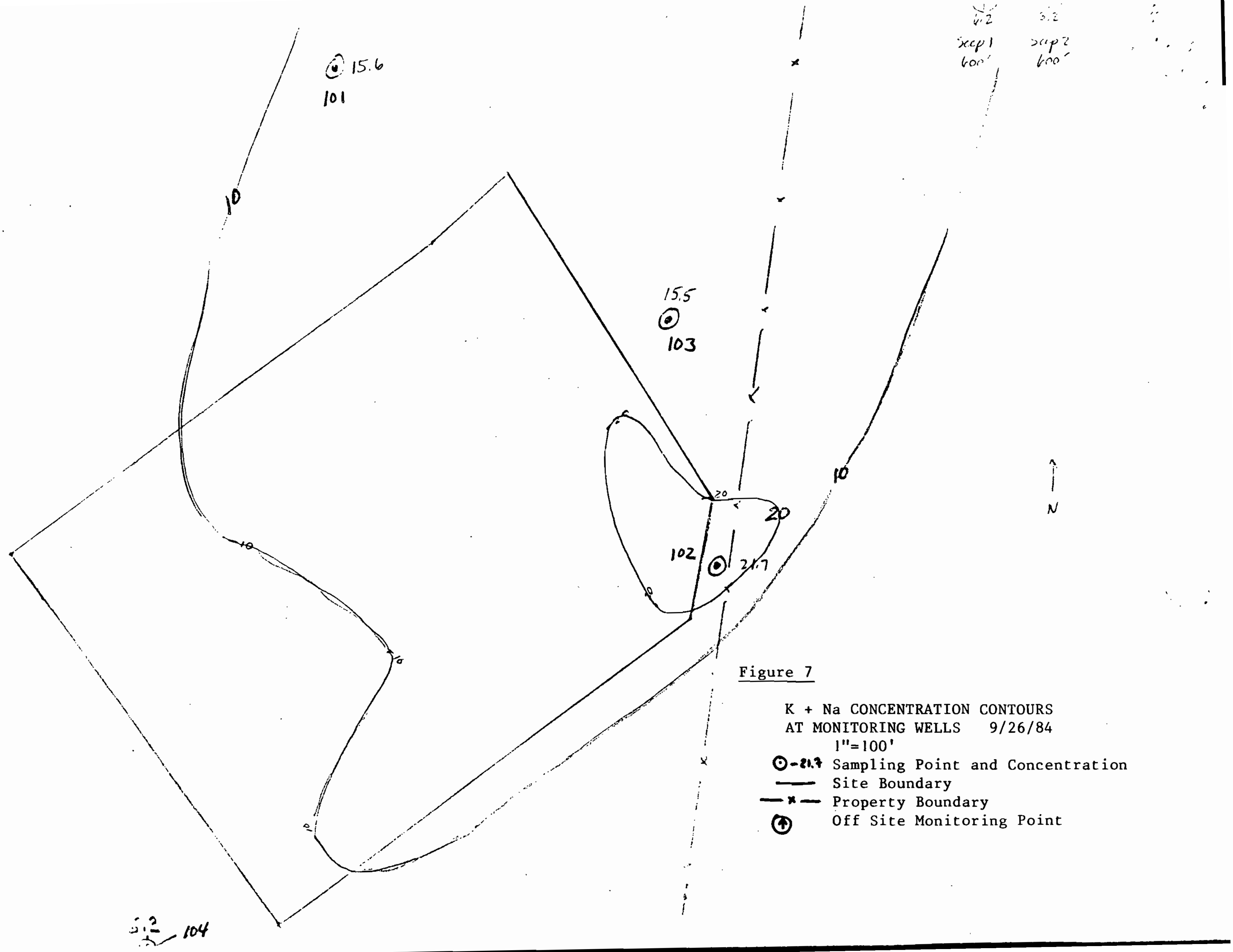


Figure 7

K + Na CONCENTRATION CONTOURS
AT MONITORING WELLS 9/26/84
1"=100'

-21.7 Sampling Point and Concentration
Site Boundary
Property Boundary
Off Site Monitoring Point

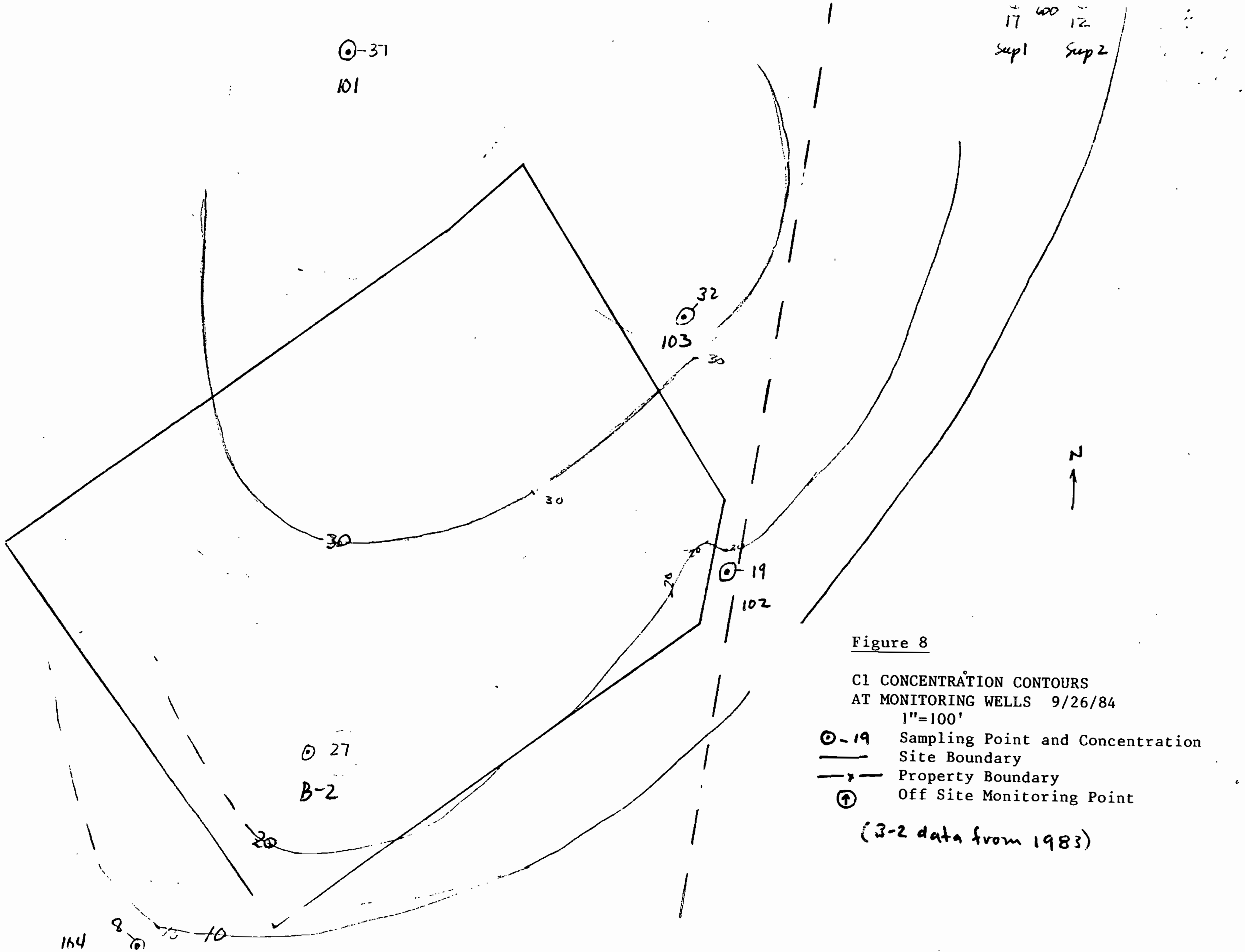


Figure 8

Cl CONCENTRATION CONTOURS
AT MONITORING WELLS 9/26/84
1"=100'

⊙- 19	Sampling Point and Concentration
——	Site Boundary
—x—	Property Boundary
⊕	Off Site Monitoring Point

(B-2 data from 1983)

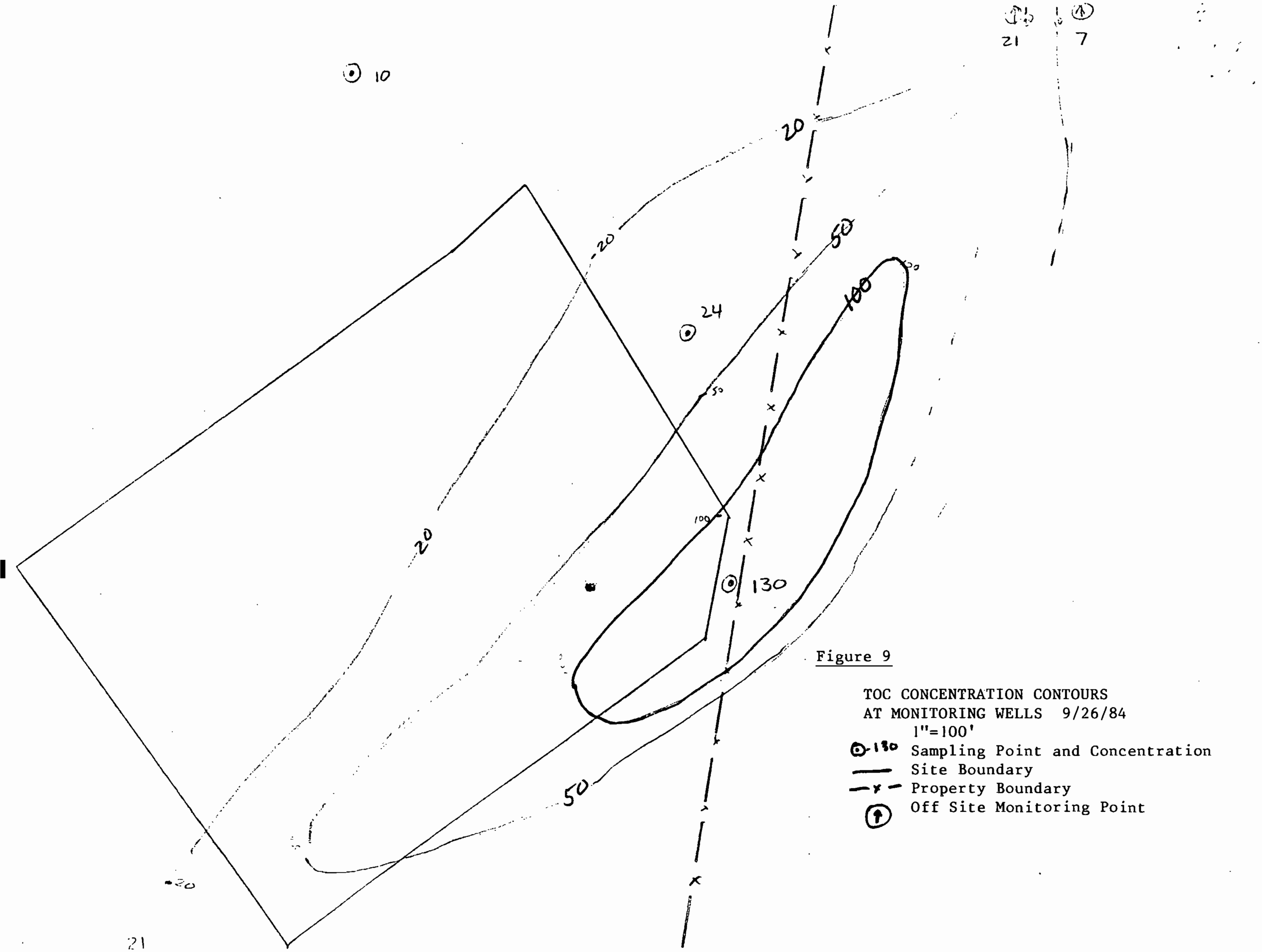


Figure 9

TOC CONCENTRATION CONTOURS
AT MONITORING WELLS 9/26/84
1"=100'

ANALYSIS

Based on the data presented above, it seems quite apparent that the SANCO landfill is impacting the ground water quality through the generation of leachate and development of reducing conditions beneath the site. Unfortunately, the most impacted well, B-102, lies in the most sensitive area, 25 feet from the abutters property line. Cursory observation of the flowlines in Figure 5 indicate that this degradation is most likely occurring off the property boundaries.

The ramifications of this impact are subject to judgement. Clearly, secondary drinking water standards are being violated in terms of iron and manganese concentrations. Additionally, volatile organics, varying from trace amounts to over 300 ppb are of concern. Fortunately, the organic substances are biodegradable and may possibly not travel significant distances off-site. The lack of measurable quantities of organics in the down-gradient seep may support this. Additionally, there are no known domestic water supplies down-gradient of the landfill, and Muchmore Road is serviced by the main municipal water line from Twin Mountain, making local on-site water supply unnecessary.

The occurrence of iron precipitate in the stream below Seep 1 creates an undesirable aesthetic effect. However, as stated above, the relationship of this occurrence to the SANCO site is tenuous in the face of the lack of other leachate indicator constituents and the proximity of the clean Seep 2. Clearly, further study is necessary to establish the source of this phenomenon.

CONCLUSIONS

1. The landfill site is located on a terrace of excessively deep, compacted silty fine-to-coarse sands.

2. The site is underlain by a dense sandy silt aquitard at an elevation approximately 1290 MSL.

3. The depth to ground water varies from 18 to 48 feet across the site and varies in elevation form 1310 to 1302 MSL.

4. The hydraulic gradient is quite flat (.01).

5. Ground water flow is predominantly to the NNE, except where locally deflected by possible mounding beneath the site.

6. The hydraulic conductivity of the most premeable unit varies from 5.7×10^{-4} cm/sec to 2.75×10^{-6} cm/sec.

7. Seepage rates in the sands are as high as 40 feet per year in preferential flow along coarser layers.

8. Elevated levels of leachate indicator constituents, particularly iron and manganese, are seen at all down-gradient monitoring wells.

9. Volatile organics, particularly MEK and acetone, are seen at the two closest monitoring wells, B-102 and B-103.

10. Ground water quality appears to be impacted off the SANCO property.

11. There is no known immediate threat to public health posed by the landfill operation.

RECOMMENDATIONS

1. This report be submitted to the BSWM as compliance with Sanco's well installation and hydrogeologic assessment requirement.

2. Perform another complete round of sampling and analysis in December, 1984, and offer to split the samples with the BSWM.

3. Commence quarterly/annual sampling and analysis program as follows: Beginning with an annual sampling in December 1984.
   Quarterly: All parameters as investigated in this report except VOA analysis

   Annually: VOA analysis by GCMS

4. Operate landfill with the highest level of management practice to minimize infiltration of surface water and further production of leachate.

APPENDIX I

PERTINENT CORRESPONDENCE

KIMBALL CHASE
company, inc.

Civil
Environmental
Engineers

40 Bridge Street
Portsmouth
New Hampshire 03801

603-431-2520

July 20, 1984

Mr. Thomas Sweeney
NH Bureau of Solid Waste Management
Dept. of Health and Welfare
Hazen Drive
Concord, New Hampshire 03301

Re: Sanco Landfill, Bethlehem, New Hampshire
Monitoring Wells 83-608

Dear Mr. Sweeney:

Please find enclosed three copies of the proposed scope of work for installation of groundwater monitoring wells at the Sanco Landfill in Bethlehem. On this project, we are working with Caswell, Eichler and Hill who are performing the required hydrogeological investigations. Enclosed also is CEH's letter of July 17, 1984 explaining the data reviewed and field work done in preparation of the proposed scope.

The proposed scope is intended to complete the hydrogeologic assessment of the site in accordance with the State's permit requirements and in a cost efficient manner. Preliminary investigations have resulted in proposed location of the upgradient well and probable locations of the downgradient wells. A sequence of downgradient well construction has been outlined to modify the placement of the second and/or third wells as may be appropriate with information gained in installing the first.

For expediency, we suggest that after the BSWM and the WSPCC have had the opportunity to review this material, that a meeting be scheduled in Bethlehem among all parties to finalize the scope, establish procedures for decision making during well construction, and make a field inspection of the proposed work. If such a meeting during the week of August 6 through 10 is possible, this would allow good progress on the project.

We will be in contact to verify this schedule. If there are any questions or comments, please do not hesitate to call.

Very truly yours,

KIMBALL CHASE COMPANY, INC.

Bill Straub

William A. Straub, P.E.

WAS:mrw
enclosures
cc: Roy Sanborn
David Hill, CEH

CEH Caswell, Eichler and Hill, Inc.
GEOLOGISTS AND HYDROLOGISTS
P.O. Box 4696
Portsmouth, N.H. 03801
Tel. 207-439-4853

July 17, 1984

Kimball Chase Company, Inc.
Bridge Street
Portsmouth, NH 03801

Attn: Mr. William A. Straub, Project Manager

Re: Sanco Landfill, Bethlehem, NH

Dear Bill:

In keeping with our contract of July 9, 1984 for professional services regarding the Sanco Landfill in Bethlehem, N.H., CEH has completed the following tasks:

1. Review existing data
2. Complete site visit
3. Perform site analysis
4. Prepare detailed scope of work

The results of the first three tasks are discussed in this letter. The scope of work is attached separately as requested.

The existing data review included both base line data and site-specific data. Base line data included 1939 soils mapping, 1984 soils mapping, 1976 water resource mapping, and 1978 aerial photography. All these sources showed the site to be in an area of excessively drained soils and moderate to high permeability. The site is located on a glacial terrace about 1500 feet south of the Ammonoosuc River at an elevation of roughly 180 feet above the river's surface.

These data are borne out by the site specific data which are made up of a series of four borings completed for the owner in 1976. However, these data do not show the site to be underlain by a ubiquitously well drained gravel, but rather show a wide variety of grain sizes from silt to boulders. Although some areas do exhibit coarse well-drained sediments, silty, sandy material currently being mined for cover material on-site has a tested repacked permeability of $3x10^{-6}$ cm/sec. This is a much lower permeability than would be estimated from cursory observation.

On June 28, 1984, a CEH geologist met with Mr. Sanborn in Bethlehem to tour the site. A basic overview of the history of the site was presented and reconnaissance geologic mapping of the site and its environs completed. Numerous observations of ground water (or the lack thereof) were made in excavations and the existing borings (two of which remain) across the site and on adjacent properties. We suggested that Mr. Sanborn have these points elevationally surveyed so that a preliminary water table map might be prepared. In a letter dated July 3, these data were delivered.

Based on the existing data, the site visit, and the elevational data, a cursory overview of ground water conditions at the site could be made. The water table is quite deep at the site as the water level was measured to be over twenty-four feet below ground surface in well #2 (see attached figure). (To assure that the well was not "plugged," the well was filled with clean water after measurement. The water level retreated quickly and was measured at the previous level within minutes.) The only other ground water noted on or about the site was in an eight-foot excavation approximately 300 feet south of well #2. Low dry points were also measured including the landfill pit, dry well #3, and the Tucker pit.

Based on these data as well as other geologic evidence and hydrologic knowledge, it can be concluded that the most likely direction of ground water flow from beneath the site is in a north-to-northeasterly direction towards the river. To that end, a monitoring well placement design has been proposed which will allow the most efficient placement of borings and will allow the on-site inspector to use the water levels in the finished borings to direct the placement of the next well more exactly.

The first monitoring well should be placed off the northeasterly trend of the existing data to create a more planar interpretation. We feel that a location approximately 165 feet north of the center of the northwest face is appropriate, as such a well would be necessary for either a northerly or northeasterly flow direction. The exact location of the other two down gradient wells is unknown at this time but will most likely be placed 165 feet from the toe of the proposed fill and separated by 300 foot intervals either side of the direct flowline from the center of the fill. The upgradient well will most likely be placed to the southwest in the vicinity of the eight-foot excavation mentioned above.

You will find attached the scope of work as well as rudimentary figures prepared to guide the uninitiated through the above discussion. If this material is in need of further clarification, please do not hestitate to call.

Sincerely,
CASWELL, EICHLER AND HILL, INC.

David B. Hill
Principal

Att.

PROPOSED SCOPE OF WORK
INSTALLATION OF MONITORING WELLS
AT THE SANCO LANDFILL
BETHLEHEM, NEW HAMPSHIRE

Based on preliminary evaluation of previous work completed at the site and reconnaissance geologic and hydrologic surveys, the following scope has been prepared for the installation of monitoring wells at the Sanco Landfill in Bethlehem, New Hampshire. This material is presented in response to a mandate issued by the New Hampshire Bureau of Solid Waste Management (BSWM) and is believed to be in keeping with their specific requests regarding this site as well as general requirements regarding all such work.

1. State Inspection. After the BSWM and New Hampshire Water Supply and Pollution Control Commission (WSPCC) have had adequate time to review and comment on this proposed scope of work, a meeting will be arranged between the owner (Sanco), the engineer (Kimball Chase Company), the hydrogeologists (Caswell, Eichler and Hill), and representatives of BSWM and WSPCC. For convenience, it is proposed that this meeting take place in the Sanco offices in Bethlehem. At the meeting, the final scope of work will be verified by all concerned. All parties will then visit the landfill site to concur on the proposed locations for the monitoring wells and finalize drilling and testing procedures.

2. Well Installation. The monitoring wells will be installed by a selected, qualified test driller under the supervision of CEH principals. It is anticipated that one upgradient well will be placed to the southwest of the site and 2-3 downgradient wells will be placed 165 feet to the north and northeast of the toe of the fill in the direction of the Ammonoosuc River (see accompanying figures). WSPCC regulations concerning compliance boundaries will be maintained. Sanco has permission from the abuttor, Harold Brown, to utilize a 500-foot buffer around the landfill site for the placement of these wells. However, the eastern property boundary of the site is only 75 feet from property owned by Tucker (see figure). If a monitoring well is required in this area, it must be placed 25 feet from the toe of the fill, or one third the distance to the compliance boundary.

   In keeping with WSPCC regulations all borings will be continued until solid bedrock is encountered or a proven aquiclude is identified. Although it is anticipated that all borings will be finished at the bedrock surface, if excessive depth to bedrock is encountered, only one boring will be advanced to bedrock while the rest will be finished just below the till surface believed to underlie the site gravels. It is hoped that a total of 200 linear feet of drilling will be adequate for the State's needs. Procedures for modifying the scope of work as approved by the State (for example, in regard to depth to bedrock) will be identified prior to well drilling. Split-spoon samples for geologic and sieve analysis will be taken at intervals specified by CEH and at each lithologic change. Sieve analyses will be performed on selected samples. Each hole will be logged by the driller and corrected by the observing geologist as necessary.

Falling-head permeability tests will be conducted in each stratum, in each of the boreholds. Both flush-bottom and open-hole techniques will be utilized and analyzed by classical methods such as Hvorslev. A well will then be constructed inside each hole using slotted PVC pipe with threaded couplings. The size of the finished wells may be two or more inches in diameter. The advantages and disadvantages of various well diameters in terms of sampling procedures shall be discussed with Sanco, and a selection made prior to installation. The well will be screened throughout the entire water column. The annular space around the slotted pipe will be backfilled with Ottawa sand and sealed above the water surface by bentonite.

A stabilization period (up to 1-2 weeks) is required to allow the water levels and water quality to equilibriate with the natural surroundings. Final elevations of water levels must be determined after that time. The elevations of the well heads must be surveyed for this purpose. It is anticipated that the most economical way to accomplish this would be for Sanco to have the well heads surveyed for elevation by local surveyors, and to measure the water levels for reporting to CEH. CEH will clearly identify the procedure to simply determine this data. pH and conductivity profiles will be conducted on the finished wells and samples taken for delivery to a qualified laboratory for analysis for Iron, Manganese, Chloride, and Volatile Organics. Organic analysis will be by GCMS (Gas-chromatograph-mass-spec).

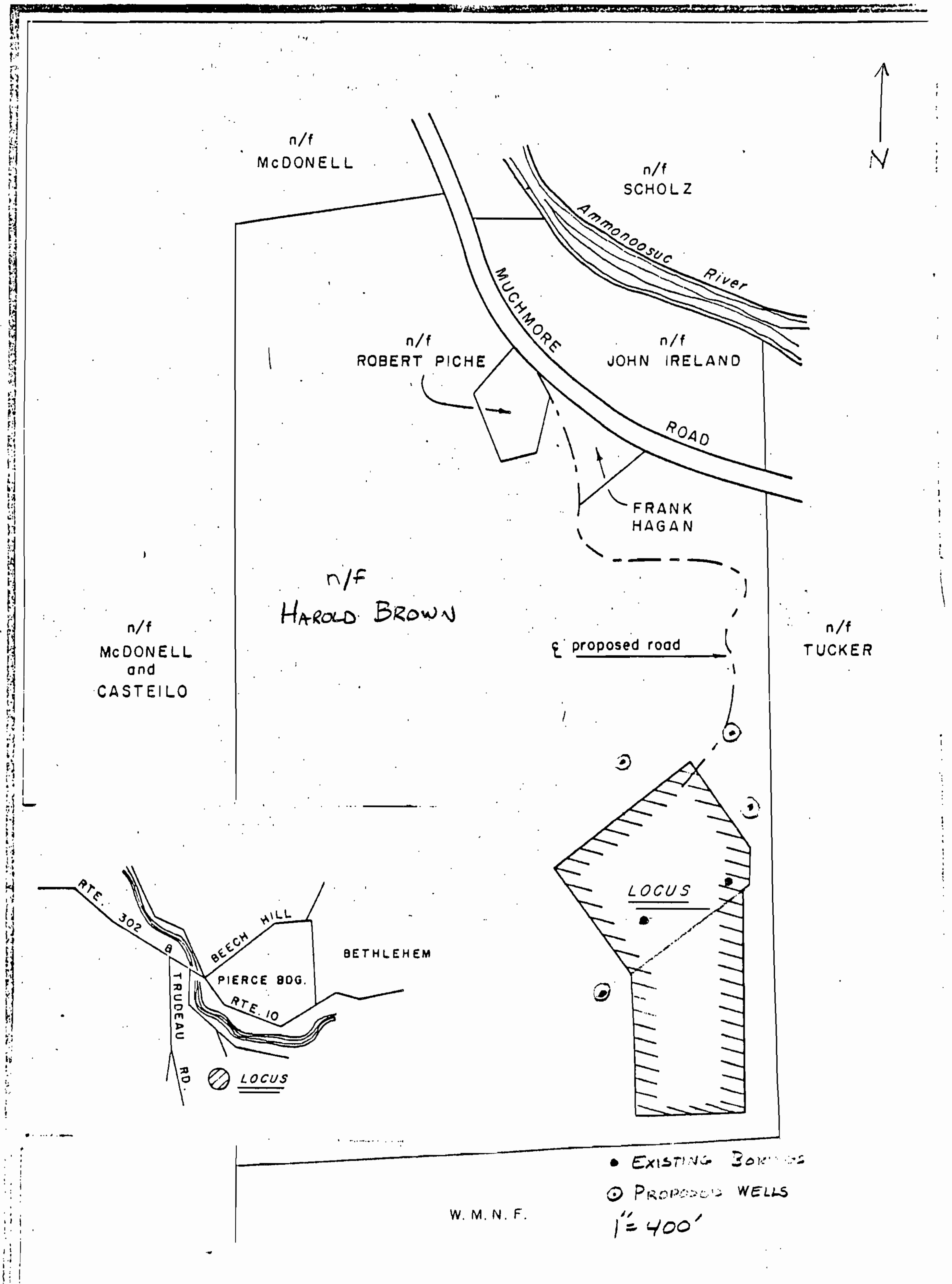
3. Data Reduction/Analysis. Collection and compilation of all necessary data for the preparation of the report.

4. Report Preparation. Prepare a report which describes the methods used and the results obtained. All pertinent and collected data will be included. Maps, figures and graphs will be developed as appropriate. In particular, the surficial geology and the hydrogeologic siting of the site will be described. Although final conclusions and recommendations concerning this site are in the jurisdiction of the State, a preliminary summary will be presented. The report will also clearly outline the procedures recommended for water quality sampling and analysis for the wells as a listing of recommended water quality parameters to be determined.

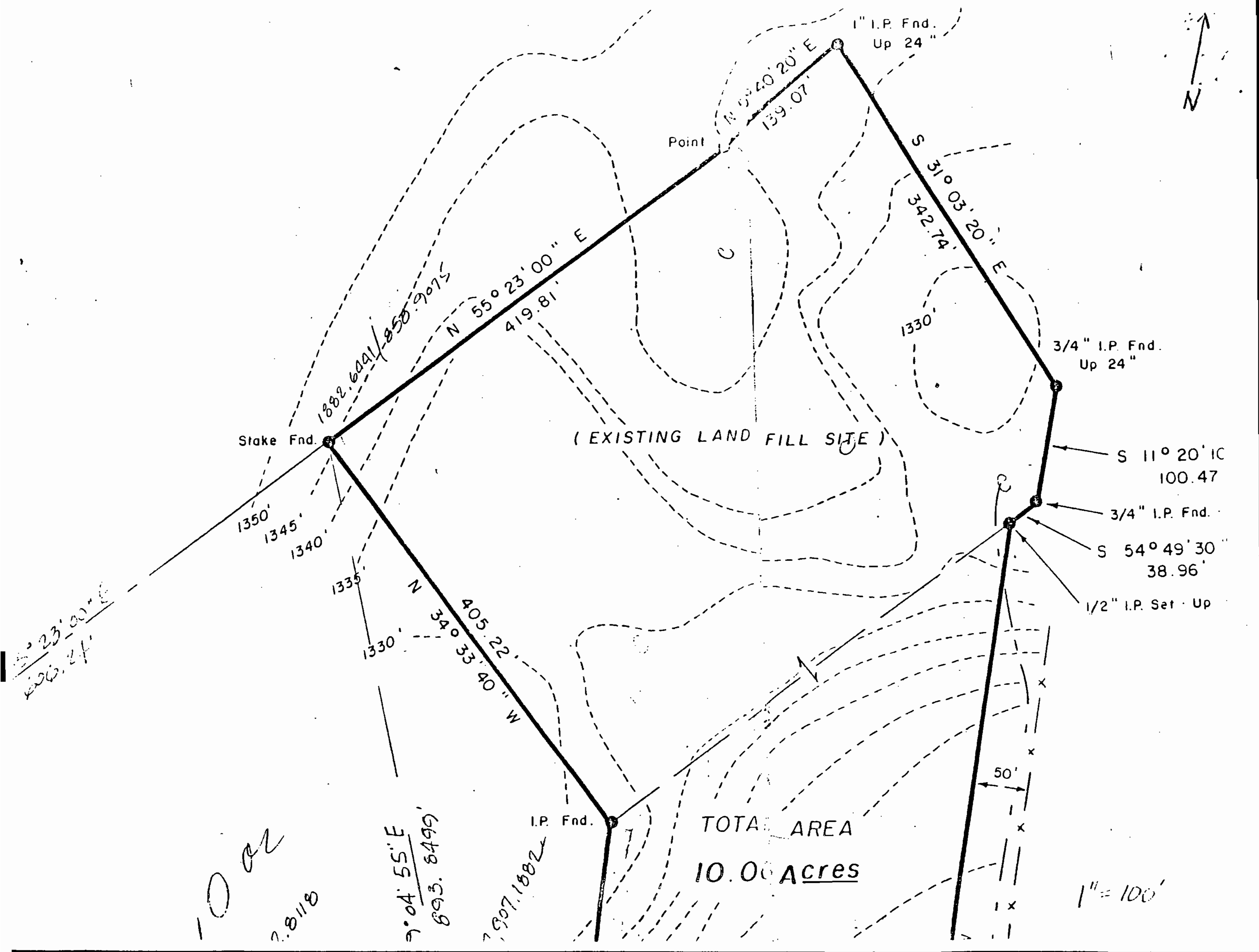
5. Final Meeting. If required or desired, a meeting in Portsmouth or Concord with all interested agencies and parties will be held at which time the results of the investigations project will be presented and discussed by Kimball Chase and CEH.

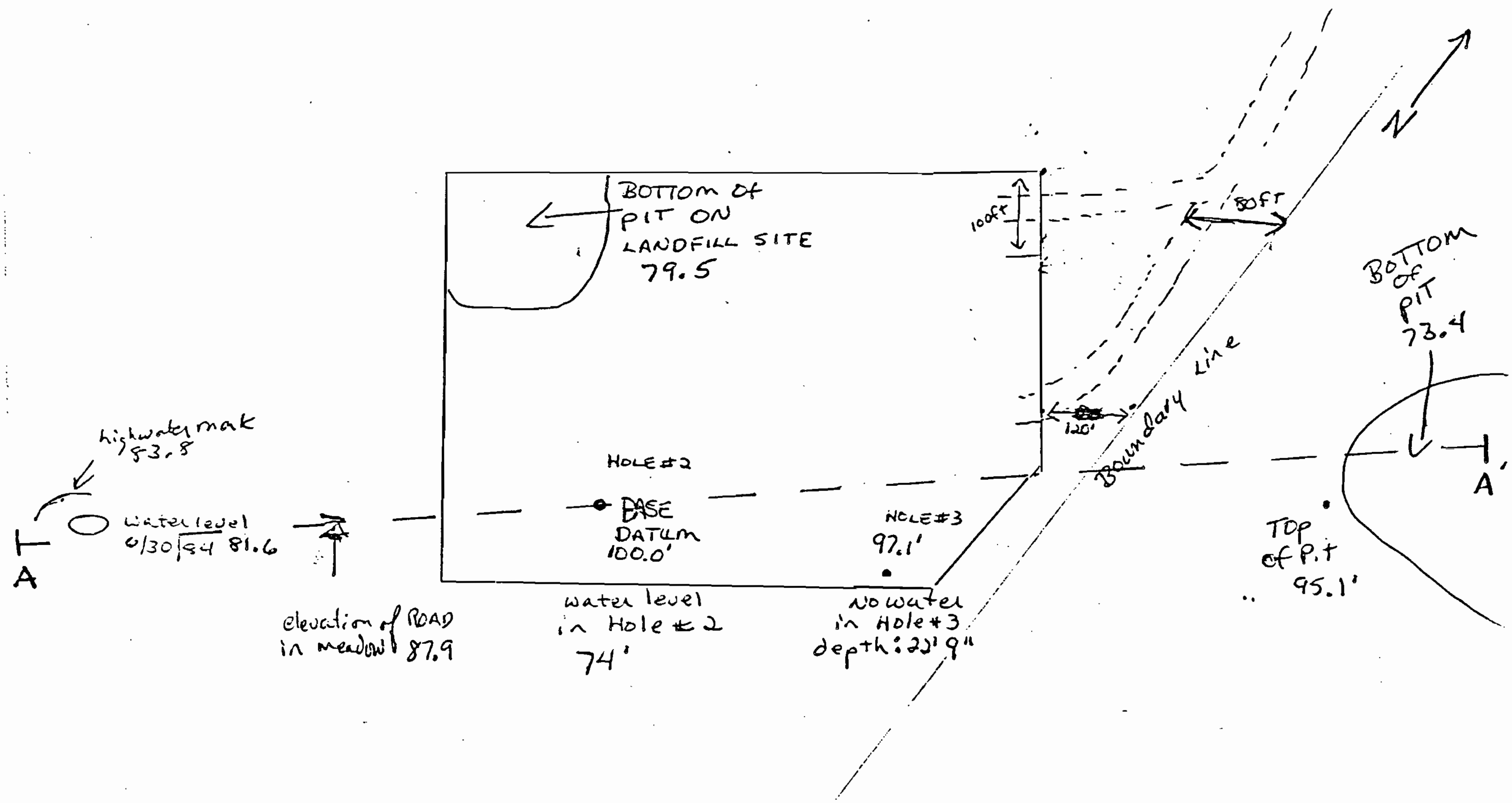
SCHEDULE

It is anticipated that Kimball Chase, CEH and selected subcontractors can complete the proposed scope of work in a period of ninety (90) days from authorization to proceed.



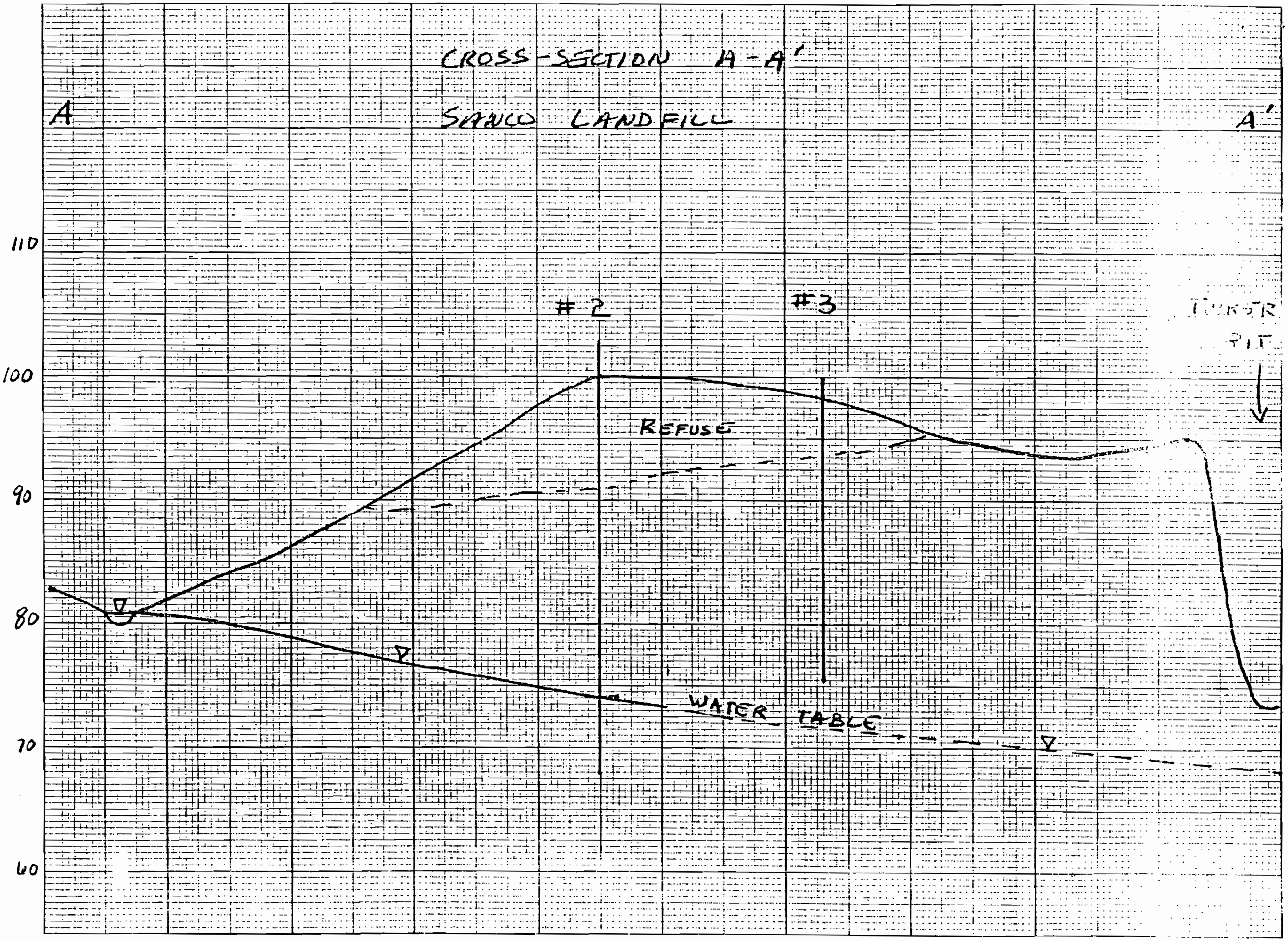
n/f
McDONELL
n/f
SCHOLZ
Ammonoosuc River
MUCHMORE ROAD
n/f
ROBERT PICHE
n/f
JOHN IRELAND
FRANK
HAGAN
n/f
HAROLD BROWN
n/f
McDONELL
and
CASTEILO
proposed road
n/f
TUCKER
LOCUS
RTE. 302
BEECH HILL
BETHLEHEM
PIERCE BDG.
RTE. 10
TRUDEAU RD.
LOCUS
W. M. N. F.
• EXISTING BORINGS
⊙ PROPOSED WELLS
1" = 400'


1" I.P. Fnd.
Up 24"
N
N 3°40'20" E
139.07'
Point
S 31°03'20" E
342.74'
N 55°23'00" E
419.81'
1882.6441
858.9075
1330'
3/4" I.P. Fnd.
Up 24"
Stake Fnd.
(EXISTING LAND FILL SITE)
S 11°20'10
100.47
1350'
1345'
1340'
3/4" I.P. Fnd.
S 54°49'30"
38.96'
1/2" I.P. Set · Up
1335'
N 34°33'40" W
405.22
1330'
50'
I.P. Fnd.
TOTAL AREA
10.00 Acres
1" = 100'
10 ac
893.8499
907.1882



Filling Hole #2 with water resulted in water going back to normal height within 60 seconds.

APPROXIMATE SCALE
1" = 130'


CROSS-SECTION A-A'
SANCO LANDFILL
A
A'
110
100
90
80
70
60
#2
#3
PIT
REFUSE
WATER TABLE

APPENDIX II

DRILLER'S LOGS

MAINE TEST BORINGS, INC. BREWER, MAINE 04412	CLIENT American Waste Disposal	SHEET 1 OF 2 HOLE NO. 101
DRILLER Ervin Giguere	PROJECT NAME Landfill wells	LINE & STATION
M.T.B. JOB NUMBER 84-157	LOCATION Bethlehem, New Hampshire	OFFSET

GROUND WATER OBSERVATIONS

AT ____ FT. AFTER ____ HOURS

AT ____ FT. AFTER ____ HOURS

	CASING	SAMPLER	CORE BARREL
TYPE	NW	SS	
SIZE I.D.	3"	1 3/8"	
HAMMER WT.	300	140	
HAMMER FALL	16"	30"	

DATE START 9-4-84 DATE FIN. 9-4-84

SURFACE ELEV. ____

GROUND WATER ELEV. ____

CASING BLOWS PER FOOT	SAMPLE NO.	O.D.	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	VANE READING	DEPTH	STRATUM DESCRIPTION
Probe											Brown gravelly silty fine sand w/cobbles
Augers											
"											
"											
"											
"	1D	2"	18"		6.5	51	41	35			
"											
"											
"											
"											
17	2D	2"	18"		11.5	20	30	37			
24											
37											
42											
56											
27	3D	2"	18"		16.5	61	41	39			
49											
53											
47											
46											
14	4D	2"	18"		21.5	41	39	40			
15											
16											
17											
16											
14	5D	2"	18"		26.5	50	51	94			
17											
19											
24											
27											
12	6D	2"	18"		31.5	59	72	152			
14											
21											
26											
31										35.5	
17	7D	2"	18"		36.5	49	79	111			Brown gravelly silty medium to coarse sand.
21											
19											
18											
20											

SAMPLES

D = Splite Spoon

C = 2" Shelby Tube

U = 3½" Shelby Tube

SOIL CLASSIFIED BY:

- [X] Driller - Visually
- [ ] Soil Technican - Visually
- [ ] Laboratory Tests

REMARKS:

HOLE NO. 101

MTB-14

MAINE TEST BORINGS, INC. BREWER, MAINE 04412	CLIENT American Waste Disposal	SHEET 2 OF 2 HOLE NO. 101
DRILLER Ervin Giguere	PROJECT NAME Landfill wells	LINE & STATION
M.T.B. JOB NUMBER 84-157	LOCATION Bethleham, New Hampshire	OFFSET

GROUND WATER OBSERVATIONS

AT ____ FT. AFTER ____ HOURS

AT ____ FT. AFTER ____ HOURS

	CASING	SAMPLER	CORE BARREL
TYPE	NW	SS	
SIZE I.D.	3"	1 3/8"	
HAMMER WT.	300	140	
HAMMER FALL	16"	30"	

DATE START 9-4-84 DATE FIN. 9-4-84

SURFACE ELEV. ____

GROUND WATER ELEV. ____

CASING BLOWS PER FOOT	SAMPLE NO.	O.D.	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	VANE READING	DEPTH	STRATUM DESCRIPTION
23	8D	2"	18"		41.5	81	92	113			Brown gravelly silty medium to coarse sand.
27											
41											
89											
143											
16	9D	2"	18"		46.5	61	92	142			
26											
31											
42											
86											
16	10D	2"	18"		51.5	59	79	101			
18											
24											
33											
69											
17	11D	2"	18"		56.5	62	100	142			
19											
21										58.0	
26											Brown, gray sandy silt w/fine sand layers.
39											
	12D	2"	18"		61.5	47	116	137			
	13D	2"	18"		66.5	43	68	106			
	14D	2"	18"		71.5	63	114	143		71.5	
											Bottom of boring @ 71.5' Installed well.

SAMPLES

D = Splite Spoon

C = 2" Shelby Tube

U = 3½" Shelby Tube

SOIL CLASSIFIED BY:

- [X] Driller - Visually
- [ ] Soil Technican - Visually
- [ ] Laboratory Tests

REMARKS:

HOLE NO. 101

MTB-14

MAINE TEST BORINGS, INC. BREWER, MAINE 04412	CLIENT: American Waste Disposal	SHEET 1 OF 2 HOLE NO. 102
DRILLER: Ervin Giguere	PROJECT NAME: Landfill wells	LINE & STATION
M.T.B. JOB NUMBER: 84-157	LOCATION: Bethlehem, New Hampshire	OFFSET

GROUND WATER OBSERVATIONS

AT ____ FT. AFTER ____ HOURS

AT ____ FT. AFTER ____ HOURS

	CASING	SAMPLER	CORE BARREL
TYPE	NW	SS	
SIZE I.D.	3"	1 3/8"	
HAMMER WT.	300	140	
HAMMER FALL	16"	30"	

DATE START 9-6-84 DATE FIN. 9-10-84

SURFACE ELEV. ____

GROUND WATER ELEV. ____

CASING BLOWS PER FOOT	SAMPLE NO.	O.D.	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	VANE READING	DEPTH	STRATUM DESCRIPTION
Probe											Brown silty fine sand.
Auger											
"										3.0	
"											Brown gravelly medium to coarse sand.
"											
"	1D	2"	18"		6.5	6	10	19			
"											
"											
"											
"	2D	2"	6"		10.5	100	+			10.0	
"											
"											Brown gravelly medium to coarse sand w/ cobbles.
"											
"											
"											
"	3D	2"	18"		16.5	26	31	30			
"											
"											
"											
"											
17	4D	2"	18"		21.5	89	110	132			
32											
47											
52											
59											
16	5D	2"	18"		26.5	55	68	74			
12											
10											
9											
10											
11	6D	2"	18"		31.5	23	37	39			
10											
9											
10											
8											
11	7D	2"	18"		36.5	37	53	89			
12											
14										38.0	
17											
23											

SAMPLES

D = Splite Spoon

C = 2" Shelby Tube

U = 3½" Shelby Tube

SOIL CLASSIFIED BY:

- [x] Driller - Visually
- [ ] Soil Technican - Visually
- [ ] Laboratory Tests

REMARKS:

HOLE NO. 102

MAINE TEST BORINGS, INC. BREWER, MAINE 04412	CLIENT American Waste Disposal	SHEET 2 OF 2 HOLE NO. 102
DRILLER Ervin Giguere	PROJECT NAME Landfill wells	LINE & STATION
M.T.B. JOB NUMBER 84-157	LOCATION Bethlemen, New Hampshire	OFFSET

GROUND WATER OBSERVATIONS

AT ______ FT. AFTER ______ HOURS

AT ______ FT. AFTER ______ HOURS

	CASING	SAMPLER	CORE BARREL
TYPE	NW	SS	
SIZE I.D.	4"	1 3/8"	
HAMMER WT.	300	140	
HAMMER FALL	16"	30"	

DATE START 9-6-84 DATE FIN. 9-10-84

SURFACE ELEV. ______

GROUND WATER ELEV. ______

CASING BLOWS PER FOOT	SAMPLE NO.	O.D.	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	VANE READING	DEPTH	STRATUM DESCRIPTION
16	8D	2"	18"		41.5	22	37	39			Brown sandy silt w/trace of gravel.
17											
16											
18											
12										45.0	
23	9D	2"	18"		46.5	47	60	78			Gray gravelly sandy silt.
26											
27											
29											
12											
23	10D	2"	18"		51.5	46	86	97			
26											
27											
29											
31											
29	11D	2"	12"		56.0	157	225				
33										57.0	
42											Gray sandy silt w/trace of gravel.
51											
56											
72	12D	2"	12"		61.0	113	200			61.0	
108											
273											
496											
637											Bottom of boring @ 61.0' Installed well.

SAMPLES

D = Splite Spoon

C = 2" Shelby Tube

U = 3½" Shelby Tube

SOIL CLASSIFIED BY:

XX Driller - Visually

☐ Soil Technican - Visually

☐ Laboratory Tests

REMARKS:

HOLE NO. 102

MTB-14

MAINE TEST BORINGS, INC. BREWER, MAINE 04412	CLIENT: American Waste Disposal	SHEET 1 OF 2 HOLE NO. 103
DRILLER: Ervin Giguere	PROJECT NAME: Landfill wells.	LINE & STATION
M.T.B. JOB NUMBER: 84-157	LOCATION: Bethlehem, New Hampshire	OFFSET

GROUND WATER OBSERVATIONS

AT ______ FT. AFTER ______ HOURS

AT ______ FT. AFTER ______ HOURS

	CASING	SAMPLER	CORE BARREL
TYPE	NW	SS	
SIZE I.D.	3"	1 3/8"	
HAMMER WT.	300	140	
HAMMER FALL	16"	30"	

DATE START 9-10-84 DATE FIN. 9-11-84

SURFACE ELEV. ______

GROUND WATER ELEV. ______

CASING BLOWS PER FOOT	SAMPLE NO.	O.D.	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	VANE READING	DEPTH	STRATUM DESCRIPTION
Probe											
Auger											Brown gravelly sandy silt w/cobbles & boulders.
"											
"											
"											
"	1D	2"	18"		6.5	30	49	48			
"											
"										8.0	
"											
"											Brown gravelly fine to coarse sand w/ cobbles.
17	2D	2"	18"		11.5	57	78	110			
27											
34											
51											
63											
17	3D	2"	18"		16.5	79	56	71			
14											
14											
17											
21											
12	4D	2"	18"		21.5	39	51	63			
12											
11											
13											
17											
11	5D	2"	18"		26.5	47	81	110			
21											
12											
13											
15											
13	6D	2"	18"		31.5	62	119	137			
16											
17											
16											
17											
19	7D	2"	18"		36.5	37	53	96			
16											
18										38.0	
19											
19											

SAMPLES
D = Splite Spoon
C = 2" Shelby Tube
U = 3½" Shelby Tube

SOIL CLASSIFIED BY:
[XX] Driller - Visually
[ ] Soil Technican - Visually
[ ] Laboratory Tests

REMARKS:

HOLE NO. 103

MTB-14

MAINE TEST BORINGS, INC. BREWER, MAINE 04412	CLIENT: American Waste Disposal	SHEET 2 OF 2 HOLE NO. 103
DRILLER: Ervin Giguere	PROJECT NAME: Landfill wells.	LINE & STATION
M.T.B. JOB NUMBER: 84-157	LOCATION: Bethlehem, New Hampshire	OFFSET

GROUND WATER OBSERVATIONS

AT ____ FT. AFTER ____ HOURS

AT ____ FT. AFTER ____ HOURS

	CASING	SAMPLER	CORE BARREL
TYPE	NW	SS	
SIZE I.D.	3"	1 3/8"	
HAMMER WT.	~~300~~	~~140~~	
HAMMER FALL	16"	30"	

DATE START 9-10-84 DATE FIN. 9-11-84

SURFACE ELEV. ____

GROUND WATER ELEV. ____

CASING BLOWS PER FOOT	SAMPLE NO.	O.D.	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	VANE READING	DEPTH	STRATUM DESCRIPTION
16	8D	2"	18"		41.5	21	22	28			Brown gravelly sandy silt.
17											
19											
20											
21											
	9D	2"	18"		46.5	22	29	51		47.0	
											Refusal @ 47.0' Installed well.

SAMPLES

D = Splite Spoon

C = 2" Shelby Tube

U = 3½" Shelby Tube

SOIL CLASSIFIED BY:

- [x] Driller - Visually
- [ ] Soil Technican - Visually
- [ ] Laboratory Tests

REMARKS:

HOLE NO. 103

MTB-14

MAINE TEST BORINGS, INC.
BREWER, MAINE 04412

CLIENT: American Waste Disposal

SHEET 1 OF 1
HOLE NO. 104

DRILLER: Ervin Giguere

PROJECT NAME: Landfill wells.

LINE & STATION:

M.T.B. JOB NUMBER: 84-157

LOCATION: Bethlehem, New Hampshire

OFFSET:

GROUND WATER OBSERVATIONS

AT ____ FT. AFTER ____ HOURS

AT ____ FT. AFTER ____ HOURS

	CASING	SAMPLER	CORE BARREL
TYPE	NW	SS	
SIZE I.D.	3"	1 3/8"	
HAMMER WT.	300	140	
HAMMER FALL	16"	30"	

DATE START 9-12-84 DATE FIN. 9-12-84

SURFACE ELEV. ____

GROUND WATER ELEV. ____

CASING BLOWS PER FOOT	SAMPLE NO.	O.D.	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	VANE READING	DEPTH	STRATUM DESCRIPTION
Probe											Brown fine to medium sand w/cobbles.
Auger											
"											
"											
"											
12	1D	2"	18"		6.5	16	22	49			
17										7.0	
47											Brown fine sandy silt.
56											
93											
12	2D	2"	18"		11.5	50	48	53			
14											
13											
17											
21											
17	3D	2"	18"		16.5	18	28	50		16.0	
19											Brown gravelly fine to medium sand.
23											
27											
31											
17	4D	2"	18"		21.5	28	29	32			
19											
21											
31											
33											
21	5D	2"	18"		26.5	27	27	30			
27											
33											
39											
30											
	6D	2"	18"		31.5	31	25	31			
										34.0	
											Refusal @ 34.0'
											Installed well.

SAMPLES
D = Splite Spoon
C = 2" Shelby Tube
U = 3½" Shelby Tube

SOIL CLASSIFIED BY:
- [x] Driller - Visually
- [ ] Soil Technican - Visually
- [ ] Laboratory Tests

REMARKS:

HOLE NO. 104

MTB-14

Soils Engineering Inc.

Main St. Charlestown, N. H. 03603

SHEET 1 OF 1	
DATE	6/8/76
HOLE NO.	B-1
LINE & STA.	
OFFSET	

TO Raymond Sanborn ADDRESS Bethlehem, N.H.

PROJECT NAME Proposed Sanitary Land Fill LOCATION Bethlehem, N.H.

REPORT SENT TO Mr. Raymond Sanborn PROJ. NO.

SAMPLE SENT TO Concord, N.H. OUR JOB NO. 359-76

GROUND WATER OBSERVATIONS

At Dry at .... Hours

At .... at .... Hours

	CASING	SAMPLER	CORE BAR.
Type	Auger 4"	2"	
Size I. D.		1½"	
Hammer Wt.		140#	BIT
Hammer Fall		30"	

SURFACE ELEV.
DATE STARTED 6/8/76
DATE COMPL. 6/8/76
BORING FOREMAN John Kennedy
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From	Sample Depths To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
									12"	Loose brown topsoil			
										Dense brown fine sand, tracksilt			
'		5'	6'3"	SP	13	22	18/3'				1	15"	15"
									6'3"				
										Dense brown gravel many cobbles & boulders			
0'		10'	10'6"	SP	22	Stone					2	7"	
									13'				
										Boulders			
										3 Attempts made			
										Note: Dense layers down to 7½' on 2nd hole. 10' on 3rd.			

GROUND SURFACE TO 13' USED CASING: THEN

140 lb. Wt. x 30" fall on 2" O. D. Sampler

Sample Type
D—Dry C—Cored W—Washed
UP—Undisturbed Piston
TP—Test Pit A—Auger V—Vane Test
UT—Undisturbed Thinwall

Proportions Used		
trace	0 to 10%	
little	10 to 20%	
some	20 to 35%	
and	35 to 50%	

Cohesionless Density	
0-10	Loose
10-30	Med. Dense
30-50	Dense
50 +	Very Dense

Cohesive Consistency	
0-4	Soft
4-8	M/Stiff
8-15	Stiff
15-30	V-Stiff
30 +	Hard

SUMMARY
Earth Boring 13'
Rock Coring
Samples 2

HOLE NO. B-1

Soils Engineering Inc.

Main St. Charlestown, N. H. 03603

SHEET ... OF ...
DATE 6/9/76
HOLE NO. B-2
LINE & STA.
OFFSET

TO Raymond Sanborn ADDRESS Bethlehem, New Hampshire
PROJECT NAME Prop. Sanitary Land Fill LOCATION Bethlehem, N.H.
REPORT SENT TO Mr. Raymond Sanborn PROJ. NO.
SAMPLE SENT TO Concord, N.H. OUR JOB NO. 359-76

GROUND WATER OBSERVATIONS
At 29' Immediately Hours
At 20½' at 36 Hours
22' on 6/19/76

	CASING	SAMPLER	CORE BAR.
Type	4" Auger	2"	
Size I. D.		1⅜"	
Hammer Wt.		140#	BIT
Hammer Fall		30"	

SURFACE ELEV.
DATE STARTED 6/9/76
DATE COMPL. 6/9/76
BORING FOREMAN M. Domingue
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From — To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	Sample No.	Pen	Rec.
								8"	Topsoil			
								4'	M/dense brown sand			
5'		5' 6'	SP	27	50/2"					1		
								11½'	Dense brown gravel w/cobbles & boulders			
10'												
15'		15' 16'	SP	19	51				Dense grey silty sand, trace of gravel, occasional Bldr	2	12"	10"
							∇	19'	water			
20'												
25'		25' 26½'	SP	9	20	36			M/dense to dense grey coarse sand, trace of gravel	3	18"	18"
30'								30'				
									No ledge to depth			
									Set 32' PVC Pipe for Water Observation			

GROUND SURFACE TO 30' USED CASING: THEN
140 lb. Wt. x 30" fall on 2" O. D. Sampler

Sample Type
D—Dry C—Cored W—Washed
UP—Undisturbed Piston
TP—Test Pit A—Auger V—Vane Test
UT—Undisturbed Thinwall

Proportions Used			
trace	0	to	10%
little	10	to	20%
some	20	to	35%
and	35	to	50%

Cohesionless Density	
0-10	Loose
10-30	Med. Dense
30-50	Dense
50 +	Very Dense

Cohesive Consistency		
0-4	Soft	30 + Hard
4-8	M/Stiff	
8-15	Stiff	
15-30	V-Stiff	

SUMMARY
Earth Boring 30'
Rock Coring
Samples 3

HOLE NO. B-2

Soils Engineering Inc.

Main St. Charlestown, N. H. 03603

SHEET 1 OF 1
DATE 6/9/76
HOLE NO. B-3
LINE & STA.
OFFSET

TO Raymond Sanborn ADDRESS Bethlehem, NEw Hampshire
PROJECT NAME Prop. Sanitary Land Fill LOCATION Bethlehem, N.H.
REPORT SENT TO Mr. Raymond Sanborn PROJ. NO.
SAMPLE SENT TO Concord, N.H. OUR JOB NO. 359-76

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At .... at .... Hours	Type	Auger 4"	2"	
	Size I. D.		1½"	
At Dry at 3 Hours 6/19/76	Hammer Wt.		140#	BIT
	Hammer Fall		30"	

SURFACE ELEV.
DATE STARTED 6/9/76
DATE COMPL. 6/19/76
BORING FOREMAN M. Domingue
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From	To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc	SAMPLE No.	Pen	Rec.
									3"	Topsoil			
								MOIST	2½'	Loose reddish silty sand			
										M/dense grey coarse sand			
5'		5'	6½'	SP	8	13	15		5½'		1	18"	18"
										M/dense to dense grey coarse sand, gravel, occasional cobble			
10'		10'	11'	SP	12	31	Ref.		11'		2	12"	10"
									13'	Boulders			
15'		15'	16'	SP	30	32			17'	Dense light brown coarse sand	3	12"	12"
20'		20'	20½'	SP	32	Refusal				Dense grey silty sand, occasional cobble	4	6"	6"
25'		25'	25½'	SP	32	64	--	wet			5	12"	
30'		30'	31'	SP	38	36	--				6	12	12
35'		No Sample							36'		No Sample		
										No ledge to depth			
										Set 29' PVC for Water Observation			

GROUND SURFACE TO 36' USED CASING THEN
140 lb. Wt. x 30" fall on 2" O. D. Sampler

Sample Type
D—Dry C—Cored W—Washed
UP—Undisturbed Piston
TP—Test Pit A—Auger V—Vane Test
UT—Undisturbed Thinwall

Proportions Used			
trace	0	to	10%
little	10	to	20%
some	20	to	35%
and	35	to	50%

Cohesionless Density	
0-10	Loose
10-30	Med. Dense
30-50	Dense
50 -	Very Dense

Cohesive Consistency			
0-4	Soft	30 -	Hard
4-8	M/Stiff		
8-15	Stiff		
15-30	V-Stiff		

SUMMARY
Earth Boring 36'
Rock Coring
Samples 6

HOLE NO. B-3

Soils Engineering Inc.
Main St. Charlestown, N. H. 03603

SHEET 1 OF 1
DATE 6/19/76
HOLE NO. B-4
LINE & STA.
OFFSET

TO Raymond Sanborn ADDRESS Bethlehem, N.H.
PROJECT NAME Prop. Sanitary Land Fill LOCATION Bethlehem, N.H.
REPORT SENT TO Mr. Raymond Sanborn PROJ. NO.
SAMPLE SENT TO Concord, N.H. OUR JOB NO. 359-76

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR
At Dry at 1 Hours	Type	4" Auger	2"	
	Size I. D.		1½"	
	Hammer Wt.		140#	BIT
At at Hours	Hammer Fall		30"	

SURFACE ELEV.
DATE STARTED 6/19/76
DATE COMPL. 6/19/76
BORING FOREMAN J. Kennedy
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From — To	Type of Sample	Blows per 6" on Sampler From 0-6	6-12	To 12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time seams and etc.	SAMPLE No.	Pen	Rec.
								6"	Brown topsoil			
									Med. dense fine sand, trace silt			
5'		5' 6½'	SP	13	50/5"			5'		1	12"	12"
									M/dense brown silty gravel some cobbles			
								8'9"				
10		10' -	SP	Boulder						2	Boulder	
									M/dense brown silty sand			
15'		15' 16'	SP	18	28	--				3	12"	12"
20'												
								22'6"				
									M/dense brown silty gravel many cobbles			
25'				Boulder						No Sample		
							wet	28'				
									Dense brown silty sand, trace of gravel			
30'										4	12"	12"
33'								33'				
									No ledge to depth			
									Set 26' PVC Pipe cobble closed hole @ 26'			

GROUND SURFACE TO 33' USED CASING: THEN
140 lb. Wt. x 30" fall on 2" O. D. Sampler

Sample Type
D—Dry C—Cored W—Washed
UP—Undisturbed Piston
TP—Test Pit A—Auger V—Vane Test
UT—Undisturbed Thinwall

Proportions Used		
trace	0 to 10%	
little	10 to 20%	
some	20 to 35%	
and	35 to 50%	

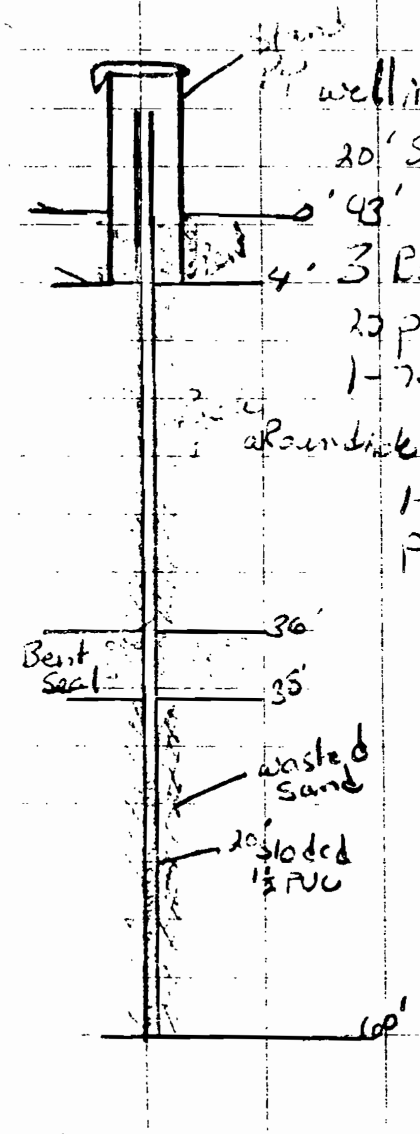
Cohesionless Density	
0-10	Loose
10-30	Med. Dense
30-50	Dense
50 +	Very Dense

Cohesive Consistency	
0-4	Soft
4-8	M/Stiff
8-15	Stiff
15-30	V Stiff
30 +	Hard

SUMMARY
Earth Boring 33'
Rock Coring
Samples 4

HOLE NO. B-4

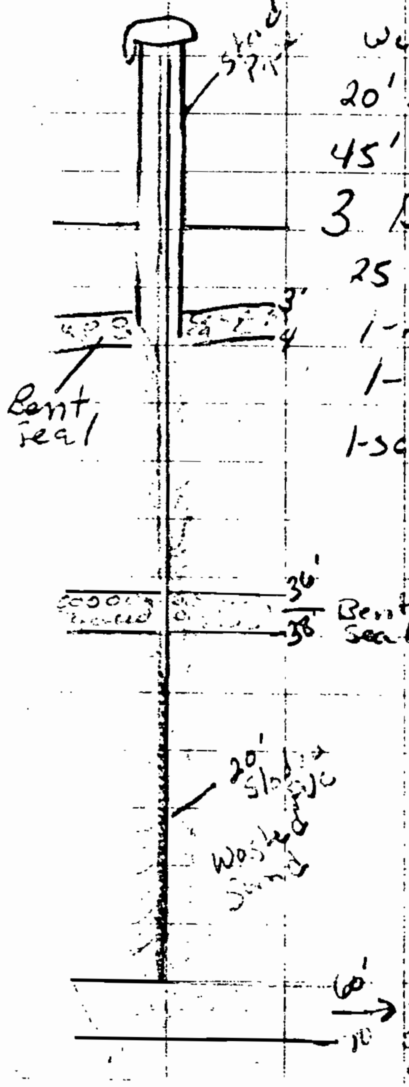
B-102 well Installation 9/10/84



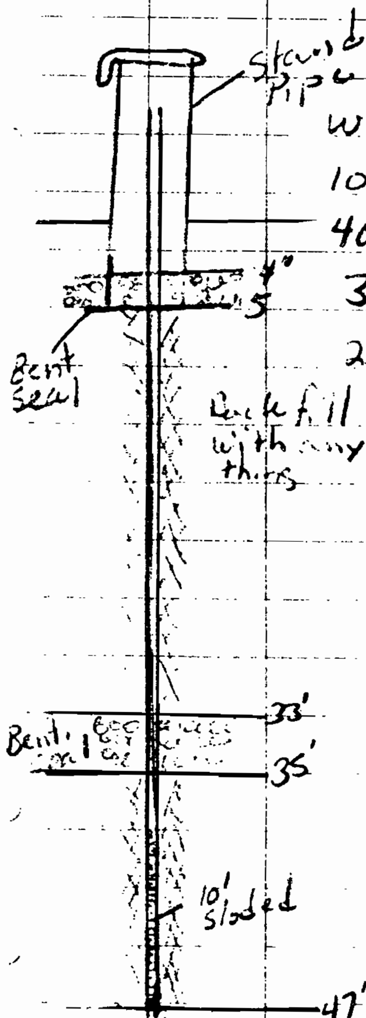
well Material
20' Sloded 1½ PVC
43' Res
3 Bag Sand 40 pound
20 pound Bent
1- 2-2½ Stand Pipe
around stick 1-locking cap
1-Screw cap Bottom PVC

9/5/84 well Installation 101

Set well at 60'
well Materials
20' Sloded 1½" PVC
45' Res " "
3 Bag Sand
25 Pound Bent
1-2-2½ Stand Pipe
1- locking cap
1-screw Plug PVC

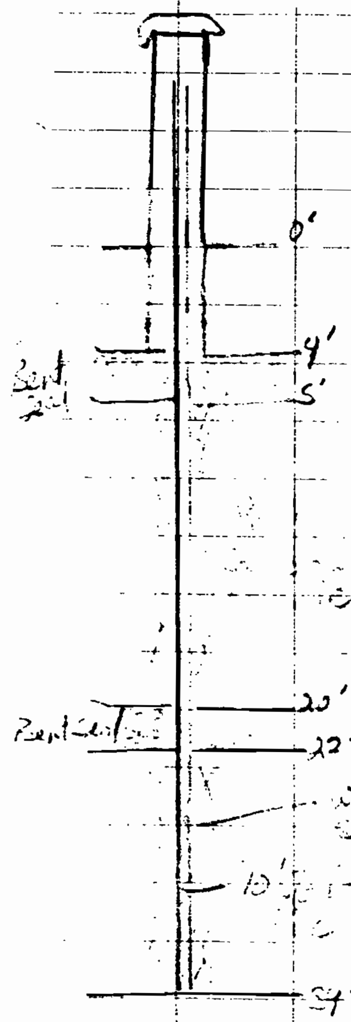


103 Well Installation



well Material
10' Sloded 1½" PVC
40' Reg " "
3 Bag Sand
25 pound Bent
1-7'-2½" Stand Pipe
1-locking cap
1-Screw Plug

B-104 Well Installation 9/12/89

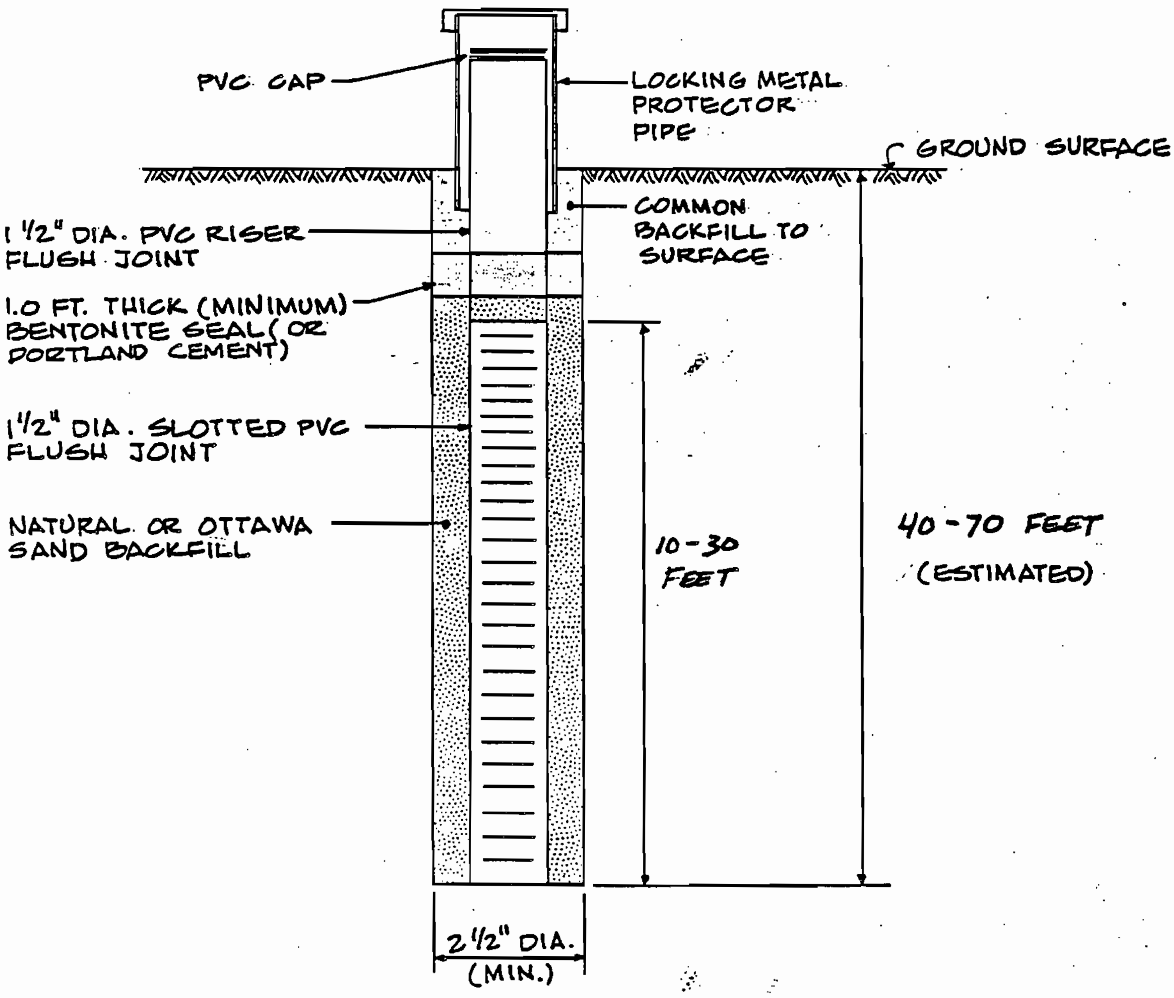


Well Material
10' Slotted PVC 1½"
30' Reg " "
2 Bag Sand
25 pound Bent
1-7'-2½" Stand Pipe
1-locking cap
1-Screw Plug

APPENDIX III

LINE ANALYSIS

TYPICAL WELL CONSTRUCTION DETAIL



ATTACHMENT 4

MONITORING WELL DETAIL-TYPICAL

NOT TO SCALE

APPENDIX IV

WATER QUALITY DATA

RAI

Resource Analysts, Incorporated
Box 4778 Hampton, NH 03842
(603) 926-7777

TO:

Mr. Dave Hill
Caswell, Eichler and Hill
PO Box 4696
Portsmouth, NH 03801

PO # Bethlem

Date Received: 8-23-84

Lab Number: 3690

Date Reported: 9-10-84

IDENTIFICATION

Water Samples

PARAMETER	method	SAMPLE DESIGNATION Cutters Seep 1
Chloride (mg/L)	407A	13
pH (units)	423	6.08
Iron, total (mg/L)	303A	52
Potassium, total (mg/L)	303A	2.4
Manganese, total (mg/L)	303A	12
Sodium, total (mg/L)	303A	7.3

The above method numbers refer to Standard Methods, 15th Edition

Clarke/Van Kouwenberg
ANALYST

DIRECTOR

RAI

Resource Analysts, Incorporated
Box 4778 Hampton, NH 03842
(603) 926-7777

TO:

Mr. David Hill
Caswell, Eichler and Hill
PO Box 4696
Portsmouth, NH 03801

PO # Sanco Bethelem

Date Received: 9-18-84

Lab Number: 3781

Date Reported: 9-28-84

IDENTIFICATION

Water samples from Sanco, Bethelem, NH

PARAMETER	method	SAMPLE DESIGNATION					
		Seep 1	Seep 2	101	102	103	104
Chemical Oxygen Demand (mg/L)	508A	<50	<50	<50	360	<50	50
Total Organic Carbon (mg/L)	505	7	7	21	74	10	18
pH (units)	423	6.67	7.10	6.26	6.26	6.61	6.94
Chloride (mg/L)	407A	1	<1	16	18	13	8.5
Sulfate (mg/L)	426B	19	18	2	2	14	9.4
Iron, total (mg/L)	303A	3.9	0.10	170	280	230	380
Potassium, total (mg/L)	303A	2.7	2.4	27	23	59	54
Manganese, total (mg/L)	303A	0.62	0.005	5.8	24	16	8.1
Sodium, total (mg/L)	303A	9.3	8.0	14	21	14	14

The above method numbers refer to Standard Methods, 15th Edition

Switalski/Clarke/Van Kouwenberg
ANALYST

DIRECTOR

Lab Number: 3781-1
Sample Designation: Seep 1 9-17-84
Date: 9-20-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	BDL	5
8V.	TRICHLOROFLUOROMETHANE	Trace	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	BDL	5
11V.	1,2-trans-DICHLOROETHYLENE	BDL	5
12V.	CHLOROFORM	BDL	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	BDL	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	BDL	5
20V.	BENZENE	BDL	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	BDL	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	Trace	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	BDL	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

Lab Number: 3781-2
Sample Designation: Seep 2 9-17-84
Date: 9-20-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	BDL	5
8V.	TRICHLOROFLUOROMETHANE	BDL	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	BDL	5
11V.	1,2-trans-DICHLOROETHYLENE	BDL	5
12V.	CHLOROFORM	BDL	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	BDL	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	BDL	5
20V.	BENZENE	BDL	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	BDL	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	BDL	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	BDL	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

Lab Number: 3781-3
Sample Designation: 101 9-17-84
Date: 9-20-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	Trace	5
8V.	TRICHLOROFLUOROMETHANE	Trace	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	5	5
11V.	1,2-trans-DICHLOROETHYLENE	5	5
12V.	CHLOROFORM	BDL	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	Trace	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	Trace	5
20V.	BENZENE	Trace	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	BDL	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	BDL	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	BDL	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

Lab Number: 3781-4
Sample Designation: 102 9-17-84
Date: 9-21-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	50
2V.	VINYL CHLORIDE	BDL	50
3V.	CHLOROETHANE	BDL	50
4V.	BROMOMETHANE	BDL	50
5V.	ACROLEIN	BDL	500
6V.	ACRYLONITRILE	BDL	500
7V.	METHYLENE CHLORIDE	BDL	50
8V.	TRICHLOROFLUOROMETHANE	BDL	50
9V.	1,1-DICHLOROETHYLENE	BDL	50
10V.	1,1-DICHLOROETHANE	BDL	50
11V.	1,2-trans-DICHLOROETHYLENE	BDL	50
12V.	CHLOROFORM	BDL	50
13V.	1,2-DICHLOROETHANE	BDL	50
14V.	1,1,1-TRICHLOROETHANE	BDL	50
15V.	CARBON TETRACHLORIDE	BDL	50
16V.	BROMODICHLOROMETHANE	BDL	50
17V.	1,2-DICHLOROPROPANE	BDL	50
18V.	1,3-trans-DICHLOROPROPENE	BDL	50
19V.	TRICHLOROETHYLENE	BDL	50
20V.	BENZENE	Trace	50
21V.	1,3-cis-DICHLOROPROPENE	BDL	50
22V.	1,1,2-TRICHLOROETHANE	BDL	50
23V.	DIBROMOCHLOROMETHANE	BDL	50
24V.	BROMOFORM	BDL	50
25V.	TETRACHLOROETHYLENE	BDL	50
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	50
27V.	TOLUENE	240	50
28V.	CHLOROBENZENE	BDL	50
29V.	ETHYLBENZENE	BDL	50
30V.	2-CHLOROETHYL VINYL ETHER	BDL	50
	ACETONE	1900	250
	THF	350	250
	MEK	300	250
	MIBK	Trace	250

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

Lab Number:	3781-5
Sample Designation:	103 9-17-84
Date:	9-20-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	15	5
8V.	TRICHLOROFLUOROMETHANE	BDL	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	6	5
11V.	1,2-trans-DICHLOROETHYLENE	BDL	5
12V.	CHLOROFORM	5	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	Trace	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	Trace	5
20V.	BENZENE	Trace	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	Trace	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	BDL	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	BDL	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

Lab Number: 3781-6
Sample Designation: 104 9-17-84
Date: 9-20-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	BDL	5
8V.	TRICHLOROFLUOROMETHANE	BDL	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	BDL	5
11V.	1,2-trans-DICHLOROETHYLENE	BDL	5
12V.	CHLOROFORM	Trace	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	BDL	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	BDL	5
20V.	BENZENE	BDL	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	BDL	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	BDL	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	BDL	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

RAI

Resource Analysts, Incorporated
Box 4778 Hampton, NH 03842
(603) 926-7777

TO:

Mr. Dave Hill
Caswell, Eichler and Hill
PO Box 4694
Portsmouth, NH 03801

PO # Sanco

Date Received: 9-27-84

Lab Number: 3822

Date Reported: 10-11-84

IDENTIFICATION

Water samples from Sanco, Inc. Bethelem, NH

PARAMETER	method	101	102	103	104	Seep 1	Seep 2
pH (units)	423	6.24	6.48	6.55	7.13	6.62	6.96
Chloride, total (mg/L)	407A	*	15	22	9	*	*
Chloride, dissolved (mg/L)	407A	37	19	32	6	17	12
Sulfate, total (mg/L)	426B	12	21	6	8	2	2
Sulfate, dissolved (mg/L)	426B	4	3	2	*	3	5
Chemical Oxygen Demand, total (mg/L)	508A	84	210	63	<50	<50	<50
Chemical Oxygen Demand, diss. (mg/L)	508A	58	310	<50	<50	<50	<50
Total Organic Carbon, total (mg/L)	505	12	140	29	21	17	4
Total Organic Carbon, dissolved (mg/L)	505	10	130	24	10	21	7
Total Suspended Solids (mg/L)	209D	18,000	15,000	110,000	25,000	22	6
Iron, total (mg/L)	303A	490	230	73	1,000	12	0.10
Iron, dissolved (mg/L)	303A	6.1	73	0.02	0.12	8.6	0.01
Potassium, total (mg/L)	303A	57	26	150	300	2.5	1.7
Potassium, dissolved (mg/L)	303A	3.6	6.7	5.9	1.4	1.7	1.0
Manganese, total (mg/L)	303A	7.0	22	12	31	2.5	6.1
Manganese, dissolved (mg/L)	303A	1.2	21	16	0.11	1.7	0.2
Sodium, total (mg/L)	303A	27	33	47	34	6	8
Sodium, dissolved (mg/L)	303A	12	15	9.6	3.8	4.5	2.2

* interferance

The above method numbers refer to Standard Methods, 15th Edition

DOES DISSOLVED = FILTERED

Clarke/Van Kouwenberg/Switalski
ANALYST

DIRECTOR

Lab Number:	3822-1
Sample Designation:	101
Date:	10-1-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	26	5
8V.	TRICHLOROFLUOROMETHANE	Trace	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	5	5
11V.	1,2-trans-DICHLOROETHYLENE	BDL	5
12V.	CHLOROFORM	Trace	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	Trace	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	Trace	5
20V.	BENZENE	Trace	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	BDL	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	BDL	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	BDL	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5
	ACETONE	BDL	25
	THF	BDL	25
	MEK	BDL	25
	MIBK	BDL	25
	XYLENES	BDL	25

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

Lab Number:	3822-2
Sample Designation:	102
Date:	10-1-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	5	5
8V.	TRICHLOROFLUOROMETHANE	BDL	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	Trace	5
11V.	1,2-trans-DICHLOROETHYLENE	BDL	5
12V.	CHLOROFORM	BDL	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	BDL	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	Trace	5
20V.	BENZENE	Trace	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	Trace	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	130	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	5	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5
	ACETONE	140	25
	THF	Trace	25
	MEK	310	25
	MIBK	BDL	25
	XYLENES	Trace	25

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

Resource Analysts, Incorporated

Lab Number:	3822-3
Sample Designation:	103
Date:	10-1-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	30	5
8V.	TRICHLOROFLUOROMETHANE	Trace	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	8	5
11V.	1,2-trans-DICHLOROETHYLENE	BDL	5
12V.	CHLOROFORM	Trace	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	BDL	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	Trace	5
20V.	BENZENE	Trace	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	Trace	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	9	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	Trace	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5
	ACETONE	90	25
	THF	Trace	25
	MEK	200	25
	MIBK	BDL	25
	XYLENES	Trace	25

BDL = BELOW DETECTION LIMIT

METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

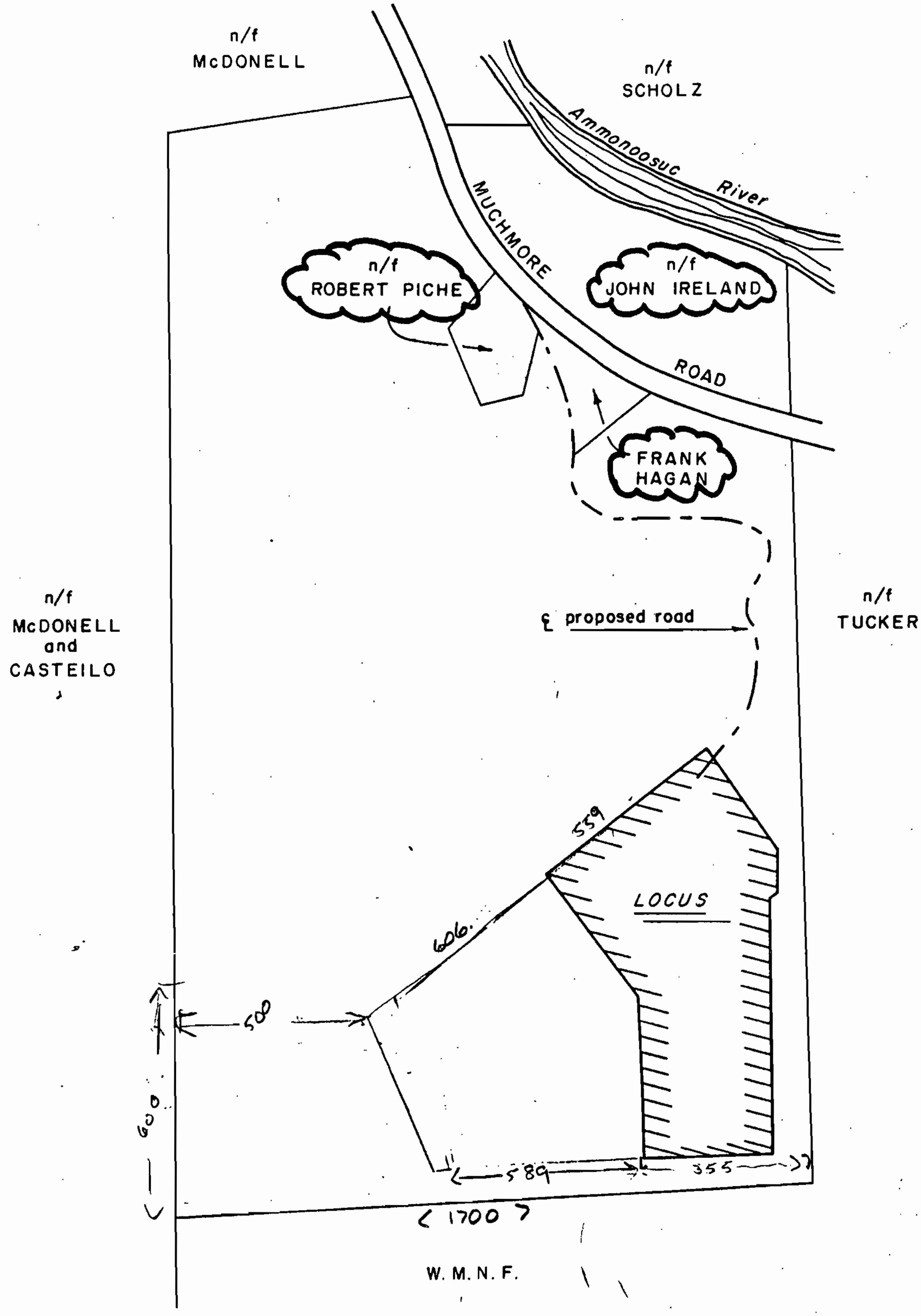
Lab Number: 3822-4
Sample Designation: 104
Date: 10-1-84

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	BDL	5
2V.	VINYL CHLORIDE	BDL	5
3V.	CHLOROETHANE	BDL	5
4V.	BROMOMETHANE	BDL	5
5V.	ACROLEIN	BDL	50
6V.	ACRYLONITRILE	BDL	50
7V.	METHYLENE CHLORIDE	BDL	5
8V.	TRICHLOROFLUOROMETHANE	BDL	5
9V.	1,1-DICHLOROETHYLENE	BDL	5
10V.	1,1-DICHLOROETHANE	BDL	5
11V.	1,2-trans-DICHLOROETHYLENE	BDL	5
12V.	CHLOROFORM	BDL	5
13V.	1,2-DICHLOROETHANE	BDL	5
14V.	1,1,1-TRICHLOROETHANE	BDL	5
15V.	CARBON TETRACHLORIDE	BDL	5
16V.	BROMODICHLOROMETHANE	BDL	5
17V.	1,2-DICHLOROPROPANE	BDL	5
18V.	1,3-trans-DICHLOROPROPENE	BDL	5
19V.	TRICHLOROETHYLENE	BDL	5
20V.	BENZENE	BDL	5
21V.	1,3-cis-DICHLOROPROPENE	BDL	5
22V.	1,1,2-TRICHLOROETHANE	BDL	5
23V.	DIBROMOCHLOROMETHANE	BDL	5
24V.	BROMOFORM	BDL	5
25V.	TETRACHLOROETHYLENE	BDL	5
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	5
27V.	TOLUENE	BDL	5
28V.	CHLOROBENZENE	BDL	5
29V.	ETHYLBENZENE	BDL	5
30V.	2-CHLOROETHYL VINYL ETHER	BDL	5
	ACETONE	BDL	25
	THF	BDL	25
	MEK	BDL	25
	MIBK	BDL	25
	XYLENES	BDL	25

BDL = BELOW DETECTION LIMIT
METHOD REFERENCE: EPA 600/4-79-020 METHOD 624

APPENDIX V

MUNICIPAL WATER BILLS, RESIDENCES ON MUCHMORE ROAD



n/f
McDONELL
n/f
SCHOLZ
Ammonoosuc River
MUCHMORE ROAD
n/f
ROBERT PICHE
n/f
JOHN IRELAND
FRANK
HAGAN
n/f
McDONELL
and
CASTEILO
℄ proposed road
n/f
TUCKER
559
LOCUS
606
500
600
589
355
1700
W. M. N. F.

To Bethlehem Water Department, Dr.

For use of water from June 1, 1984 to June 1, 1985

Mr. Robert Piche
PO Box 573
Bethlehem, NH 03574

Laurel Lane

1 Residence $85.00

Total Due $85.00

$8.50 = **10% DISCOUNT IF PAID BY AUGUST 1st, 1984**

Bethlehem, NH ____________________ 198

Received Payment by the Commissioners

____
Karleen Sanborn, Collector

The Water Department is not responsible for customers service beyond the main shut-off or interruptions of service beyond their control. Please notify the Water Department when closing your house for the season.

Service discontinued without notice if not paid September 1st.

Office Hours at Town Building:
9:00 AM to 12 Noon - Monday, Wednesday and Friday
1:00 to 4:00 PM - Tuesdays and Thursdays.

After initial turn-on and shut-off, there will be a $15.00 charge for each service.

THE DEPARTMENT REQUIRES A 48-HOUR NOTICE TO TURN ON OR SHUT OFF WATER.

To Bethlehem Water Department, Dr.

For use of water from June 1, 1984 to June 1, 1985

Mr. Frank Hagan
PO Box 743
Bethlehem, NH 03574

Muchmore Road

Paid CK# 1114
82.80

1 Residence	$85.00
1 Bahh room	7.00
Total Due	$92.00

$9.20 = **10% DISCOUNT IF PAID BY AUGUST 1st, 1984**

Bethlehem, NH June 27 1984

Received Payment by the Commissioners

Karleen Sanborn, Collector

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1:00 to 4:00 PM - Tuesdays and Thursdays.

After initial turn-on and shut-off, there will be a $15.00 charge for each service.

THE DEPARTMENT REQUIRES A 48-HOUR NOTICE TO TURN ON OR SHUT OFF WATER.

To Bethlehem Water Department, Dr.

For use of water from June 1, 1984 to June 1, 1985

Sandra Ireland
PO Box 565
Bethlehem, NH 03574

Muchmore Road

Paid ck# 1490 $82.80

1 Residence	$85.00
1 Shower bath	7.00
Total Due	$92.00

$9.20 - **10% DISCOUNT IF PAID BY AUGUST 1st, 1984**

Bethlehem, NH July 31 1984

Received Payment by the Commissioners

KS

Karleen Sanborn, Collector

The Water Department is not responsible for customers service beyond the main shut-off or interruptions of service beyond their control. Please notify the Water Department when closing your house for the season.

Service discontinued without notice if not paid September 1st.

Office Hours at Town Building:
9:00 AM to 12 Noon - Monday, Wednesday and Friday
1:00 to 4:00 PM - Tuesdays and Thursdays.

After initial turn-on and shut-off, there will be a $15.00 charge for each service.

THE DEPARTMENT REQUIRES A 48-HOUR NOTICE TO TURN ON OR SHUT OFF WATER.

Calex Environmental Consulting

March 22, 2024

BCM Environmental and Land Law, PLLC
3 Maple Street
Concord, New Hampshire 03301

Attn: Amy Manzelli, Esq.

SUBJECT: Hydrogeological Opinion
Release Events at the NCES Landfill Site
Bethlehem, New Hampshire

Dear Attorney Manzelli,

Calex Environmental, LLC (Calex) was asked by North Country Alliance for Balanced Change (NCABC) for an opinion regarding whether the North Country Environmental Services (NCES) Landfill Site (Site) in Bethlehem, New Hampshire has in the past or is currently experiencing releases due to its landfilling activities. Of particular concern to NCABC is the potential source(s) of per- and polyfluoroalkyl substances (PFAS) that have been detected in groundwater monitoring wells downgradient of the operating NCES solid waste landfill and in surface water seeps entering the Ammonoosuc River. In addition, NCABC asked whether the detected PFAS at the Site is likely originating (solely) from leachate released from the historical Sanco landfill (excavated in the early 1990's and placed into Stage I, Phase I of the double lined NCES Landfill) or whether (all/some of) the PFAS could have originated from the current, active landfill operations. The consultant for the operating NCES Landfill Site, Sanborn Head and Associates (SHA) has recently opined (October 6, 2023) that the PFAS originates from the historical Sanco landfill that ceased operations in 1987.

In its evaluation of these questions, Calex reviewed the history of the NCES Landfill Site and focused on the most recent groundwater data as reported by SHA in "July 2023 Tri-Annual/2023 Annual Water Quality Monitoring Results" dated August 24, 2023, referred to as the 'Report' in this Opinion. For ease of following the discussion and referring to the appropriate Report page(s), the numbering refers to the entire 483-page PDF e.g., pg. 280/483 is page 280 of the 483-page PDF of the SHA 2023 Report.

EXECUTIVE SUMMARY

This analysis focused on historical groundwater analytical results for the NCES site, as presented in the Report. The first release evaluated occurred as a result of the excavation of the historical Sanco Landfill and placement into Stage I of the NCES landfill. This release of landfill contaminants into the groundwater is seen in the monitoring well data as spikes of typical landfill leachate parameters such as manganese, iron, sulfate etc. and in some wells, volatile organic compounds (VOCs). For VOCs, the return to background appeared to occur mostly prior to 2000, as illustrated in **Figure 1**. These trend plots clearly illustrate the slug of contaminants that were released into groundwater during Sanco landfill removal activities that dissipated over time.

The second release event evaluated was in the mid 2000's to about 2012. The extensive regulatory record shows that these landfill releases were clearly from current operations (e.g., leachate spills, sumps, tanks, force mains, caps, and liners) which were impacting downgradient groundwater conditions. The Leachate Management Improvement Project (LMIP) particularly addressed leachate storage and handling areas in use for those current landfill operations, leachate generated because of several phases of cells later (e.g., more recent) than leachate residuals from the former Sanco Landfill. The data from many monitoring wells show that contaminant release(s) are still migrating in groundwater from the active landfill operations and likely commingled with some leachate residuals from the former Sanco landfill. The ultimate goal of Release Detection Monitoring at a lined landfill site such as NCES is for all groundwater to maintain background quality. This environmental condition has not been attained at the NCES Site, and not just because of residual leachate from the former Sanco landfill. The detection of elevated bromide (a tracer required to be added in some NCES stages) in some of the wells (B-304UR, B-304DR, B-928U, B-928D, and B-926U) demonstrates that these wells are impacted by contaminants released from the more recent Stage II and Stage III landfill operations.

Lastly, the presence of PFAS at the NCES site was evaluated, to see if it could only have been sourced from leachate generated by the former Sanco Landfill. PFAS have been detected in groundwater at many locations on the NCES Site, both upgradient and downgradient of the former Sanco footprint. This fact indicates that not <u>all</u> the detected PFAS could have originated solely from leachate residuals of the former unlined Sanco landfill. When PFAS detections coincide with bromide detections, the source of the PFAS may originate from post-1996 waste leachate releases, because the tracer sodium bromide was added to waste deposited in Stages II and III of the NCES lined landfill cells.

ARE THERE DOCUMENTED RELEASES AT THE NCES SITE?

Yes, there are many releases from the Site that are documented in the regulatory record and groundwater data represented in the Report.

1) Initial releases between 1990 to 1993

It was reported by SHA and agreed to by the New Hampshire Department of Environmental Services (NHDES) (November 10, 1994) that the excavation of the historical Sanco Landfill and its placement into Stage I of the NCES Landfill resulted in a release of typical landfill contaminants due to the exposure of the Sanco wastes to precipitation during the 22 months of excavation and placement activities. This release of landfill contaminants into the groundwater is seen in the monitoring well data as spikes of typical landfill leachate parameters such as manganese, iron, sulfate etc. and in some wells, volatile organic compounds (VOCs).

Examples of groundwater contaminated by these releases can be seen in Appendix C, Time Series Plots for groundwater monitoring wells in the Report, such as B-102S (pg. 280/483), B-102D (pg.281/483), B-103S (pg. 282/483), and B-103D (pg. 283/483). **Figure 1** shows some example trend plots for B-103D which illustrate the historical jump in contamination in the post removal time of the early/mid 1990s when the Sanco landfill relocation project occurred and the relatively rapid decline of contaminants after capping of the Sanco waste and its footprint with the next landfill cell. The plots in **Figure 1** were taken from the B-103D trend plots shown on pg. 283/483 of the Report. The location of well B-103D is noted in red on the Site plan sketch, showing that it is located north of and very close to the old Sanco landfill, shown by the small rectangle. The large, angled, rectangle-like area depicts the Groundwater Management Zone assigned to define historical groundwater contamination from the former Sanco Landfill.

These historical analytical data show that historical releases from the old landfill flowed downgradient with the groundwater and dissipated, such that the groundwater data returned to “background” conditions in some wells. In B-103D illustrated in **Figure 1**, the iron and manganese returned to background a bit after 2010. For VOCs, the return to background appeared to occur mostly prior to 2000, as illustrated in **Figure 1**. These trend plots clearly illustrate the slug of contaminants that were released into groundwater during Sanco landfill removal activities that dissipated over time.

Even some of the wells monitored outside the Groundwater Management Zone (GMZ) show this trend, such as monitoring wells located laterally to the old landfill, B-914U and B-914L pg. 245 and 246/483, showing relatively rapid dissipation of manganese and iron between 2000 and 2010. In addition, the Main Seep (S-1) trends shown on pg. 286/483, illustrate the significant decrease in landfill constituents with time, again likely due to the waste relocation and capping over the former old landfill footprint.

The historical landfill release interpretation prior and during its excavation and emplacement into a lined cell is not the only source of contamination detected in the onsite monitoring wells. Releases from the old landfill do not solely explain the recently detected PFAS data onsite.

Introduction of a Tracer

As the construction of the new lined NCES landfill meant disposing of waste over the former Sanco landfill footprint, the NHDES wanted to be able to verify that changes in downgradient groundwater quality could be differentiated between new NCES landfill operations versus residual Sanco landfill releases remaining in the underlying soil/aquifer. To facilitate this understanding, SHA recommended using an ionic tracer, which NHDES agreed to and added its use to NCES’ operating permit. Specifically, sodium bromide was required to be added to the NCES landfilling operations beginning in 1996 for its Stage II and Stage III waste disposal cells. This requirement meant that detections of landfill contaminants coincident with bromide detections would be interpreted by the Agency to mean that current (e.g., post-1996) NCES operations were likely the source of that contamination and not residual contamination originating from under the old Sanco landfill footprint. More on this in the following Section 2.

2) Release(s) to Groundwater mid 2000’s to 2012

In September 2008, the NHDES completed its technical review of documents submitted in support of an Application to expand the NCES permit for Stage IV Phase II cell construction. In their response letter NHDES denied a requested modification to the NCES’ Landfill permit citing as one of their reasons, downgradient groundwater contamination from VOCs and bromide as indicative “… that the operation of the existing landfill has resulted in releases of regulated contaminants in violation of condition #9 of Groundwater Management and Releases Detection Permit …” (December 12, 2008, NHDES). In their denial of the modification request, the NHDES listed seven wells, MW-402U, MW-403L, B-913M, B-919U, B-921M, B-921U, and B-304UR as exhibiting data that supported their rationale, namely the presence of VOCs and detections of bromide in groundwater.

Calex looked for the data for these seven wells cited by the NHDES in the most recent groundwater quality Report, but the Report provided only historical data for two of the seven wells, as apparently the others have been decommissioned due to landfill expansion over time. The trend plots in Appendix C of the Report show the historical data for B-919U (pg. 274/483) illustrating the dissipation of an apparent spike of VOCs and 1,4 dioxane in the mid 2000s to early 2012 timeframe while B-304UR (pg. 269/483) showed high VOCs and low detections of bromide in the subject timeframe. **Figure 2** illustrates some of the trend plots for B-304UR taken from the Report, pg. 269/483.

The Site plan on **Figure 2** identifies the location of B-304UR as a red dot which is located about halfway down into the GMZ. In looking at the analyte plots of **Figure 2**, one sees large spikes of VOC detections in the mid 2000s until about 2012 or 2013, while the apparent smaller detections of bromide are driven by the different plot scales (mg/l versus ug/l) of the results. The 1,4 dioxane plot shows consistent detections in the same timeframe. These data, (and the other wells listed by NHDES) showing spikes in VOCs comingled with bromide detections, indicated to NHDES that these release(s) were not from the old landfill, but had instead occurred from the operating landfill.

NHDES in its December 23, 2008, letter required that NCES propose corrective actions that include "… both soil and groundwater data needed to identify the source of each exceedance of the background concentrations for VOCs and bromide, and to confirm that the source(s) of the exceedances have been effectively remediated." The Agency issued a second denial for the landfill expansion on March 25, 2009, noting that NCES had failed to determine the source of continuing groundwater contamination at the site.

In response to NHDES' continued requests for evaluation of source(s) of releases from the current operations to the groundwater, NCES submitted a 2009 Corrective Action Plan (CAP) that was revised in response to Agency comments and resubmitted on February 19, 2010, which was subsequently approved by NHDES on May 19, 2010. Conditions that were identified as contributing to landfill releases causing the groundwater exceedances and actions undertaken to correct those conditions, were summarized on Figure 6 of the CAP for MW-402U as follows:

- March 2001, Force Main break repair.
- September through November 2002 Stage I toe repair.
- March 3, 2006, Leachate Tanker Truck Spill at Load-Out Building.
- May 12, 2006, Leachate Spill at Leachate Load-Out Building.
- April/May 2007, Stage I CAP and Detention Pond #3 Inlet Culvert drainage improvements including east portion of Stage I anchor trench.
- September 26, 2008 – January 3, 2009, and April 13, 2009 – May 15, 2009, Leachate Management Improvements Project (LMIP) and related contaminated soil removals (i.e., adjacent to Stage II and consolidation tanks; force main and swales).
- August/September 2009, Repair of Stage I Down Chute Drainage and east portion of Stage I anchor trench.
- November 19, 2009 – January 7, 2010, Stage I Landfill Gas Extraction System Improvements.

Conditions that were identified as contributing to landfill releases causing the groundwater exceedances and actions undertaken to correct those conditions, were summarized on Figure 8 of the CAP for B-913M as follows:

- August 7, 2006, Leachate Spill along temporary Stage II Leachate Force Main.
- April/May 2007, Stage I CAP and Detention Pond #3 Inlet Culvert drainage improvements including east portion of Stage I anchor trench.
- August/September 2009, Repair of Stage I Phase I Capping System Down Chute Drainage System and east portion of Stage I anchor trench.

On August 27, 2010, NHDES granted the initially requested 2008 permit modification for expansion of lined cells for the NCES Landfill. This extensive regulatory record shows that landfill releases were clearly from current operations (e.g., leachate spills, sumps, tanks, force mains, caps, and liners) which were impacting downgradient groundwater conditions. The Leachate Management Improvement Project (LMIP) particularly addressed leachate storage and handling areas in use for current operations, leachate generated because of several phases of cells later (e.g., more recent) than leachate residuals from under the former Sanco Landfill.

Continued groundwater monitoring and statistical trend analyses were required by NHDES after the 2010 Corrective Action Plan to assess the success of the remedial actions and document groundwater improvements. The NCES Groundwater Release Detection permit under RSA 485-C:13 for lined landfills requires that if groundwater conditions begin to exceed background conditions, assessment monitoring is required and if groundwater quality trends do not go back to background, as some wells appeared to do after the Sanco Landfill was removed, a corrective action plan would be required to identify and remediate source(s) of releases, addressed in the next section.

3) Groundwater trends in 2018 – 2023

Calex evaluated the analytical trend plots in Appendix C for monitored wells in the Report to see if the remedial actions performed in the 2010 timeframe had caused the Release Detection Wells to return to background conditions. It did in some cases, but several wells continue to show background exceedances and/or upward trends in recent years, a timeframe starting in approximately 2018 and continuing into 2023, some of which are listed here:

- B-304UR (pg. 269/483) shows contaminated groundwater containing dioxane, volatile organic compounds (VOCs), bromide, chloride, and nitrate.
- B-304DR (pg. 270/483) shows spikes in bromide, chloride, manganese, dioxane, and total VOCs.
- MW-803 (pg. 273/483) illustrates spikes in manganese, iron, and chloride.
- B-919M (pg. 275/483) shows detections of arsenic, manganese, and iron.
- B-928 U and B-928 D (pgs. 277-278/483) both detect dioxane, and bromide.
- B-927M (pg. 262/483) illustrates exceedances of iron, an increasing trend in manganese, and VOCs.
- B-926U (pg. 259/483) has bromide and manganese above background.
- MW-701 (pg. 240/483) shows variable increases in manganese.

Figure 3 illustrates some trend plots from B-304DR, a well located within the GMZ and near B-304UR that was illustrated in **Figure 2**. The plots show spikes in bromide detections very clearly beginning prior to 2020 and falling off sharply. The manganese plot in **Figure 3** shows a broad spike around the same period, but still remaining above standards, while the VOCs plot shows a similar discrete timeframe of detections. These data suggest impacts from releases from the operating landfill since the bromide is commingled in the groundwater. These same trend observations are also illustrated in **Figure 2** for the same 2018 to 2023 timeframe.

The data from these monitoring locations show that contaminant release(s) are still migrating in groundwater onsite from the active landfill operations and likely commingled with some residuals from the former Sanco landfill. The ultimate goal of Release Detection Monitoring at a lined landfill site such as NCES is for all groundwater to maintain background quality. This environmental condition has not been attained at the NCES Site, and not just because of residuals from the former Sanco landfill.

The detection of elevated bromide in some of the wells (B-304UR, B-304DR, B-928U, B-928D, and B-926U) demonstrates that these wells are impacted by contaminants released from the more recent Stage II and Stage III landfill operations where leachate carrying bromide would be managed. Monitoring is ongoing under the CAP to evaluate the effectiveness of remedial actions performed (i.e. the Leachate Management Improvement Project in response to multiple releases in the 2001 - 2006 timeframe).

Calex's analysis of the groundwater quality data and regulatory history of the NCES landfill site clearly shows that:

1) Contaminant releases from former Sanco landfill operations have occurred,
2) Contaminant releases from recent (post-1996) landfill operations have occurred, and
3) Groundwater is still impacted above background in the leachate management area for landfill operations (upgradient of the former Sanco landfill footprint) as well as downgradient of the former Sanco landfill footprint and current landfill operations.

These conclusions are consistent with the findings discussed in the Report.

4) Per- and polyfluoroalkyl substances (PFAS)

Within the last decade, per- and polyfluoroalkyl substances (PFAS), sometimes called "forever chemicals", have figured prominently at many contaminated sites. Due to the concerns of pervasive PFAS compounds being detected around the country and in New Hampshire, NHDES began requiring testing of various potential PFAS source areas (e.g., car washes, certain manufacturing sites, CERCLA sites, dry cleaners, landfills). In 2017, NCES first added some wells to its testing regime for PFAS and has expanded its testing and analysis since that time. As of the Report, thirty-one monitoring wells were tested for selected PFAS constituents. In addition, surface water testing for PFAS was required by NHDES in 2023, which was reported by SHA in its October 2023 SSI Report.

The attached **Figure 4** utilizes Figure 3 from the Report as a base plan and illustrates the locations of current and former detections of PFAS around the NCES landfill site, both in groundwater and surface water. The Figure also highlights the approximate footprint of the former Sanco landfill as a red box and illustrates the approximate direction of groundwater flow (blue arrows) near the footprint of the historical landfill based on groundwater contours from July 2023. Groundwater, in general, flows northerly to northwesterly away from the former Sanco footprint and current NCES landfill. This interpretation is consistent with the Report.

WHAT ARE THE POSSIBLE SOURCES OF PFAS AT THE NCES SITE?

Figure 4 illustrates that PFAS have been detected in groundwater at many locations on the NCES Site, both upgradient and downgradient of the former Sanco footprint. This fact indicates that not all the detected PFAS could have originated solely from residuals under the former unlined Sanco landfill. The unlined historical Sanco landfill is likely a source of PFAS to the NCES Site due to the age of its waste, but other factors at the NCES Site point to additional source(s) of PFAS. Factors which indicate PFAS source(s) other than, or in addition to, the former unlined Sanco landfill are:

- Location – Whether a sampled well is located hydraulically upgradient or downgradient of the historical unlined Sanco landfill determines whether it intercepts PFAS contamination from residual releases from the historical landfill. Some PFAS detections occur at well locations that encountered PFAS sources from other than the old landfill:
    - MW-701 contained PFAS concentrations that substantially increased between April 2023 and July 2023 (pg. 306/483), while this location is outside the GMZ and is upgradient of the historical former unlined Sanco landfill **(Figure 4)**. Leachate source(s) for PFAS at this location must somehow be from the NCES landfill operations and subject to its Release Detection Permit.
    - B-915 U and B-915M located near the stormwater ponds (**Figure 4**) are upgradient of the former historical landfill footprint. PFAS detections at this location originated from current NCES landfill operations. The Report points to its source from historical leachate infrastructure operations and releases, was addressed by the Leachate Management Improvement Project (LMIP) completed in May 2009.
    - B-918U, B-918M, B-918D located cross gradient to the former historical landfill and within the historical leachate infrastructure area that experienced multiple releases of leachate in the 2001 to 2008 timeframe, addressed by the 2010 CAP remediation and the LMIP (**Figure 4**).
- Bromide – When PFAS detections coincide with bromide detections, the source of the PFAS may originate from post-1996 waste leachate releases, because the tracer sodium bromide was added to waste deposited in Stages II and III of the NCES lined landfill cells.
    - High PFAS concentrations in B-304DR and B-304UR (pgs. 269-279/483 in the Report) exceed NHDES Ambient Groundwater Quality Standards (AGQS) for selected PFAS compounds and are coincident with other parameters that show post-1996 waste leachate generation due to the detected bromide tracer and VOCs. (as illustrated in **Figures 2 and 3**). This condition suggests that a “recent” (post-1996) leachate source is contributing PFAS at this location.
    - PFAS concentrations in B-919U (pg. 315/483 of the Report) appear to be steady or possibly increasing with consistent exceedances of the AGQS for PFOA. The location of this sampling point is proximate to the NCES landfill operations and in an area that shows VOCs and bromide (B-919M) in groundwater, post-1996 generated leachate.

- PFAS concentrations in B-918M (pg. 257/483), located in the infrastructure area remediated due to releases in 2001-2006 timeframe, are also coincident with high bromide detections, suggesting PFAS contributions from post-1996 leachate.
- MW-802/803 (pgs. 272-273/483) PFAS detections, are located downgradient of the former Sanco Landfill, yet show consistent detections of bromide, with spikes in bromide that appear to correlate with significant changes in water levels. The coincidence of PFAS with consistent bromide concentrations suggests that some PFAS contributions at this location may come from releases of post-1996 leachate.
- Detections of PFAS occur in B-919M (pg. 275/483) where consistent detections of bromide are seen. The spikes in bromide appear to coincide with a significant drop in water levels in the 2014/2015 timeframe. The coincidence of PFAS with consistent bromide concentrations suggests that some PFAS contributions at this location may come from releases of post-1996 leachate.

HYDROGEOLOGICAL OPINIONS

Based on a comparison of historical groundwater quality data to the recent PFAS data, it is Calex's opinion that the PFAS constituents are sourced from both historical leachate releases originating from the former Sanco landfill and recent (post-1996) landfilling operations, based on the following lines of evidence:

- Detection of PFAS in several monitoring well locations that are hydraulically upgradient of the former unlined Sanco landfill.
- Presence of PFAS in many monitoring well locations where groundwater is comingled with detections of the bromide tracer, indicating that post-1996 leachate has impacted water quality of the well.
- The NCES landfill site exhibits many documented releases of leachate, both originating from the unlined former Sanco landfill area as well as significant releases of leachate in the infrastructure area and onsite from active (post-1996) landfill operations. These releases are documented in NCES' regulatory history and in the long-term groundwater quality data for the Site. Therefore, the NCES Site has two primary sources of PFAS contamination originating onsite. 1) Residual contamination from waste disposed of during the 1980's under the footprint of the old Sanco landfill, as well as 2) leachate from post-1996 landfilled waste in NCES cells that has documented releases onsite. To date, there has been no attempt by NCES or NHDES to differentiate these two sources of PFAS contributions, instead generically calling PFAS contamination "from the old landfill".
- The NCES landfill site is currently operating while many of the Release Detection Wells show exceedances of background conditions. In some groundwater locations, analytes even show exceedances of AGQS. As reflected in groundwater contours of **Figure 4**, contaminated groundwater is moving northerly towards the Ammonoosuc River, while contaminated surface water seeps, one within approximately 50 feet of the river, flow northerly towards the River. It is Calex's opinion that the data indicate that discharges of contaminated groundwater and surface water are likely entering the Ammonoosuc

River. Surface water sampling in the river has not detected any contamination likely due to dilution.

CONCLUSIONS

Regardless of the precise hydrogeological source(s) to the PFAS contamination, the data show that PFAS, as well as other regulated compounds, have migrated beyond the historical and current landfill footprints and are migrating downgradient in groundwater onsite. Some of the groundwater manifests as discharges to seeps, one of which is very close to the compliance boundary and the Ammonoosuc River. The current landfill owner/operator is responsible for keeping any and all landfill-derived contaminants controlled onsite whether the contaminants originate from the old unlined landfill residuals or current operations.

The NCES Site is required by law to operate in compliance with its Permits. Any regulated contaminant should not be allowed to leave the Site and enter the Ammonoosuc River. With a seep (SF-1) (**Figure 4**) that shows contamination located less than 50 feet from the edge of the River, it is important for the NHDES to require a multi-level pore water investigation of the groundwater/river interface to determine, and quantify, the contaminant loading to the River so that effective groundwater/surface water mitigation measures can be implemented to keep regulated contaminants from leaving the Site and entering the River.

Please do not hesitate to call if you have any questions. Thank you.

Sincerely,

CALEX ENVIRONMENTAL, LLC

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Senior Consultant
muriel@calexenvironmental.com

REFERENCED DOCUMENTS

November 7, 2023, NHDES Comments on 2023 Water Quality Submittal and SSI-Surface Water PFAS Sampling.

October 6, 2023, SSI Surface Water PFS Sampling Data Transmittal, NCES Landfill, SHA.

August 24, 2023, July 2023 Tri-Annual/2023 Annual Water Quality Monitoring Results, SHA.

August 28, 2010, NHDES Permit Modification for NCES Stage IV landfill.

February 19, 2010, Corrective Action Plan, SHA.

February 8, 2010, NHDES Comments on November 24, 2009 Corrective Action Plan.

March 25, 2009, NHDES Denial of NCES Application Permit Modification for Stage IV Phase II.

September 10, 2008, NHDES letter to NCES noting issues of concern.

November 10,1994, NHDES Memorandum, North Country Environmental Services Landfill Water Quality Evaluation and Release Detection Permit Modification.

October 5, 1994, NCES Stage II Expansion, SHA.

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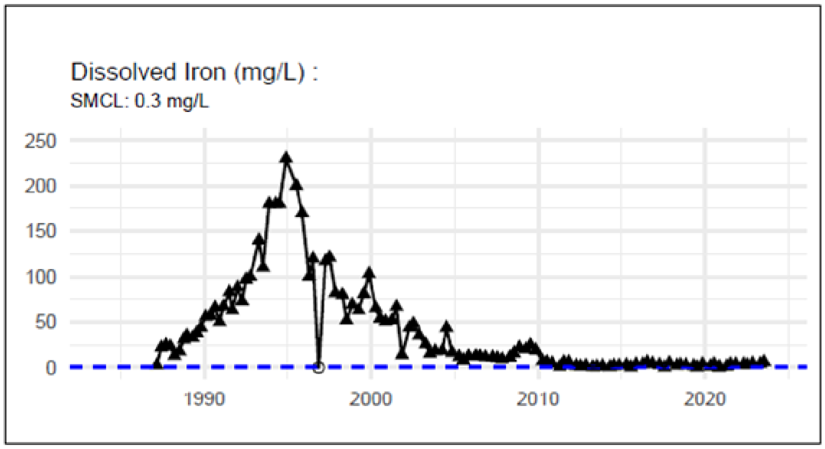
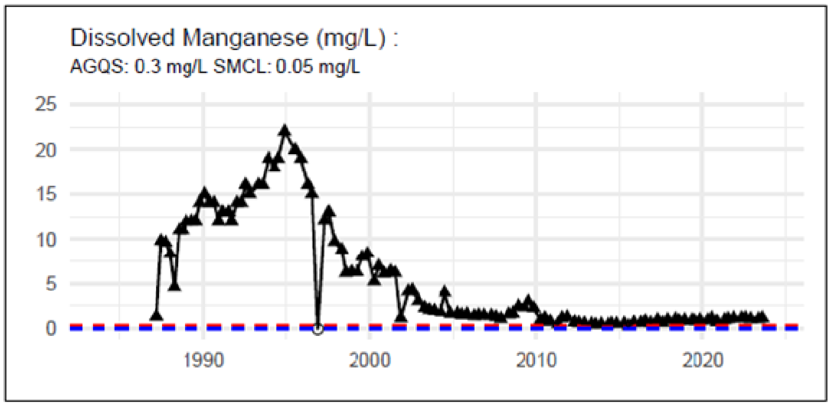
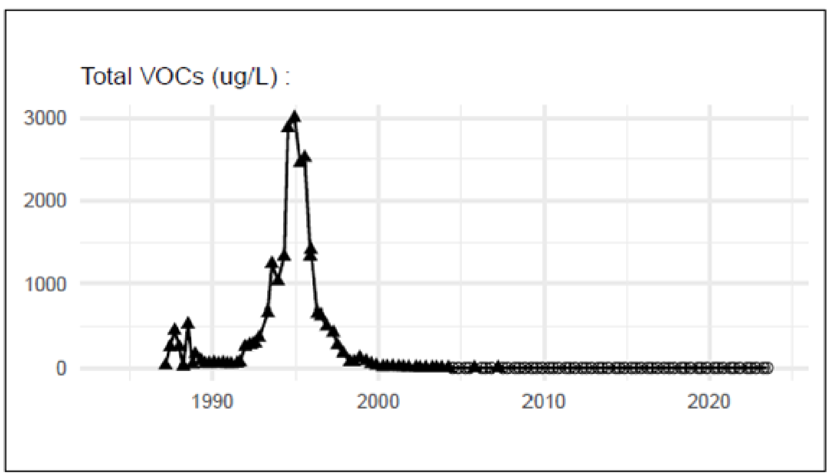
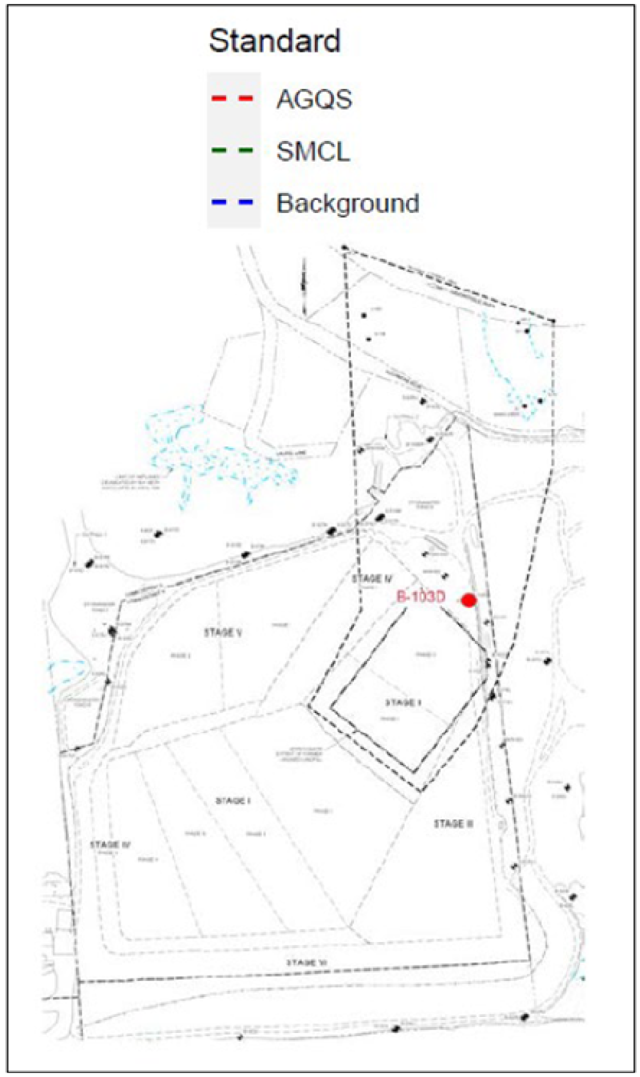
FIGURES









Notes: Plots taken from Page 283/483 of July "2023 Tri-Annnual/2023 Annual Water Quality Monitoring Results", August 2023, SHA.

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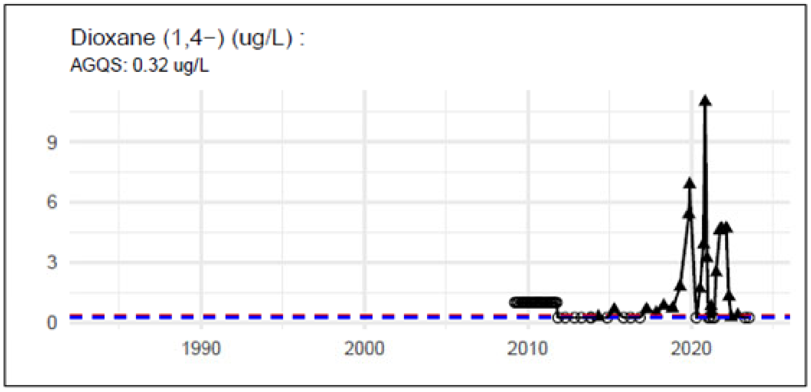
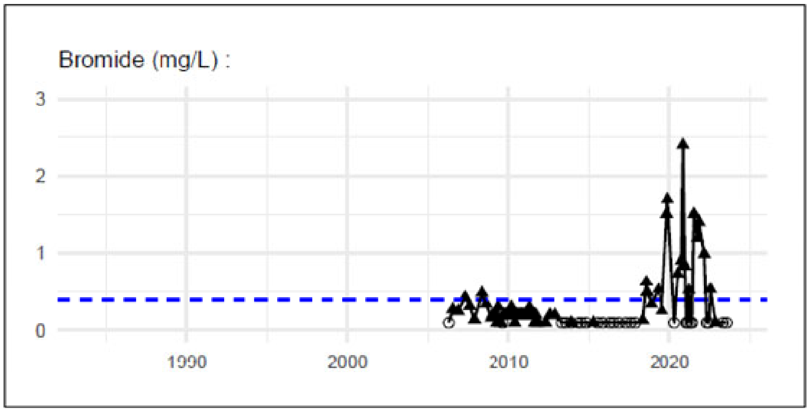
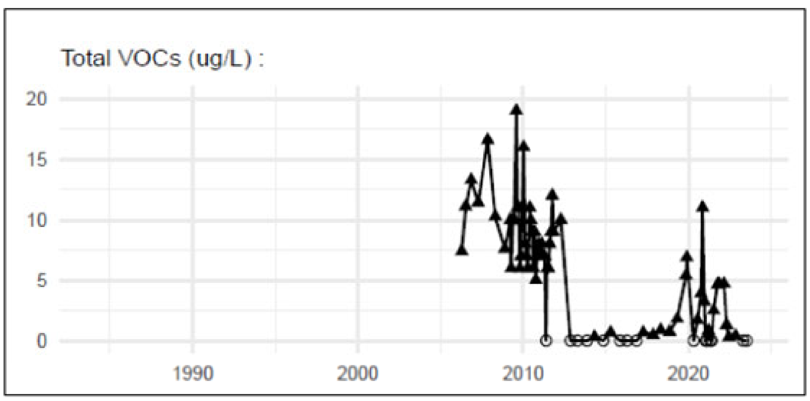
DES Site:

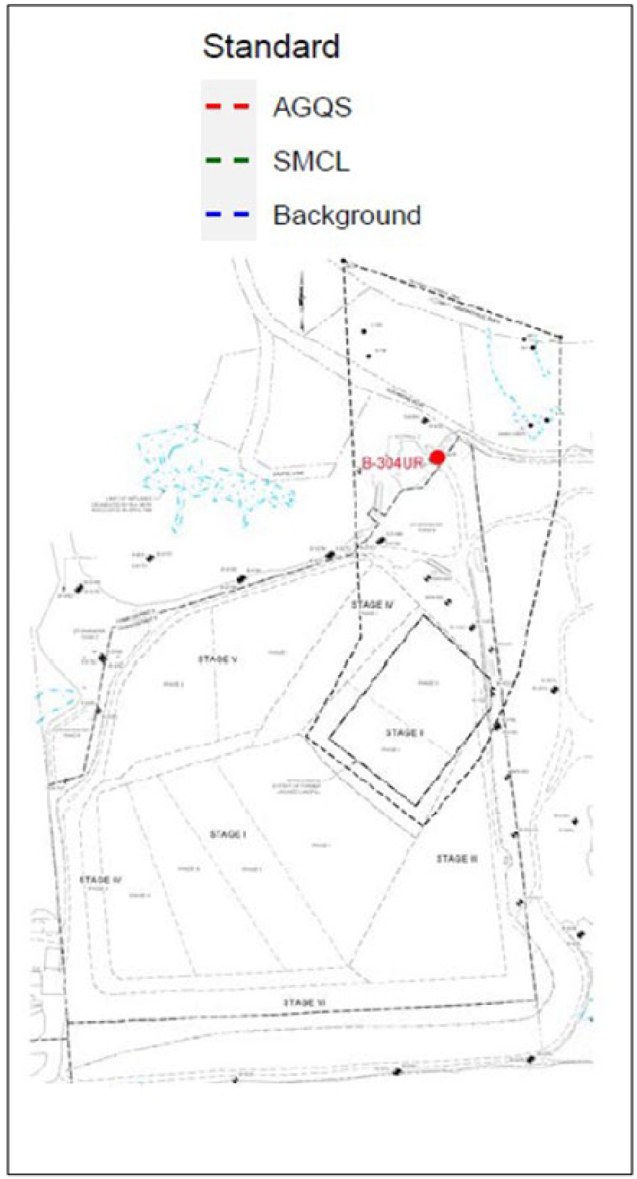
Example Trend Plots from B-103D for Releases from Sanco Landfill Excavation

SIZE	CALEX PROJECT	DWG NO	REV
		Figure 1	
Drawn By:	March 2024	SHEET	



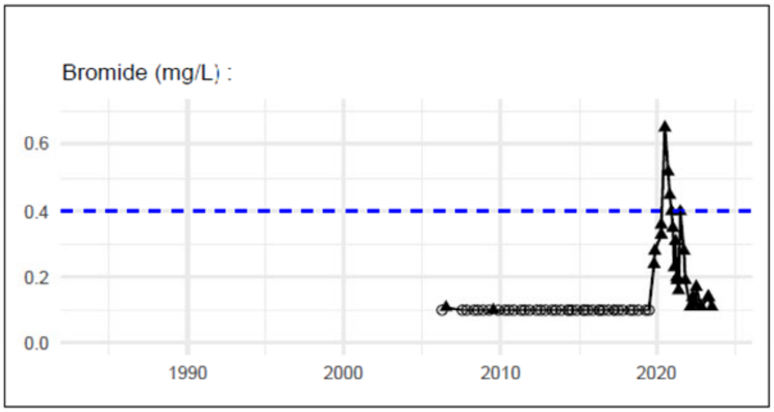


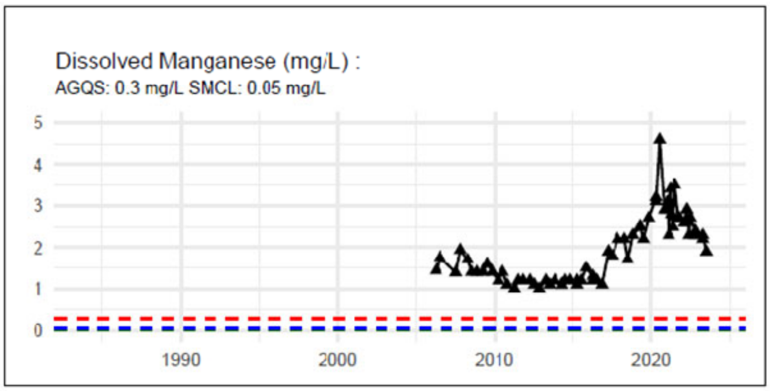


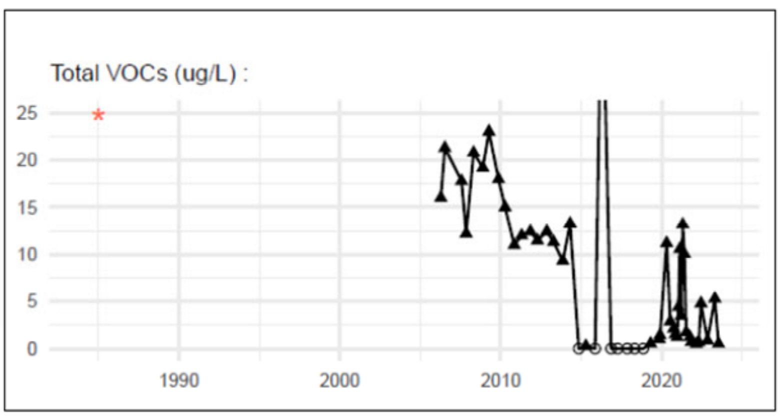


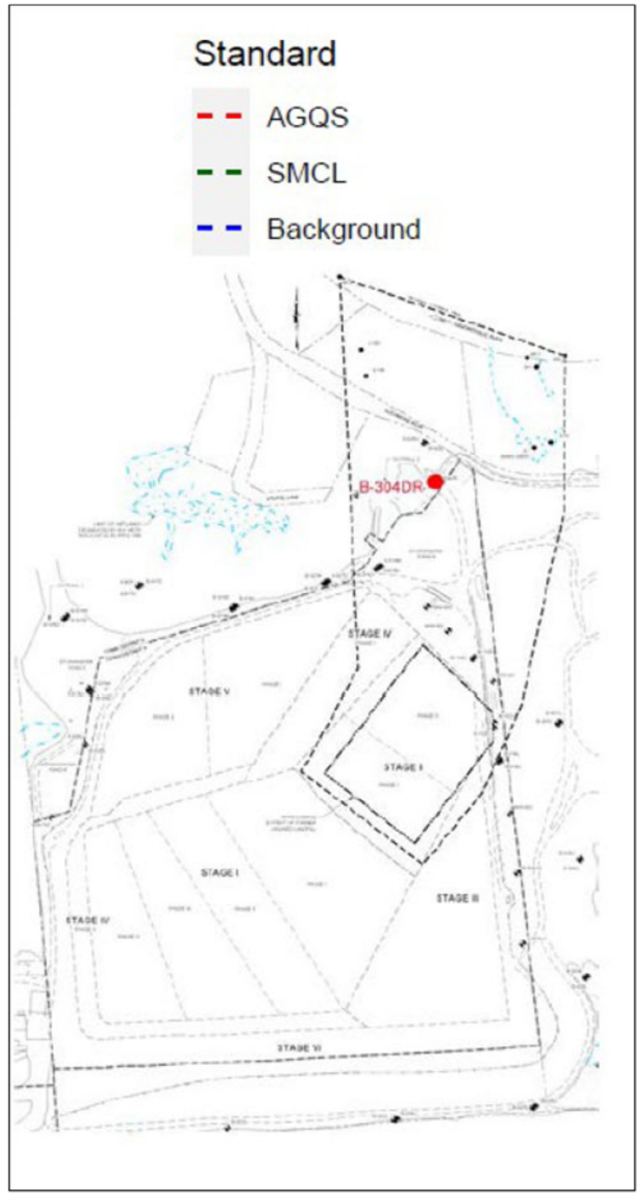
Notes: Plots taken from Page 269/483 of July "2023 Tri-Annnual/2023 Annual Water Quality Monitoring Results", August 2023, SHA.

calex Environmental Consulting	**Example Trend Plots from B-304UR for Releases from Post – 1996 Waste Disposal Operations**			
PO Box 236 Colebrook, NH 03576	SIZE	CALEX PROJECT	DWG NO **Figure 2**	REV
DES Site:	Drawn By:	March 2024	SHEET	









Notes: Plots taken from Page 270/483 of July "2023 Tri-Annnual/2023 Annual Water Quality Monitoring Results", August 2023, SHA.

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DES Site:

Example Trend Plots from B-304DR Showing Comingled Releases from Post – 1996 Operations

SIZE	CALEX PROJECT	DWG NO	REV
		Figure 3	

Drawn By:	March 2024	SHEET

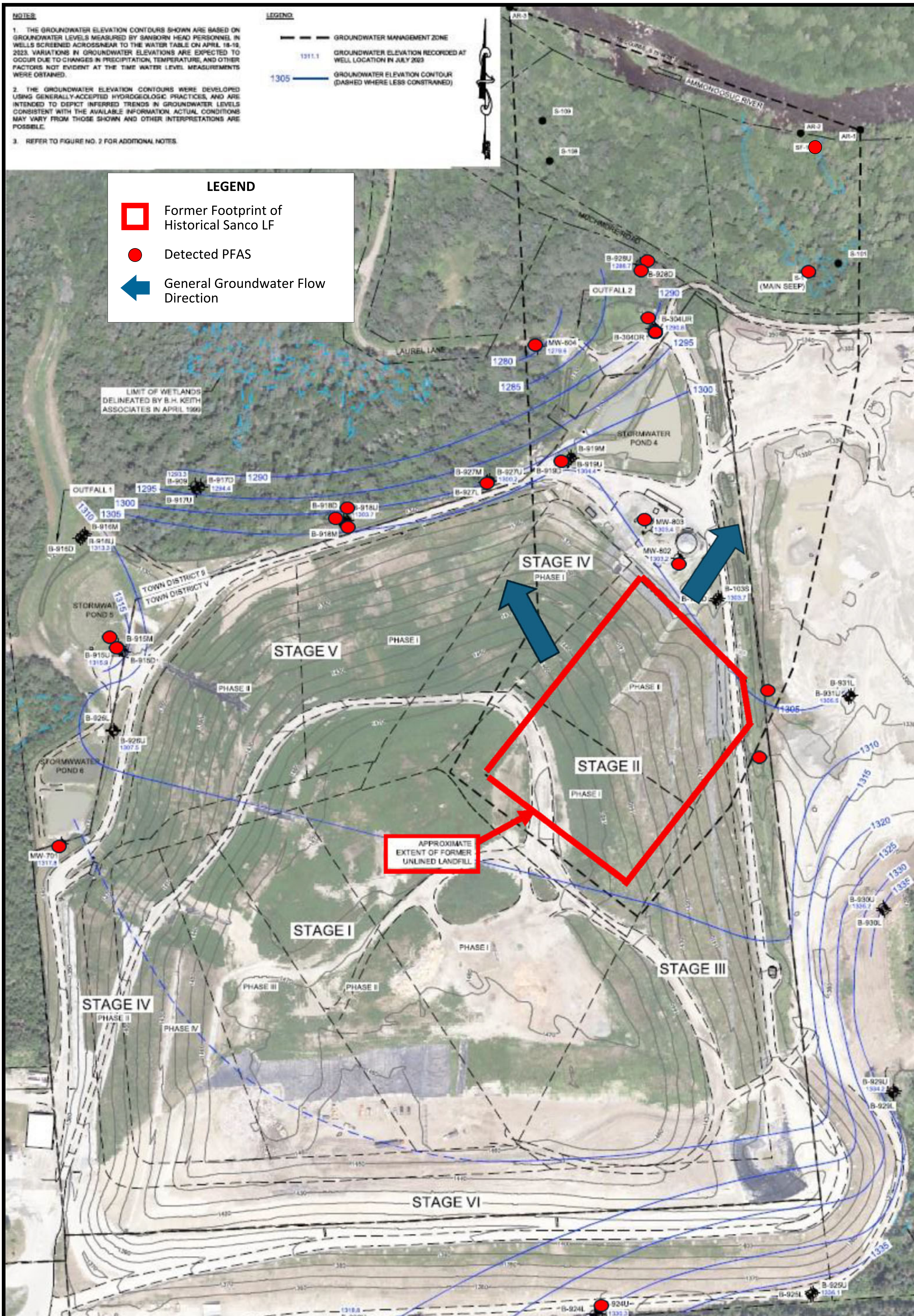

Figure taken from Sanborn Head & Associates (SHA), July 2023 Groundwater Elevation Contour Plan.
PFAS data from SHA, July 2023 Tri-Annual/2023 Annual Water Quality Monitoring Results.
SHA October 2023 SSI Surface Water PFAS Sampling Data Transmittal.

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DES Site:

PFAS DETECTIONS AT NCES LANDFILL SITE

SIZE	CALEX PROJECT	DWG NO	REV
		Figure 4	
Drawn By:	March 2024	SHEET	