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* Assessment Plan
Sept. 3rd, 1993

DAA Job No. 6520-13
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Watauga County LF

THE WATAUGA COUNTY LANDFILL
PERMIT NO. 95-02
ASSESSMENT PLAN

Prepared for Watauga County
Board of Commissioners

Prepared By
Draper Aden Associates

September 3, 1993

DAA Job No.
6520-13

NORTH CAROLINA PROFESSIONAL SEAL 8568 ENGINEER WILLIAM A. ADEN
9/3/93

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ENCLOSED:

AS SEPARATE:

I. INTRODUCTION

1.1 Consent Agreement

On July 7, 1993, Watauga County and the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR), Division of Waste Management, Solid Waste Section entered into a Consent Agreement, a copy of which is attached to this draft plan as Appendix IV. Under the Consent Agreement, the County agrees to take steps to determine the status of groundwater and surface water quality at and in the vicinity of its sanitary landfill.

Pursuant to the Consent Agreement, Watauga County has drafted the enclosed Watauga County Landfill Assessment Plan. The Assessment Plan has been prepared under the responsible charge of a North Carolina registered Professional Engineer at Draper Aden Associates. DAA has extensive experience providing consulting services to municipal solid waste facilities including site assessment, risk assessment, and remediation assessment of contaminated groundwater.

The Consent Agreement specifies that the objectives of the Assessment Plan shall be to determine the following:

a. The nature and concentration of the contamination in the ground and surface waters.
b. The horizontal and vertical extent of contamination ("the plumes") and the direction and rate of migration of the plumes in the groundwater.
c. The source(s) of contamination detected in ground and surface water.
d. Potential ground and surface water receptors that could be affected by the Watauga County landfill if identified as a source of contamination detected in ground and surface water.
e. The possible effects of the contaminated groundwater moving off-site.

The Assessment Plan shall also contain a detailed plan for the initial phase of the investigation and a strategy and timetable for accomplishing the overall goals of the water quality assessment.

Under the terms of the Consent Agreement the assessment plan must specify:

1. The procedures and methods necessary to determine fully flow direction and rate of movement of the groundwater and surface waters.

2. The methods and techniques to be used in defining the horizontal and vertical extent of the groundwater contaminant plumes.

3. The proposed number, location and depth of plume assessment wells. The proposal shall include a discussion of the reasons for the location and depth of each plume assessment monitoring well.

4. A ground and surface water sampling plan prepared in accordance with the North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities.

5. A ground and surface water analysis plan which specifies parameters to be tested for in the plume assessment wells and surface water samples, including detectable levels and appropriate test methods. Additionally, a description of chain-of-custody and the laboratory's quality control and quality assurance procedures shall be included. In implementing the plan, analytical results must be submitted to the Division within 30 calendar days of sample collection and must specify collection date and well numbers (with a corresponding map of the wells).

6. Evaluation procedures, including any use of previously gathered groundwater quality data.

7. The location of the nearest downstream surface water intake in the watershed, and the location of all groundwater wells within at least one half mile of the landfill site (which could be potentially impacted by the contaminant plumes).

8. A schedule for implementation of the work described in the Assessment Plan.

The Consent Agreement sets out the process by which the draft Assessment Plan will be reviewed, commented on and, if determined to be adequate, approved.

1.2 DOCUMENT ORGANIZATION

The Watauga County Landfill Assessment Plan document is organized into eight sections. The first section is this introduction. It includes the goals and objectives of the Assessment Plan. Section II presents a summary of all the available information on the Watauga County Landfill including history, waste and cover characterization, geology, hydrogeology, and a description and the results of past sampling and analysis activities.

Section III evaluates the existing information on the site. It also discusses the field investigations which are being conducted immediately prior to development of the Assessment Plan and which will help better understand the site dynamics. The conceptual site model and preliminary exposure assessment presented in Section III form the basis for the Assessment Plan work tasks presented in the following section.

Section IV and related appendices form the core of the proposed Assessment Plan. The primary focus of the Assessment Plan work tasks is the Groundwater and Surface Water Sampling and Analysis Plan (SAP). The SAP is included in the Appendix as a separate document.

Also included in the Appendix as a separate document is the Site Health and Safety Program (HASP). The primary focus of the HASP involves obtaining information concerning landfill gas and leachate generation and composition to protect against potential hazards and risks posed to technicians working around the landfill. The HASP will be updated as necessary during the implementation of the Assessment Plan to account for additional information, activities, and/or changing site conditions.

Leachate and landfill gas sampling as well as continuing waste investigations will be performed concurrent with the Groundwater and Surface Water Monitoring Program and are also covered in Section IV. Section IV additionally covers all the Quality Assurance/Quality Control (QA/QC) procedures that will be required for all Assessment Work Plan Tasks.

Contained within the presentation of Assessment Plan field activities is a discussion of analysis and data validation procedures as well as data evaluation criteria. Section IV concludes with a discussion of associated risk assessments and remediation evaluations.

Section V presents cost estimates for conducting the various components of the Assessment Work Plan including key assumptions used in preparing cost estimates.

Section VI presents a schedule for conducting the Assessment Plan work tasks.

Section VII presents an outline of project management activities such as staffing and coordination of Assessment Plan work task responsibilities.

The document concludes with Section VIII, which presents a bibliography referencing the documents utilized in preparing the Assessment Plan.

II. EVALUATION OF EXISTING DATA

2.1 SITE DESCRIPTION

The Watauga County Landfill is located off of US Highway 421, approximately 1 mile east of the Town of Boone limits (Figure 1). The Watauga County Landfill site encompasses approximately 100 acres of land situated roughly one half mile east of the South Fork of the New River and two miles west of the Blue Ridge Parkway. Approximately 20 acres of landfill property have been used for fill areas. Existing structures on the site include a baling facility, scale house, maintenance facility and the Watauga County Dog Pound (Figure 2).

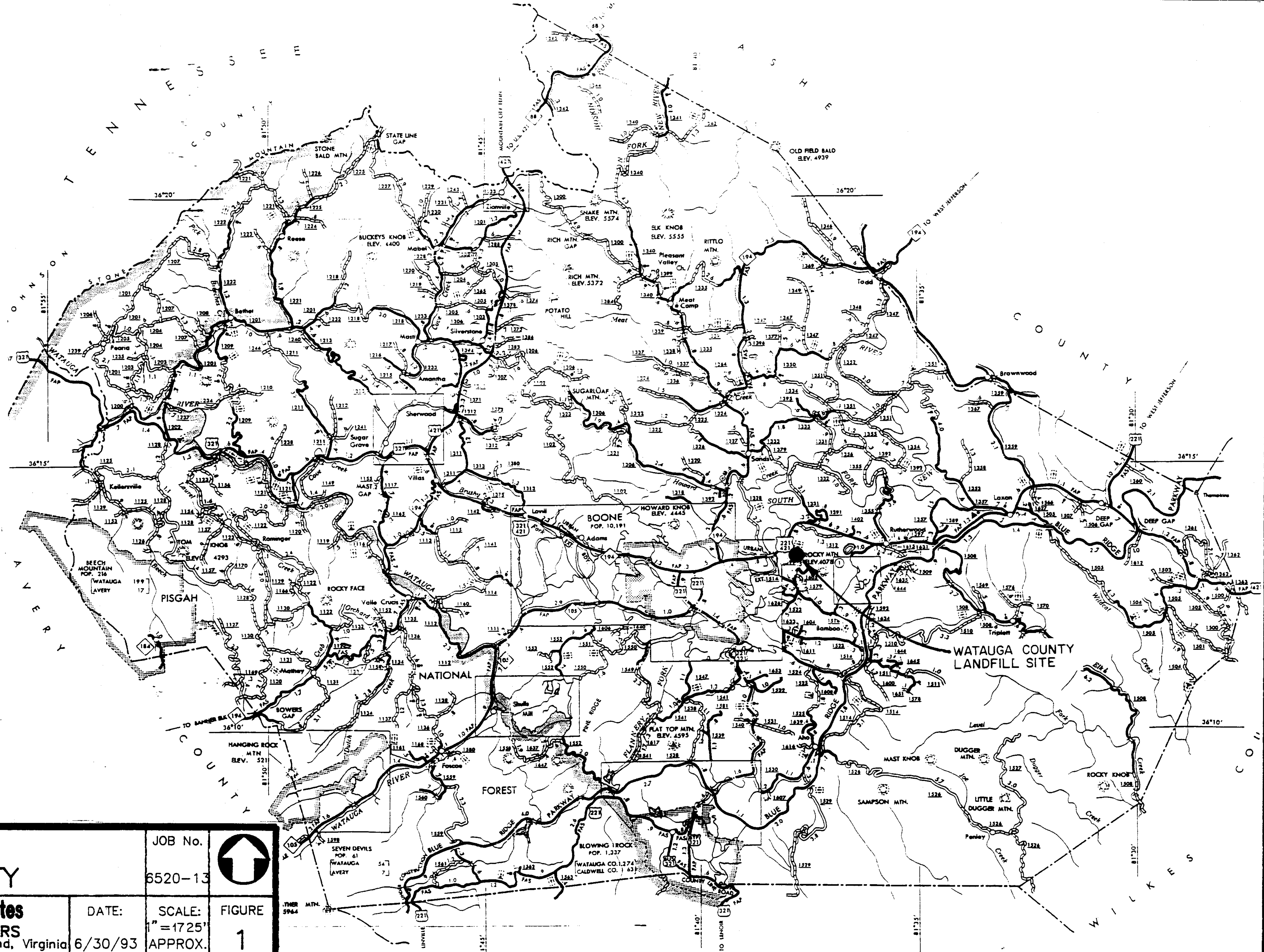
The landfill site was originally composed of several relatively steep hills with the disposal area residing at the head of a steep drainage within a natural bowl configuration. After approximately five decades of formal and informal waste disposal at the site, the head of the drainage has been filled with refuse. Principle contributors of waste to the Watauga County Landfill presently include Watauga County, the Town of Boone, the Town of Blowing Rock, and Appalachian State University. Industrial, commercial, and municipal waste are generally mixed throughout the fill area with the exception of debris waste which was generally restricted to the northeast section of the site. A small perennial drainage runs below the northeast section of the site eventually discharging into Rocky Branch one half mile from the south Fork of the New River.

The Watauga County Landfill, although originally located in an undeveloped portion of the County, currently is in an area experiencing increased growth as a result of development pressures from the expanding Town of Boone. Approximately 100 residences, including 2 trailer parks and six businesses, are currently located within one half mile of the site. In June of 1993, approximately 60 domestic water wells utilized groundwater resources within one-half mile of the site. A 10 acre rock quarry is also reported to be in operation, located within the half-mile radius, south of the landfill site. The Vicinity Map (Figure 3) depicts the locations of all appropriate features and structures located within a one half-mile radius of the landfill, including all residences and well heads.

2.2 SITE HISTORY

A summary of the landfill's history was compiled by conducting a preliminary review of relevant site records and correspondence for information regarding site operations, waste disposal practices, waste descriptions, and site engineering studies. An effort was also made to compile information obtained from local residents, historical aerial photographs, and the operations of parties who have contributed waste to the landfill. A summary of the site history follows.

Local residents indicate that the area encompassing the Watauga County Landfill property had been utilized as an open dump by the community residents apparently since the late 1930's or early 1940's. In approximately 1968, after the area was chosen by an Appalachian Regional Commission funded study as a favorable site for a regional landfill, the Town of Boone began managing waste disposal operations at the landfill site. A landfill site previously operated within the Town of Boone limits (currently on the campus of Appalachian State University) was



LOCATION MAP WATAUGA COUNTY		JOB No. 6520-13	
Draper Aden Associates CONSULTING ENGINEERS Blacksburg, Virginia – Richmond, Virginia Nashville, Tennessee	DATE: 6/30/93	SCALE: 1"=1725' APPROX.	FIGURE 1

Drawing Under Seperate Cover

abandoned at this time. On November 21, 1972, the State of North Carolina Solid Waste and Vector Control Section authorized the conversion of the waste disposal area to a permitted sanitary landfill. The Town of Boone operated under Permit No. 95-01 from November 21, 1972 to April 19, 1984.

Watauga County has operated a sanitary landfill at the site permitted to receive solid, non-hazardous waste for disposal under Solid Waste Permit No. 95-02 since April 19, 1984. Watauga County's Solid Waste Permit No, 95-02 was amended in November, 1986 and again in January, 1991, to allow a vertical expansion. In May, 1992, the County began utilizing a baler which compresses the waste into compact bales to allow for more efficient use of the vertical expansion.

After five decades of waste disposal at the site, approximately 15 acres of land have been utilized for the disposal of municipal, industrial, commercial, and domestic waste and approximately 5 acres of land have been used exclusively for the disposal of construction/demolition/debris waste.

2.3 WASTE CHARACTERIZATION

2.3.1 General Waste Composition

Landfill records for the site have been maintained by Watauga County since April 19, 1984. A review of the landfill records indicates that the landfill has accepted a variety of municipal, industrial, commercial, and domestic wastes. Waste generally has not been separated and has arrived from many locations within Watauga County by a variety of means. Consequently, industrial, commercial, municipal, and domestic wastes are mixed generally throughout the fill area.

Prior to 1965, the landfill was an unsupervised open dump. The steep ravine afforded a convenient location for disposing of waste. Large bulky items, such as automobiles, washing machines, etc., apparently were allowed to descend into the ravine while a majority of the refuse remained along the top of the topographic divide between the Bolick site and the landfill site. The use of the site as an open dump presents the possibility that hazardous substance disposal occurred during this time.

During the period from 1968 to 1984, few records were maintained or are available that document the composition of incoming waste. Inspections conducted during this time period by the Solid and Hazardous Waste Management Branches reveal that a lack of access control existed at the site. Lack of access control presents the possibility that hazardous substance disposal occurred during this time.

Currently, waste disposed of at the site consists primarily of typical domestic solid waste. The dominant component typical of domestic waste is paper, plastic, and glass. Domestic waste also may include common hazardous items, including paint cans, aerosols, degreasers, waste oil, batteries, and other domestically-generated hazardous items.

Industrial wastes have been generated primarily from industries located in the Town of Boone, and have been collected concurrent with domestic and commercial wastes prior to disposal.

2.3.2 Hazardous Waste Components

Continued characterization of hazardous components of waste disposed at the Watauga County Landfill, conducted concurrent with the implementation of the Assessment Plan, will assist in characterizing contaminant sources. Preliminary assessments of the waste composition indicate that no identifiable "hot spots" exist within the waste disposal area and that selective identification and removal of contamination sources is not a feasible alternative.

2.4 COVER CHARACTERIZATION

Prior to 1968, the landfill was an unsupervised open dump. Aerial photographs from 1955, 1958, and 1964 reveal signs of excavations undertaken along the topographic divide between the Bolick site and the landfill site. It is likely the excavations were either an attempt to cover existing waste or the creation of trenches for waste disposal. Thus, these excavations indicate some form of management of the landfill area, including an attempt to cover some waste, may have been undertaken during the 1950s and 1960s.

Between 1968 and 1984, State inspections identify various deficiencies related to disposal and cover procedures. Inspection reports show improper slopes and grades to waste disposal units and improper water drainage in and around the waste. These reports also note improper compacting of waste and failure to restrict waste to the smallest possible area, making the maintenance of suitable cover over the waste difficult. Daily cover apparently was not routinely applied. In addition, the reports indicate that off-site siltation prevention devices designed to forestall eroded cover from silting the stream below the fill areas were improperly administered, and on-site development of grasses to prevent erosion was neglected.

Since 1984, portions of the landfill have been closed out and are no longer used for fill activities. No final cap has been installed over previous waste disposal areas, but non-active portions of the landfill have been closed preliminarily by the application and grading of approximately two to four feet of cover. The active fill area currently is covered daily by six inches of soil. The operational face of the landfill is kept to a minimum by the use and effective placement of compacted bales of waste.

2.5 GEOLOGY

2.5.1 Regional Geology

Watauga County resides in the southeastern edge of the Blue Ridge belt geologic province in northwestern North Carolina. The Blue Ridge belt is composed primarily of 1,000-million to 1,100-million-year-old metamorphic and plutonic rocks. Near the southeastern edge of the Blue Ridge belt, the metamorphic bedrock has been thrust many miles northwestward across unmetamorphosed Cambrian sedimentary rocks.

In southwestern Watauga County, the Blue Ridge thrust sheet is breached by erosion, and the rocks beneath are exposed in the Grandfather Mountain window. The Watauga County Landfill resides on the Blue Ridge thrust sheet just northeast of the Grandfather Mountain window. A generalized regional geologic map and geologic cross-section of the Blue Ridge belt in the Grandfather Mountain window area as compiled by Bartholemew and Lewis is depicted in Figure 4.

The Blue Ridge thrust sheet surrounding the Grandfather Mountain window consists largely of schist, gneiss, and amphibolite and of Cranberry Gneiss. The schist, gneiss, and amphibolite were derived by metamorphism of sedimentary and volcanic rocks and the Cranberry Gneiss is a complex of migmatitic and granitic rocks which underlies the metasedimentary and metavolcanic rocks. The schist, gneiss, and amphibolite and the Cranberry Gneiss probably formed during the same metamorphic episode.

The rocks of the Blue Ridge thrust sheet moved northwestward at least 35 miles over the Grandfather Mountain window after the close of metamorphism 350 million years ago. Left-lateral strike-slip movement greater than 135 miles was concurrent with, but may have lasted somewhat longer than, thrusting. Mineral lineation, layering and foliation in rocks of the blue Ridge thrust sheet are generally subparallel to the fault structures originating from the thrusting. These structures are found to dip away from the Grandfather Mountain window on all sides and broad flexures in these structures plunge away from its northwest and northeast corners (Bryant and Reed, 1970).

2.5.2 Site Specific Geology

Within the context of the regional geologic map, the Watauga County Landfill is located within an assemblage of metamorphic and plutonic rocks referred to by Bartholemew and Lewis as the Watauga Massif. The regional geologic map depicts the Cranberry-Mine Layered Gneiss and small intrusion of late Precambrian plutonic rocks mapped as granitoids immediately southeast of the Town of Boone, North Carolina (Bartholemew and Lewis, 1984). This body of plutonic rocks is not included in more detailed mapping conducted by Bryant and Reed as depicted in Figure 5. An assemblage of a diverse group of rocks transitional between predominantly amphibolitic rocks and predominantly granitic Cranberry gneiss have been mapped by Bryant and Reed in a narrow belt that approximates the shape and orientation of the plutonic granitoid body depicted on the geologic map compiled by Bartholemew and Lewis.

This assemblage is mapped and referred to by Bryant and Reed as "mixed rocks". The "mixed rocks" assemblage is a narrow band less than one half mile wide between the low grade metamorphic rocks of the layered cataclastic Cranberry gneiss and the tectonically overlying medium grade amphibolite and hornblende gneiss. The mixed rocks consist of interlayered and intergrading amphibolite calc-silicate granofels, biotite-hornblende gneiss, hornblende-epidote-biotite gneiss, biotite-hornblende-plagioclase schist and gneiss, epidote-biotite-plagioclase schist and gneiss, and granitic gneiss ranging from quartz diorite to quartz monzonite. These rocks are mapped as a unit, the contacts of which are drawn at the first occurrence of layers of granitic rock in the amphibolitic on one side, and the place where granitic layers become dominant on the other side.(Bryant and Reed, 1970).

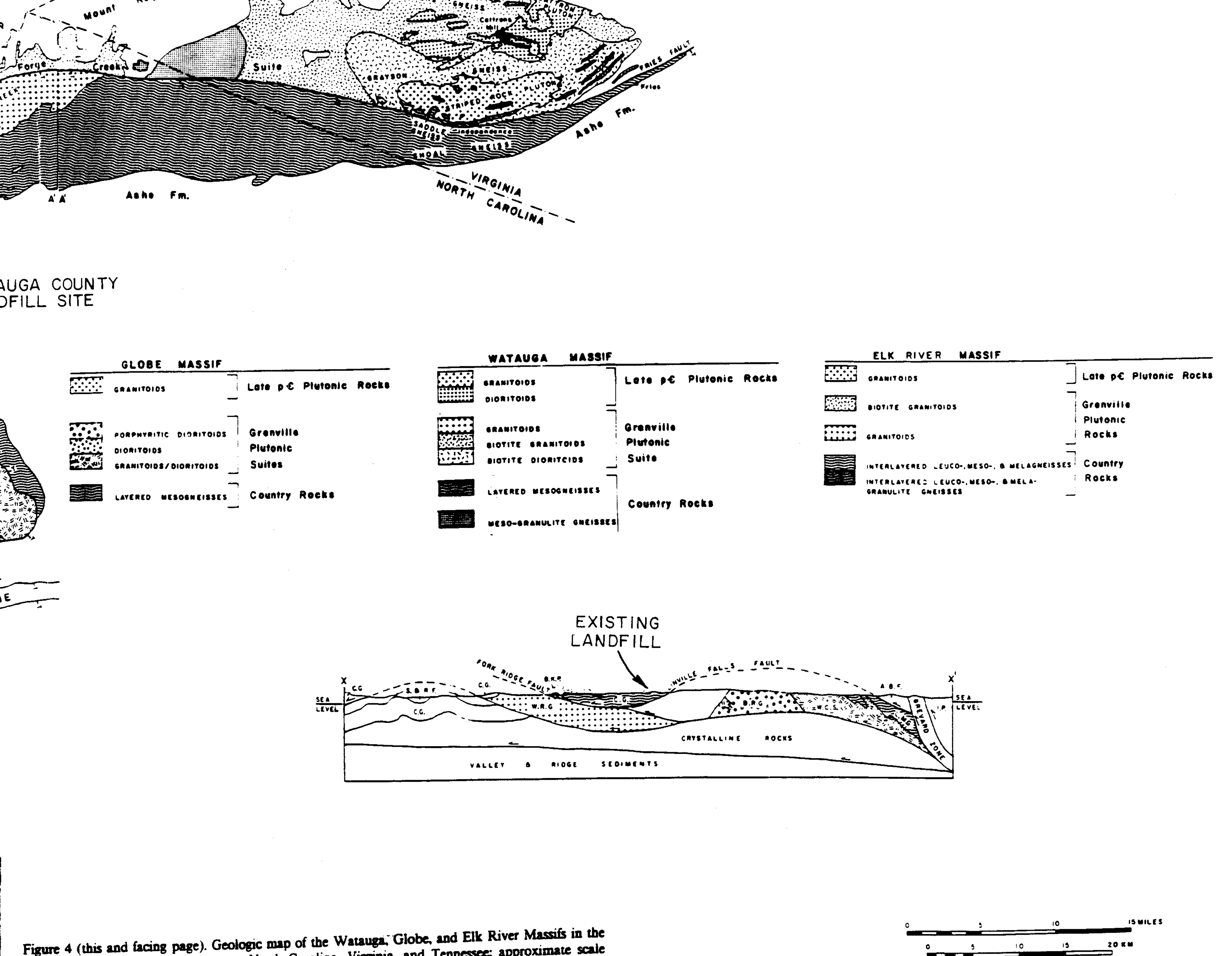


Figure 4 (this and facing page). Geologic map of the Watauga, Globe, and Elk River Massifs in the Grandfather Mountain window area, North Carolina, Virginia, and Tennessee; approximate scale 1:500,000.

Drawings Under Seperate Cover

All of the components of the mixed rock are of medium metamorphic grade and probably originated through incipient and local feldspathization of rocks similar to the adjacent amphibotite. Most, if not all of the strongly developed layering within the mixed rocks has been produced by shearing of migmatitic layering. The most strikingly layered rocks are the most sheared. Less sheared rocks are generally more granitic and have a migmatitic aspect. The mixed rocks appear to be a gradation zone between migmatitic Cranberry Gneiss and schist, gneiss, and amphibolite, all of which underwent subsequent metamorphism (Bryant and Reed, 1970).

The mapped contact between the "mixed rocks" and the predominantly amphibolitic rocks is located directly beneath the Watauga County Landfill trending along a series of previously documented springs that have subsequently been buried by landfill activities. This contact trends in a northwesterly direction along the central drainage of the Bolick site and trends in a southwesterly direction along the toe of the slope of Rocky Knob, located above the Rocky Heights Subdivision. The contact along the toe of the slope of Rocky Knob is again characterized by a series of springs.

2.6 HYDROGEOLOGY

2.6.1 Surface Water

The Watauga County Landfill site resides within the watershed of the South Fork of the New River. The area of the watershed potentially influenced by the site is comprised of the following three (3) primary drainages:

- the unnamed tributary of Rocky Branch located directly below the surficial drainage of the fill area
- the unnamed drainage located below the Bolick Site and
- the unnamed tributary of Mutton Creek located within the Rocky mountain Heights subdivision

The unnamed tributary of Rocky Branch is the only drainage directly influenced by surface flow from the fill area. The other two drainages may only be influenced by subsurface flow from the fill area.

2.6.2 Groundwater

Two primary aquifer systems exist beneath the Watauga County Landfill property, an unconfined soil aquifer and a fractured bedrock aquifer. Wells installed in the two aquifer systems reveal that the potentiometric surface is similar at variable aquifer depths of groundwater encountered. The shared potentiometric surface suggests that soil and fracture water production zones may be somewhat interconnected by hydraulically conductive fractures, joints, and/or shear zones. The shared potentiometric surface of the soil and fracture aquifer system is presented in Figure 6.

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The fracture system aquifer extent is largely governed by its global geometry within the regional bedrock. The continuous and/or discontinuous nature of core fracture zones within the regional bedrock dictates the aquifer system's extent. The fracture system aquifer appears to possess considerable lateral and vertical extent. Some of the groundwater from the fracture system is discharged to the soil at lower elevations where it eventually migrates to the South Fork of the New River and its tributaries. The domains and core regions of the soil and fracture aquifer system is presented in the Conceptual Site Model (Figure 7).

Within the fractured bedrock, a succession of interconnected discontinuities supply groundwater at various depths. Wells installed within this fracture systems have documented water production zones occurring at variable depths from 40 to 400 feet from the surface. The primary permeability of the unfractured metamorphic rock is likely <2%. Because of the pressures of the overlying bedrock, fracture occurrence and permeability generally decrease with depth.

A review of over sixty wells installed within the bedrock aquifer system in the vicinity of the site reveals that greater than 90% of the wells encountered sufficient water production zones before reaching depths of 200 feet from the ground surface. Although some wells were drilled to depths of 500 to 600 feet from the surface, no wells access water production zones beyond 400 feet in depth. Attempts to install some of the wells in the vicinity of the site have not encountered sufficient water production zones after reaching depths of 500 to 600 feet from the surface.

The discontinuities within the bedrock owe their origin to stresses related to thrust faulting and therefore are not likely to be horizontally oriented, although they may have a rather continuous lateral extent. The resulting fracture flow directions are not necessarily the flow directions suggested by the potentiometric flow gradient, but rather flow patterns determined by fracture orientation. These flow patterns, can however, be generally predicted by overall drainage characteristics of the area.

During the Bolick site investigation, a variety of aquifer tests were performed on the network of monitoring wells and piezometers at the Watauga County Landfill property. The information derived from the aquifer tests is presented in Section 3.1.8 of this Assessment Plan. Estimates of variable flow rates within the interconnected aquifer system beneath the site are utilized in Section 3.1.8 to define a preliminary model of the fracture aquifer system's global geometry.

2.7 NCDEHNR REGULATED LANDFILL SAMPLING AND ANALYSIS RESULTS

2.7.1 Surface Water Analysis

A variety of leachate and stream sampling events have been conducted at the landfill since July, 1980 by both the state and landfill representatives. Leachate and stream water quality analyses were originally initiated as a result of routine state inspections. Beginning in December of 1990, stream and leachate sampling and analysis were incorporated as part of the routine sampling scheduled at the landfill.

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The absence of a documented analysis plan prior to December, 1990, resulted in analytical parameters varying considerably among different sampling events. Documentation regarding sampling locations for specific sampling events is often inconclusive.

Twenty three (23) of the most common leachate and surface water analysis parameters and analysis results compiled since July 1980 are presented in Table 1. The parameters presented in the summary table duplicate the inorganic and indicator parameters required for routine, annual groundwater monitoring by the current North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities (1987, SW-1001-87). The leachate and surface water analysis summary table is presented only to provide an indication of past evaluation efforts and is not intended to be utilized as a basis of future Assessment Plan investigations. A discussion of leachate and stream sampling and analysis results is contained in Section 3.1.4.

2.7.2 Groundwater Analysis

NCDEHNR regulated groundwater sampling and analysis was initiated at the landfill on March 29, 1988 with the sampling of four recently installed monitoring wells. Two of the landfill's current monitoring well network's monitoring points, MW-1 and MW-2, were sampled on this day. The other two wells sampled during this event were located in the general area of the current monitoring well MW-3 but were subsequently abandoned due to the construction of a clay berm along the property boundary below the Bolick site.

The next groundwater sampling event was conducted on April 4, 1989, and encompassed the current Watauga County Landfill Monitoring Well Network of MW-1, MW-2, MW-3, and MW-4. The locations of the monitoring wells are depicted on the Site Map (Figure 2). A summary of monitoring well completion data is presented in Table 2.

Sampling and analysis of the current monitoring well network has been performed annually since 1989. A compilation of all the routine regulated groundwater sampling and analysis results conducted on the current Watauga County Landfill Monitoring Well Network is presented in Table 3. Since 1989, all routine regulated groundwater sampling performed by Watauga County has been conducted by Engineering Tectonics, located in Winston-Salem, North Carolina. Analyses have been conducted by an assortment of labs contracted through Engineering Tectonics. Analytical labs are specified in the footnotes of the summary tables (Table 3).

Review of the summary tables of the regulated groundwater sampling and analysis indicates that monitoring wells MW-2 and MW-3 are the most impacted wells in the monitoring well network. MW-4, however, is not as significantly impacted and MW-1, the upgradient well in the network does not conclusively appear to be impacted at all. Recent sampling in August, 1993 indicated the dog pound well at the landfill was not impacted by VOC's. The indicator parameters, Conductivity and Total Organic Halides (TOX) reveal the most evident signs of contamination occurring in monitoring wells MW-2 and MW-3. The metal parameters, Barium, Iron, Manganese, Cadmium and Zinc, although showing high concentrations on specific sampling events, do not reflect a clear pattern of contamination. Metal concentrations are sporadic and levels are often as high in monitoring wells MW-1 and MW-4 as in MW-3 and MW-2.

TABLE 1A
LANDFILL STREAM AND LEACHATE ANALYSIS SUMMARY
INORGANIC AND INDICATOR ANALYSIS

WATAUGA COUNTY LANDFILL
BOONE, NC

Parameters	Date	Leachate	Stream
pH (s.u.)	07/17/80	6.1	6.8
	09/30/80	6.3	
	08/10/82	6.7	
	03/08/83		6.8
	06/21/84		6.8
	03/08/89	6.7	
	04/04/89		7.9
	05/09/90		6.3
	12/11/90		
	12/11/90	6.6	7.1
	12/11/91	6.6	7.6
	06/25/92	6.42	7.52
Conductivity (umhos/cm)	07/17/80		
	09/30/80		
	08/10/82	610	
	03/08/83		350
	06/21/84		500
	03/08/89	740	
	04/04/89		340
	05/09/90		
	12/11/90		
	12/11/90	680	420
	12/11/91	670	520
	06/25/92	770	450
TOC (mg/L)	07/17/80		
	09/30/80		
	08/10/82	57	
	03/08/83		35.2
	06/21/84		36
	03/08/89	21	
	04/04/89		3.1
	05/09/90		1.4
	12/11/90	5.81	4.67
	12/11/90	18	9
	12/11/91	12	7
	06/25/92	12	3.2
TOX (mg/L)	07/17/80		
	09/30/80		
	08/10/82		
	03/08/83		
	06/21/84		
	03/08/89		
	04/04/89		< 0.001
	05/09/90		0.077
	12/11/90	0.08	0.066
	12/11/90		
	12/11/91	0.034	0.014
	06/25/92	0.016	0.016
Chloride (mg/L)	07/17/80	82.81	1.28
	09/30/80		
	08/10/82	67	
	03/08/83		27
	06/21/84		49
	03/08/89	84	
	04/04/89		53
	05/09/90		200
	12/11/90	51.5	42
	12/11/90	26	42
	12/11/91	24	29
	06/25/92	74	42

Parameters	Date	Leachate	Stream
Flouride (mg/L)	07/17/80	0.11	< 0.05
	09/30/80		
	08/10/82	< 0.1	
	03/08/83		< 0.1
	06/21/84		< 0.1
	03/08/89		
	04/04/89		0.1
	05/09/90		< 0.15
	12/11/90	< 0.1	< 0.1
	12/11/90	< 0.1	< 0.1
	12/11/91	0.15	0.15
	06/25/92	0.062	0.057
BOD (mg/L)	07/17/80	49	5
	09/30/80		
	08/10/82	107	
	03/08/83		
	06/21/84		
	03/08/89		
	04/04/89		4.8
	05/09/90		28
	12/11/90	7	2.5
	12/11/90		
	12/11/91	16	1.9
	06/25/92	20	1.4
COD (mg/L)	07/17/80	178.9	6.9
	09/30/80	460	740
	08/10/82		
	03/08/83		
	06/21/84		
	03/08/89		
	04/04/89		10
	05/09/90		37
	12/11/90	30.6	24.5
	12/11/90	16	16
	12/11/91	85	10
	06/25/92	47	16
TDS (mg/L)	07/17/80		
	09/30/80		
	08/10/82	386	
	03/08/83		208
	06/21/84		296
	03/08/89	360	
	04/04/89		231
	05/09/90		410
	12/11/90	299	209
	12/11/90	324	204
	12/11/91	360	280
	06/25/92	380	250
Nitrate-N (mg/L)	07/17/80		
	09/30/80		
	08/10/82	0.75	
	03/08/83		< 0.05
	06/21/84		< 1
	03/08/89	< 1	
	04/04/89		0.12
	05/09/90		< 0.05
	12/11/90	0.11	0.29
	12/11/90	< 1	< 1
	12/11/91	0.1	0.21
	06/25/92	0.14	0.16

TABLE 1A(Cont.)
LANDFILL STREAM AND LEACHATE ANALYSIS SUMMARY
INORGANIC AND INDICATOR ANALYSIS

WATAUGA COUNTY LANDFILL
BOONE, NC

Parameters	Date	Leachate	Stream
Sulphates (mg/L)	07/17/80		
	09/30/80		
	08/10/82	6	
	03/08/83		9
	06/21/84		5
	03/08/89	< 30	
	04/04/89		8
	05/09/90		7.2
	12/11/90	8.6	4.5
	12/11/90	6	5
	12/11/91	5.2	2.1
	06/25/92	13	11
Arsenic (mg/L)	07/17/80	< 0.0005	< 0.0005
	09/30/80		
	08/10/82	< 0.1	
	03/08/83		< 0.01
	06/21/84		< 0.01
	03/08/89	< 0.01	
	04/04/89		0.005
	05/09/90		< 0.05
	12/11/90	< 0.003	< 0.003
	12/11/90	< 0.01	< 0.01
	12/11/91	0.021	< 0.01
	06/25/92	< 0.01	< 0.01
Barium (mg/L)	07/17/80	< 0.01	< 0.01
	09/30/80	< 0.01	
	08/10/82	0.6	
	03/08/83		0.2
	06/21/84		0.4
	03/08/89	0.4	
	04/04/89		0.18
	05/09/90		0.38
	12/11/90	0.35	0.26
	12/11/90	0.53	0.29
	12/11/91	0.6	0.3
	06/25/92	0.97	0.29
Cadmium (mg/L)	07/17/80	< 0.002	< 0.002
	09/30/80	< 0.05	
	08/10/82	< 0.005	
	03/08/83		< 0.005
	06/21/84		< 0.005
	03/08/89	< 0.005	
	04/04/89		< 0.002
	05/09/90		< 0.01
	12/11/90	< 0.01	< 0.01
	12/11/90	< 0.005	< 0.005
	12/11/91	< 0.005	< 0.005
	06/25/92	< 0.005	< 0.005
Chromium (mg/L)	07/17/80	< 0.02	< 0.02
	09/30/80	< 0.07	
	08/10/82	< 0.01	
	03/08/83		1.02
	06/21/84		< 0.01
	03/08/89	< 0.01	
	04/04/89		< 0.005
	05/09/90		< 0.05
	12/11/90	< 0.02	< 0.02
	12/11/90	< 0.01	< 0.01
	12/11/91	< 0.05	< 0.05
	06/25/92	< 0.05	< 0.05

Parameters	Date	Leachate	Stream
Copper (mg/L)	07/17/80	0.03	< 0.01
	09/30/80	0.04	0.04
	08/10/82	< 0.05	
	03/08/83		< 0.05
	06/21/84		< 0.05
	03/08/89	< 0.05	
	04/04/89		< 0.005
	05/09/90		< 0.05
	12/11/90	< 0.01	< 0.01
	12/11/90	< 0.05	< 0.05
	12/11/91	< 0.05	< 0.05
	06/25/92	< 0.05	< 0.05
Iron (mg/L)	07/17/80	76.1	0.02
	09/30/80	60	
	08/10/82	34.7	
	03/08/83		3.2
	06/21/84		1.91
	03/08/89	18.84	
	04/04/89		3.3
	05/09/90		10
	12/11/90	15.5	12
	12/11/90	20.44	10.44
	12/11/91	45	14
	06/25/92	66	15
Lead (mg/L)	07/17/80	< 0.05	< 0.05
	09/30/80	< 0.01	
	08/10/82	< 0.03	
	03/08/83		< 0.03
	06/21/84		< 0.03
	03/08/89	< 0.03	
	04/04/89		0.03
	05/09/90		< 0.05
	12/11/90	< 0.003	0.0127
	12/11/90	< 0.005	< 0.005
	12/11/91	< 0.05	< 0.05
	06/25/92	< 0.05	< 0.05
Mercury (mg/L)	07/17/80	< 0.0002	< 0.0002
	09/30/80	< 0.0005	
	08/10/82	< 0.0002	
	03/08/83		< 0.0002
	06/21/84		< 0.0002
	03/08/89	< 0.002	
	04/04/89		< 0.001
	05/09/90		< 0.002
	12/11/90	< 0.0001	< 0.0001
	12/11/90	< 0.0002	< 0.0002
	12/11/91	< 0.0011	< 0.0011
	06/25/92	< 0.0011	< 0.0011
Manganese (mg/L)	07/17/80	6.75	< 0.01
	09/30/80	4.8	
	08/10/82	3.6	
	03/08/83		2.72
	06/21/84		3.25
	03/08/89	1.03	
	04/04/89		1.4
	05/09/90		< 0.015
	12/11/90	0.953	2.18
	12/11/90	1.64	2.38
	12/11/91	3.2	3
	06/25/92	3.3	2.4

TABLE 1A(Cont.)
LANDFILL STREAM AND LEACHATE ANALYSIS SUMMARY
INORGANIC AND INDICATOR ANALYSIS

WATAUGA COUNTY LANDFILL — 07/21/93
BOONE, NC —

Parameters	Date		Leachate		Stream
Silver	07/17/80	<	0.01	<	0.01
(mg/L)	09/30/80	<	0.05	<	0.05
	08/10/82	<	0.02		
	03/08/83			<	0.05
	06/21/84			<	0.05
	03/08/89	<	0.05		
	04/04/89			<	0.003
	05/09/90			<	0.05
	12/11/90	<	0.0005	<	0.0005
	12/11/90	<	0.05	<	0.05
	12/11/91	<	0.04	<	0.04
	06/25/92	<	0.05	<	0.05
Selenium	07/17/80	<	0.0005	<	0.0005
(mg/L)	09/30/80				
	08/10/82	<	0.005		
	03/08/83			<	0.005
	06/21/84			<	0.005
	03/08/89				
	04/04/89			<	0.002
	05/09/90			<	0.01
	12/11/90	<	0.006	<	0.006
	12/11/90	<	0.005		
	12/11/91	<	0.01	<	0.01
	06/25/92	<	0.01	<	0.01
Zinc	07/17/80		0.028		0.003
(mg/L)	09/30/80		0.17		
	08/10/82	<	0.05		
	03/08/83				0.08
	06/21/84			<	0.05
	03/08/89	<	0.05		
	04/04/89				0.003
	05/09/90				0.17
	12/11/90		0.015		0.016
	12/11/90	<	0.05	<	0.05
	12/11/91		0.022		0.031
	06/25/92		0.11		0.031

Footnotes:

1)Blanks indicate either no sampling event conducted or no analysis done.
2)Values less than detection, denoted by "<", are reported at 1/2 the detection value.

07/17/80 - Samples collected and analyzed by PAR Laboratories, Charlotte, NC.

09/30/80 - Samples collected and analyzed by the NC Dept. of Natural Resources, Solid Waste Branch.

08/10/82, 03/08/83, 06/21/84, 03/08/89, 12/11/90 - Samples collected by the NC Dept. of Human Resources, Solid Waste Branch and analyzed by the NC State Laboratory of Public Health.

04/04/89 - Samples collected by Engineering Techtonics, NC. and analyzed by Black & Veatch, Inc. Charlotte, NC.

12/11/90 - Split Sample taken by Engineering Techtonics, NC. and analyzed by Normandeau Associates, Inc.

05/09/90, 12/11/91, 06/25/92 - Samples collected by Engineering Techtonics, NC. and analyzed by Analytikem, Inc. NJ.

TABLE 1B
LANDFILL STREAM AND LEACHATE ANALYSIS SUMMARY
VOLATILE ORGANIC ANALYSIS

WATAUGA COUNTY LANDFILL
BOONE, NC

07/21/93
Page 4 of 4

		Concentrations (ug/L)	
Parameters	Date	Leachate	Stream
chloroethane	03/08/89	231	*
	05/09/90	*	120
	12/11/90	146	ND
methylene chloride	03/08/89	J 4	*
	05/09/90	*	4.7
	12/11/90	J 2	ND
1,1-dichloroethane	03/08/89	51	*
	05/09/90	*	12
	12/11/90	21	ND
1,2-trans-dichloroethene	03/08/89	16	*
	05/09/90	*	1.6
	12/11/90	ND	ND
1,2-dichloroethane	03/08/89	J 1	*
	12/11/90	ND	ND
1,1,1-trichloroethane	03/08/89	J 1	*
	12/11/90	5	ND
1,2-dichloropropane	03/08/89	trace	*
	12/11/90	ND	ND
trichloroethylene	03/08/89	J 3	*
	12/11/90	ND	ND
benzene	03/08/89	J 3	*
	12/11/90	trace	ND
tetrachloroethene	03/08/89	J 1	*
	12/11/90	ND	ND
toluene	03/08/89	20	*
	12/11/90	J 4	ND
chlorobenzene	03/08/89	trace	*
	12/11/90	ND	ND
ethylbenzene	03/08/89	6	*
	12/11/90	trace	ND
2-butanone	03/08/89	5	*
	12/11/90	ND	ND
4-methyl-2-pentanone	03/08/89	5	*
	12/11/90	ND	ND
xylenes	03/08/89	30	*
	12/11/90	trace	ND

Footnotes:

"J" - Lab Estimated Value
"ND" - Material was analyzed for but not detected
"*" - Indicates sampling was not preformed on that date.

03/08/89 - Samples collected by the NC Dept. of Human Resources,
12/11/90 Solid Waste Branch and analyzed by the NC State Laboratory of Public Health.

05/09/90 - Samples collected by Engineering Techtonics, NC. and analyzed by Analytikem, Inc. NJ.

TABLE 2

Watauga County Landfill, Monitoring Well Completion Data

All measurements are in feet and elevations are in feet above sea level.

Existing Monitoring Wells

Well No.	Ground Elevation	Casing Elevation	SWL* Elevation	SWL*	Total Depth*	Screen Length Depth Interval**	Filter Packing Depth Interval**	Annular Seal Depth Interval**	Screened in Soil or Bedrock
MW-1	3339.03	3341.50	3304.59	36.91	76.65	80.0-70.0	85.0-48.0	48.0-46.0	Bedrock
MW-2	3151.24	3152.73	3145.80	6.93	177.50	180.0-170.0	185.0-168.0	168.0-166.0	Bedrock
MW-3	3182.25	3183.06	3164.46	18.60	39.60	42.0-32.0	42.0-30.0	30.0-28.0	Soil
MW-4	3150.06	3151.52	3141.71	9.81	29.40	32.0-22.0	32.0-21.0	20.0-18.0	Soil

Proposed Monitoring Wells installed in August,1992

Well No.	Ground Elevation	Casing Elevation	SWL* Elevation	SWL*	Total Depth*	Screen Length Depth Interval**	Filter Packing Depth Interval**	Annular Seal Depth Interval**	Screened in Soil or Bedrock
MW-5 (PZ-19)	3263.81	3266.86	3216.11	50.75	73.0	73.0-63.0	63.0-61.0	61.0-59.0	Bedrock
MW-6 (PZ-24)	3262.55	3265.15	3223.19	41.96	58.0	58.0-48.0	58.0-46.0	46.0-44.0	Bedrock
MW-7 (PZ-25)	3270.56	3273.61	3246.46	27.15	50.0	50.0-40.0	50.0-38.0	38.0-36.0	Bedrock

*As recorded from top of well casing on September 9, 1992
**As recorded from ground elevation

Survey by Draper Aden Associates, September 10, 1992

WATAUGA COUNTY LANDFILL
BOONE, NC

PHASE I MONITORING RESULTS
Upgradient Well(s): MW-1

TABLE 3
GROUNDWATER INORGANIC AND INDICATOR ANALYSIS SUMMARY

		pH - (s.u.)					Specific Conductivity - (umhos/cm)				
		Field Replicates					Field Replicates				
WELL ID	DATE	A	B	C	D	Average	A	B	C	D	Average
MW-1	03/29/88	9.45	9.95	9.65	#	9.68	125	143	125	#	131
	04/04/89	6.70	6.70	6.70	6.70	6.70	60	60	60	60	60
	05/09/90	5.90	5.90	5.90	5.90	5.90	#	#	#	#	
	12/11/90	#	#	#	#		#	#	#	#	
	12/11/91	6.30	6.30	6.30	6.30	6.30	79	79	79	79	79
	06/25/92	6.44	6.44	6.44	6.44	6.44	120	120	120	120	120
	09/10/92	7.72	7.51	7.34	7.11	7.42	114	92	93	92	98
	11/18/92	6.87	6.90	6.86	6.80	6.86	98	96	95	94	96
MW-2	03/29/88	7.50	7.45	7.40	#	7.45	133	115	111	#	120
	04/04/89	8.10	8.10	8.10	8.10	8.10	190	190	190	190	190
	05/09/90	7.50	7.50	7.50	7.50	7.50	#	#	#	#	
	12/11/90	#	#	#	#		#	#	#	#	
	12/11/91	6.40	6.40	6.40	6.40	6.40	140	140	140	140	140
	06/25/92	7.86	7.86	7.86	7.86	7.86	250	250	250	250	250
	09/10/92	8.29	8.11	8.01	8.01	8.11	239	227	233	232	233
	11/18/92	8.88	8.82	8.79	8.76	8.81	221	223	224	224	223
MW-3	03/29/88	#	#	#	#		#	#	#	#	
	04/04/89	6.40	6.40	6.40	6.40	6.40	50	50	50	50	50
	05/09/90	#	#	#	#		#	#	#	#	
	12/11/90	#	#	#	#		#	#	#	#	
	12/11/91	7.90	7.90	7.90	7.90	7.90	210	210	210	210	210
	06/25/92	6.37	6.37	6.37	6.37	6.37	160	160	160	160	160
	09/10/92	6.62	6.51	6.46	6.71	6.58	170	153	148	149	155
	11/18/92	7.63	7.60	7.51	7.52	7.57	163	162	160	160	161
MW-4	03/29/88	#	#	#	#		#	#	#	#	
	04/04/89	7.90	7.90	7.90	7.90	7.90	340	340	340	340	340
	05/09/90	#	#	#	#		#	#	#	#	
	12/11/90	#	#	#	#		#	#	#	#	
	12/11/91	6.40	6.40	6.40	6.40	6.40	47	47	47	47	47
	06/25/92	6.39	6.39	6.39	6.39	6.39	57	57	57	57	57
	09/10/92	7.46	7.43	7.37	7.49	7.44	72	56	52	67	62
	11/18/92	8.77	8.69	8.61	8.55	8.66	49	50	50	50	50

Notes:
1) Values less than detection, denoted by " < ", are reported at 1/2 the detection value.
2) Values not measured are indicated by " # ".

PHASE I MONITORING RESULTS

Upgradient Well(s): MW-1

TABLE 3(Cont.)
GROUNDWATER INORGANIC AND INDICATOR ANALYSIS SUMMARY

		TOC - mg/L					TOX - mg/L				
		Replicates					Replicates				
WELL ID	DATE	A	B	C	D	Average	A	B	C	D	Average
MW-1	03/29/88	2.00	#	#	#	2.00	< 1.000	#	#	#	1.000
	04/04/89	6.30	6.30	6.30	6.30	6.30	0.004	0.004	0.004	0.004	0.004
	05/09/90	< 0.50	< 0.50	< 0.50	< 0.50	0.50	0.013	0.013	0.013	0.013	0.013
	12/11/90	1.03	1.03	1.03	1.03	1.03	0.012	0.012	0.012	0.012	0.012
	12/11/91	< 0.50	< 0.50	< 0.50	< 0.50	0.50	0.011	0.011	0.011	0.011	0.011
	06/25/92	< 0.50	< 0.50	< 0.50	< 0.50	0.50	< 0.003	< 0.003	< 0.003	< 0.003	0.003
	09/10/92	< 0.50	< 0.50	< 0.50	< 0.50	0.50	0.023	0.023	0.024	0.025	0.024
	11/18/92	#	#	#	#		< 0.003	< 0.003	< 0.003	< 0.003	0.003
MW-2	03/29/88	0.10	0.05	0.05	0.05	0.06	< 1.000	#	#	#	1.000
	04/04/89	0.05	0.05	0.05	0.05	0.05	0.001	0.001	0.001	0.001	0.001
	05/09/90	< 0.50	< 0.50	< 0.50	< 0.50	0.50	0.480	0.480	0.480	0.480	0.480
	12/11/90	1.67	1.67	1.67	1.67	1.67	0.324	0.324	0.324	0.324	0.324
	12/11/91	6.10	6.10	6.10	6.10	6.10	0.160	0.160	0.160	0.160	0.160
	06/25/92	< 0.50	< 0.50	< 0.50	< 0.50	0.50	0.036	0.036	0.036	0.036	0.036
	09/10/92	8.00	8.00	8.00	8.00	8.00	0.366	0.386	0.386	0.368	0.377
	11/18/92	#	#	#	#		0.517	0.516	0.517	0.525	0.519
MW-3	03/29/88	#	#	#	#		#	#	#	#	
	04/04/89	3.00	3.00	3.00	3.00	3.00	0.001	0.001	0.001	0.001	0.001
	05/09/90	#	#	#	#		#	#	#	#	
	12/11/90	1.29	1.29	1.29	1.29	1.29	0.202	0.202	0.202	0.202	0.202
	12/11/91	< 0.50	< 0.50	< 0.50	< 0.50	0.50	0.092	0.092	0.092	0.092	0.092
	06/25/92	< 0.50	< 0.50	< 0.50	< 0.50	0.50	0.059	0.059	0.059	0.059	0.059
	09/10/92	9.00	9.00	9.00	9.00	9.00	1.190	1.060	1.090	1.120	1.115
	11/18/92	#	#	#	#		0.230	0.235	0.229	0.229	0.231
MW-4	03/29/88	#	#	#	#		#	#	#	#	
	04/04/89	3.10	3.10	3.10	3.10	3.10	0.001	0.001	0.001	0.001	0.001
	05/09/90	#	#	#	#		#	#	#	#	
	12/11/90	< 0.00	< 0.00	< 0.00	< 0.00	0.00	0.054	0.054	0.054	0.054	0.054
	12/11/91	< 0.50	< 0.50	< 0.50	< 0.50	0.50	< 0.003	< 0.003	< 0.003	< 0.003	0.003
	06/25/92	< 0.50	< 0.50	< 0.50	< 0.50	0.50	< 0.003	< 0.003	< 0.003	< 0.003	0.003
	09/10/92	17.00	17.00	17.00	17.00	17.00	0.040	0.040	0.040	0.040	0.040
	11/18/92	#	#	#	#		0.032	0.036	0.032	0.032	0.033

Notes:

1) Values less than detection, denoted by " < ", are reported at 1/2 the detection value.

2) Values not measured are indicated by " # ".

PHASE I MONITORING RESULTS
Upgradient Well(s): MW-1

TABLE 3(Cont.)
GROUNDWATER INORGANIC AND INDICATOR ANALYSIS SUMMARY

WELL ID	DATE	BOD mg/l	Chloride mg/L	COD mg/L	Flouride mg/L	As Nitrogen Nitrate mg/L	TDS mg/L	Sulfate mg/L	Nitrate + Nitrite mg/L
MW-1	03/29/88	1.2	0.508	9.7	0.12	0.431	98	7	#
	04/04/89	4	2.2	5	0.1	0.53	67	< 2.5	#
	05/09/90	#	27	12	< 0.075	#	130	< 2.5	#
	12/11/90	8.5	1.01	15.4	< 0.05	0.55	84	3.6	#
	12/11/91	< 0.5	1.3	< 5	< 0.075	1.2	78	< 0.5	#
	06/25/92	1.2	< 0.25	7.4	< 0.025	1.035	66	10	#
	09/10/92	< 1	< 0.5	10	< 0.05	< 0.5	80	2	0.59
MW-2	03/29/88	< 1	2.78	13	< 0.1	0.05	42	6.1	#
	04/04/89	2.5	13	10	0.3	0.17	155	8	#
	05/09/90	#	23	10	0.44	#	210	32	#
	12/11/90	1.5	9.98	24.5	0.378	0.82	163	1.5	#
	12/11/91	< 0.5	1.5	< 5	< 0.075	1.3	110	4.6	#
	06/25/92	1.2	9.4	< 2.5	0.3	0.55	130	13	#
	09/10/92	< 1	11	< 21	0.3	< 0.5	161	12	< 0.01
MW-3	03/29/88	#	#	#	#	#	#	#	#
	04/04/89	1.2	3.1	35	0.1	1.9	65	2.5	#
	05/09/90	#	#	#	#	#	#	#	#
	12/11/90	1.5	8.29	24.5	< 0.05	0.9	102	4	#
	12/11/91	< 0.5	1.6	< 5	0.36	< 0.05	140	4	#
	06/25/92	2.5	7.9	< 2.5	< 0.025	0.8	90	11	#
	09/10/92	< 1	11	< 31	< 0.05	< 0.5	129	21	0.42
MW-4	03/29/88	#	#	#	#	#	#	#	#
	04/04/89	4.8	53	10	0.1	0.12	231	8	#
	05/09/90	#	#	#	#	#	#	#	#
	12/11/90	4	4.05	12.3	0.127	0.42	54	14.5	#
	12/11/91	1.8	1.6	< 5	< 0.075	< 0.05	54	< 0.5	#
	06/25/92	1.6	7.4	6.3	< 0.025	< 0.05	38	11	#
	09/10/92	< 1	1	49	< 0.05	< 0.05	67	2	0.79

Notes:

1) Values less than detection, denoted by " < ", are reported at 1/2 the detection value.

2) Values not measured are indicated by " # ".

PHASE I MONITORING RESULTS
Upgradient Well(s): MW-1

TABLE 3(Cont.)
GROUNDWATER INORGANIC AND INDICATOR ANALYSIS SUMMARY

WELL ID	DATE		Silver mg/l		Arsenic mg/L		Barium mg/L		Cadmium mg/L		Chromium mg/L		Copper mg/L
MW-1	03/29/88	<	0.1	<	0.001	<	0.25	<	0.03	<	0.1	<	0.1
	04/04/89	<	0.0015	<	0.001		0.05	<	0.001	<	0.0025	<	0.0025
	05/09/90	<	0.025	<	0.025		0.57	<	0.005	<	0.025	<	0.025
	12/11/90	<	0.00025	<	0.0015		0.127	<	0.005	<	0.01		0.019
	12/11/91	<	0.02	<	0.005		0.15	<	0.0025	<	0.025	<	0.025
	06/25/92	<	0.025	<	0.005	<	0.1	<	0.0025	<	0.025	<	0.025
	09/10/92	<	0.005	<	0.0005		0.159		0.033		0.02		0.021
	11/18/92	#		#			0.125	<	5E-05	#		#	
MW-2	03/29/88	<	0.1	<	0.001	<	0.25	<	0.03	<	0.1	<	0.1
	04/04/89	<	0.0015	<	0.001		0.15	<	0.001	<	0.0025	<	0.0025
	05/09/90	<	0.025		0.0068		0.15	<	0.005	<	0.025	<	0.025
	12/11/90	<	0.00025	<	0.0015		0.175	<	0.005	<	0.01	<	0.005
	12/11/91	<	0.02	<	0.005		0.26	<	0.0025	<	0.025	<	0.025
	06/25/92	<	0.025	<	0.0005	<	0.1	<	0.0025	<	0.025	<	0.025
	09/10/92	<	0.005	<	0.0005		0.166		0.01		0.007	<	0.01
	11/18/92	#		#			0.141	<	5E-05	#		#	
MW-3	03/29/88	#		#		#		#		#		#	
	04/04/89	<	0.0015		0.106		0.54	<	0.001		0.03		0.03
	05/09/90	<	2.2E-05	#		#		#		#		#	
	12/11/90	<	0.00025	<	0.0015		0.1		0.005	<	0.01	<	0.005
	12/11/91	<	0.02	<	0.005		0.15	<	0.0025	<	0.025	<	0.025
	06/25/92	<	0.025	<	0.005	<	0.1	<	0.0025	<	0.025	<	0.025
	09/10/92	<	0.005	<	0.0005		0.045		0.043	<	0.008	<	0.01
	11/18/92	#		#			0.363		0.0002	#		#	
MW-4	03/29/88	#		#		#		#		#		#	
	04/04/89	<	0.0015		0.005		0.18	<	0.001	<	0.0025	<	0.0025
	05/09/90	#	0.00022	#		#		#		#		#	
	12/11/90	<	0.00025	<	0.0015		0.07	<	0.005	<	0.01	<	0.005
	12/11/91	<	0.02	<	0.005		0.05	<	0.0025	<	0.025	<	0.025
	06/25/92	<	0.025	<	0.005	<	0.1	<	0.0025	<	0.025	<	0.025
	09/10/92	<	0.005	<	0.0005		0.038		0.018		0.003	<	0.01
	11/18/92	#		#			0.024		0.0003	#		#	

Notes:
1) Values less than detection, denoted by " < ", are reported at 1/2 the detection value.
2) Values not measured are indicated by " # ".

WATAUGA COUNTY LANDFILL
BOONE, NC

PHASE I MONITORING RESULTS
Upgradient Well(s): MW-1

TABLE 3(Cont.)
GROUNDWATER INORGANIC AND INDICATOR ANALYSIS SUMMARY

WELL ID	DATE	Iron mg/L	Mercury mg/L	Manganese mg/L	Lead mg/L	Selenium mg/L	Zinc mg/L
MW-1	03/29/88	0.117	< 0.001	< 0.1	< 0.2	0.002	< 0.05
	04/04/89	1	< 0.0005	0.02	< 0.01	< 0.001	0.02
	05/09/90	20	< 0.001	0.35	< 0.025	< 0.005	1.5
	12/11/90	2.48	< 5E-05	0.0497	0.0034	< 0.003	0.55
	12/11/91	5.3	< 0.00055	0.083	< 0.025	< 0.005	< 0.01
	06/25/92	2.8	< 0.00055	0.041	< 0.025	< 0.005	0.26
	09/10/92	6.7	0.0004	0.093	< 0.004	< 0.0005	0.32
	11/18/92	#	< 0.0001	0.003	#	#	0.026
MW-2	03/29/88	< 0.1	< 0.001	< 0.1	< 0.2	0.003	< 0.05
	04/04/89	0.67	< 0.0005	0.02	< 0.01	< 0.001	0.02
	05/09/90	0.15	< 0.001	0.028	< 0.025	< 0.005	0.044
	12/11/90	3.69	< 5E-05	0.0911	< 0.0015	< 0.003	0.117
	12/11/91	43	< 0.00055	0.74	< 0.025	< 0.005	0.051
	06/25/92	< 0.05	< 0.00055	0.019	< 0.025	< 0.005	< 0.01
	09/10/92	0.06	< 0.0001	0.01	< 0.0005	< 0.0005	0.061
	11/18/92	#	0.0008	0.023	#	#	0.024
MW-3	03/29/88	#	#	#	#	#	#
	04/04/89	41	< 0.0005	1.5	0.03	< 0.001	0.13
	05/09/90	#	#	#	#	#	#
	12/11/90	6.61	< 5E-05	0.228	< 0.0015	< 0.003	0.056
	12/11/91	0.23	< 0.00055	0.033	< 0.025	< 0.005	< 0.01
	06/25/92	13	< 0.00055	0.25	< 0.025	< 0.005	0.025
	09/10/92	2.1	0.0024	0.052	0.007	< 0.0005	0.618
	11/18/92	#	< 0.0001	0.561	#	#	0.08
MW-4	03/29/88	#	#	#	#	#	#
	04/04/89	3.3	< 0.0005	1.4	0.03	< 0.001	0.003
	05/09/90	#	#	#	#	#	#
	12/11/90	3.04	< 5E-05	0.107	0.0032	< 0.003	0.077
	12/11/91	2.6	< 0.00055	0.07	< 0.025	< 0.005	< 0.01
	06/25/92	6.4	< 0.00055	0.2	< 0.025	< 0.005	0.031
	09/10/92	0.35	0.0003	0.024	0.013	< 0.0005	0.258
	11/18/92	#	< 0.0001	0.031	#	#	0.027

Notes:
1) Values less than detection, denoted by " < ", are reported at 1/2 the detection value.
2) Values not measured are indicated by " # ".

09/10/92 and 11/18/92 Samples collected by Draper Aden Assoc. and analyzed by Central Virginia Laboratories and Consultants. Sample collection contractor and analytical laboratories for all other dates located on Page 3 of Table 1A.

2.8 BOLICK SITE INVESTIGATION

Draper Aden Associates' initial geotechnical and hydrogeologic investigation was conducted between August, 1992 and February, 1993 at the request of the Watauga County Board of Commissioners to develop information necessary to undertake a Permit Modification of their existing landfill to utilize a contiguous portion of the site identified as the Bolick site. Solid Waste Management Rule 15A NCAC 13B.0504(1)(c) requires that sufficient hydrogeologic information be supplied during the permit modification to support the chosen design and monitoring program. The goals of the hydrogeologic investigation of the Bolick site addressed these issues and may be summarized as follows:

- Provide the required hydrologic and geologic information for the permit modification;

- Evaluate the potential influence of the existing unlined landfill on groundwater quality beneath the Bolick site; and

- Evaluate groundwater flow direction and aquifer configuration beneath the Bolick site to determine additional monitoring well needs.

To supplement previous hydrogeologic information, additional soil borings, rock corings, soil testing, aquifer flow testing and groundwater sampling and analysis were undertaken for the Bolick site investigation.

Twelve borings were drilled at the Bolick site in August, 1992 to determine the depth to bedrock and groundwater, and to evaluate groundwater flow rates and directions beneath the site. This information was obtained to determine allowable excavation depths for development of the site, the available soil materials, and the monitorability of the site's impact on groundwater quality. All borings that encountered groundwater were completed as piezometers. The locations of all the piezometers are depicted on the Site Map (Figure 2).

Three of the borings, B-19, B-24 and B-25, were air rotary drilled into bedrock, along the ridge separating the Bolick site and the active fill area, until the uppermost aquifer was reached within fractures. A 6" diameter bore hole was made during this operation utilizing a 5" diameter air rotary hammer. PVC well casings with ten foot screens were emplaced in the three borings and constructed with grout backfill to meet preliminary monitoring well construction requirements of the Solid Waste Management Division of the NCDEHNR.

The resultant piezometers PZ-19, PZ-24, and PZ-25 were located along the original topographic divide to assess the water quality beneath the boundary between the Bolick site and the existing landfill. The piezometers PZ-19, PZ-24, and PZ-25, proposed as plume assessment monitoring wells MW-5, MW-6, and MW-7 respectively, only require the addition of a concrete pad and protective metal casing to become permanent monitoring wells as per North Carolina groundwater monitoring well construction standards (1987, SW-1001-87).

Two of the borings, B-18 and B-23, were drilled to auger refusal utilizing a 4.25" inner diameter hollow-stem auger and continued into bedrock by tri-cone drilling and wire-line coring. Both of these corings encountered groundwater within fractures in the upper 20 feet of the bedrock. Piezometers were emplaced in these two rock core borings to determine the nature of the groundwater flow within the bedrock. A separate boring, B-18A, was drilled to bedrock 6 feet to the southeast of boring B-18 and a piezometer was installed to provide information concerning the relationship between the soil and the bedrock aquifers. Soil was split spoon sampled and collected in bulk. Bulk samples were later utilized for additional soil testing.

The other six borings, B-13, B-14, B-15, B-16, B-17, and B-22, were drilled to auger refusal utilizing a 4.25" inner diameter hollow-stem auger. Soil was also split-spoon sampled and collected in bulk in these six borings. Four of these six borings, B-13, B-14, B-17 and B-22, encountered groundwater above refusal (i.e. bedrock). Piezometers were emplaced in these four borings to characterize the nature of groundwater flow within this zone.

A discussion of the results of the Bolick site geotechnical and hydrogeologic investigation are presented in Sections 3.1.7 and 3.1.8. The borings and piezometers are summarized in Tables 6 and 8, respectively.

2.9 DRAPER ADEN ASSOCIATES LANDFILL SAMPLING AND ANALYSIS RESULTS

Review of routine, annual groundwater analyses conducted at the Watauga County Landfill between April of 1989 and June of 1992 revealed inconclusive evidence for evaluating the potential influence of the existing landfill on groundwater quality beneath the Bolick site. Sporadic trends in the historical groundwater analysis data required that any analyses of the three grouted piezometers, PZ-19, PZ-24, and PZ-25, (i.e. proposed monitoring wells MW-5, MW-6, and MW-7 discussed in Section 4.3.5) located along the original topographic divide between the Bolick site and the active landfill, would need to be supported by similar analyses conducted on the four monitoring well network of the existing landfill, MW-1, MW-2, MW-3, and MW-4.

Generally, relative to the upgradient well MW-1, previously collected data indicated increasing levels of Conductivity and Total Organic Halides (TOX) at downgradient wells MW-2 and MW-3, with slightly higher levels of pH also observed downgradient. Monitoring of twelve metals at the site since 1989 did not indicate any obvious, consistent differences in levels between upgradient and downgradient sources. Data available for monitoring of surface water in the drainage below the waste disposal area collected and analyzed in 1990 by the NCDEHNR Solid Waste Section did however indicate the presence of several chlorinated organic compounds, including Chloroethane, Methylene Chloride, 1,1-Dichloroethane, and Trans-1,2-Dichloroethane.

Draper Aden Associates conducted three (3) sampling events between September 10, 1992 and March 5, 1993 to evaluate the influence of the existing landfill on groundwater quality beneath the Bolick Site. A summary of these sampling events follows and a table summary of organic constituents detected from these events is contained in Table 4.

TABLE 4
WATAUGA COUNTY LANDFILL GROUNDWATER
ORGANIC CONSTITUENTS DETECTED
December 11, 1990, November 16-18, 1992 and March 3, 1993 SAMPLING EVENTS

Analyte	Date Sampled	Analytical Method	MDL	MW-1	MW-2	MW-3	MW-4	PZ-24	NCS	MCL	TRIP
Trichloroethene	December 11, 1990	SW846 Method 8240	5			9		---	2.8	5	
(TCE)	November 16-18, 1992	SW846 Method 8010	1			23		110	2.8	5	
	March 5, 1993	EPA Method 502.2	0.2	0.4	2.4	18.1	0.7		2.8	5	
	March 5, 1993	SW846 Method 8021	0.2		2.1	15.7	0.8	79.5	2.8	5	
1,1,1-Trichloroethane	December 11, 1990	SW846 Method 8240	5		394	102			200	200	
(1,1,1-TCA)	November 16-18, 1992	SW846 Method 8010	1		980	68	6		200	200	
	March 5, 1993	EPA Method 502.2	0.4		1646	19.0	10.5		200	200	
	March 5, 1993	SW846 Method 8021	0.4		1212	19.0	22.5	1.4	200	200	
Tetrachloroethene	December 11, 1990	SW846 Method 8240	5		7	25			0.7	5	
(PCE)	November 16-18, 1992	SW846 Method 8010	1		5	39		4	0.7	5	
	March 5, 1993	EPA Method 502.2	0.5	0.5	11.2		1.6		0.7	5	
	March 5, 1993	SW846 Method 8021	0.5		11.8	24.9	1.6	12.5	0.7	5	
1,1,-Dichloroethane	December 11, 1990	SW846 Method 8240	5		52	178			700[1]	---	
(1,1-DCA)	November 16-18, 1992	SW846 Method 8010	1		41	250		81	700[1]	---	
	March 5, 1993	EPA Method 502.2	0.7		96	173.3	1.2	77	700[1]	---	
	March 5, 1993	SW846 Method 8021	0.7		82	161	1.1	43.7	700[1]	---	
1,1-Dichloroethene	December 11, 1990	SW846 Method 8240	5		80	7			7	7	
(1,1-DCE)	November 16-18, 1992	SW846 Method 8010	1		110	14			7	7	
	March 5, 1993	EPA Method 502.2	0.7		232	10.3	5.1	0.9	7	7	
	March 5, 1993	SW846 Method 8021 and *(8240)	0.7 *(0.3)		143.6	9	4.5	*	7	7	
cis-1,2-Dichloroethene	March 5, 1993	EPA Method 502.2	0.7	0.7	1.4	36.4		225	70	70	
(cis-1,2-DCE)	March 5, 1993	SW846 Method 8021 and *(8240)	0.7 *(0.7)		1	26.6	*	87.8	70	70	

Note: All Concentrations are in ppb (ug/L) (other footnotes located on page 4)

TABLE 4 (CON'T)
WATAUGA COUNTY LANDFILL GROUNDWATER
ORGANIC CONSTITUENTS DETECTED
DECEMBER 11, 1990, NOVEMBER 16-18, 1992 AND MARCH 5, 1993 SAMPLING EVENTS

Analyte	Date Sampled	Analytical Method	MDL	MW-1	MW-2	MW-3	MW-4	PZ-24	NCS	MCL	TRIP
Methylene Chloride	December 11, 1990	SW846 Method 8240	5			23		---	5	5	
	November 16-18, 1992	SW846 Method 8010	1			16		15	5	5	
	March 5, 1993	EPA Method 502.2	0.6		4.2	9.4			5	5	
	March 5, 1993	SW846 Method 8021	0.6						5	5	
Vinyl Chloride	December 11, 1990	SW846 Method 8240	10					---	.015	2	
	November 16-18, 1992	SW846 Method 8010	1			3		12	.015	2	
	March 5, 1993	EPA Method 502.2	0.4			3.4		18.3	.015	2	2.6
	March 5, 1993	SW846 Method 8021 and *(8240)	0.4 *(1.0)			*		*	.015	2	
Dichlorodifluoromethane	December 11, 1990	SW846 8240	5			21		---	0.19	---	
	November 16-18, 1992	SW846 Method 8010	1						0.19	---	
	March 5, 1993	EPA Method 502.2	0.8			11.8		6.9	0.19	---	
	March 5, 1993	SW846 Method 8021 and *(8240)	0.8 *(0.8)			*			0.19	---	
Chloroethane	December 11, 1990	SW846 Method 8240	10					---	---	---	
	November 16-18, 1992	SW846 8010	1			5		8	---	---	
	March 5, 1993	EPA Method 502.2	1.4		2.6				---	---	
	March 5, 1993	SW846 method 8021 and *(8240)	1.4 *(10)			*		*	---	---	
Trans-1,3-Dichloropropene	December 11, 1990	SW846 Method 8240	5			9-J		---	70	100	
	November 16-18, 1992	SW846 Method 8010	1					3	70	100	
	March 5, 1993	EPA Method 502.2	0.7			0.9		5.5	70	100	
	March 5, 1993	SW846 Method 8021 and *(8240)	0.7 *(0.7)			*			70	100	

Note: All Concentrations are in ppb (ug/L) (other footnotes located on page 4)

TABLE 4 (CON'T)
WATAUGA COUNTY LANDFILL GROUNDWATER
ORGANIC CONSTITUENTS DETECTED
DECEMBER 11, 1990, NOVEMBER 16-18, 1992 AND MARCH 5, 1993 SAMPLING EVENTS

Analyte	Date Sampled	Analytical Method	MDL	MW-1	MW-2	MW-3	MW-4	PZ-24	NCS	MCL	TRIP
Benzene	December 11, 1990	SW846 Method 8240	5					---	1.0	5	
	March 5, 1993	EPA Method 502.2	0.1			1.5	0.5	6.3	1.0	5	
	March 5, 1993	SW846 Method 8021	0.1			1.3		6.3	1.0	5	
1,4-Dichlorobenzene	November 15-18, 1992	SW846 Method 8010	0.3			0.5			0.19	75	
	March 5, 1993	EPA Method 502.2	0.5		0.8				1.8	75	
	March 5, 1993	SW846 Method 8021	0.5						1.8	75	
Chloroform	December 11, 1990	SW846 Method 8240	5					---	0.19	100	
	November 16-18, 1992	SW846 Method 8010	1				2	1	0.19	100	3
	March 5, 1993	EPA Method 502.2	0.3						0.19	100	
	March 5, 1993	SW846 Method 8021	0.3			0.5			0.19	100	
1,2-Dichloropropane	December 11, 1990	SW846 Method 8240	5					---	0.56	5	
	November 16-18, 1992	SW846 Method 8010	1						0.56	5	
	March 5, 1993	EPA Method 502.2	0.3		0.3	0.3			0.56	5	
	March 5, 1993	SW846 Method 8021 and *(8240)	0.3 *(0.3)			*	*	*	0.56	5	
2,2-Dichloropropane	March 5, 1993	EPA Method 502.2	0.7	0.7	1.4				---	---	
	March 5, 1993	SW846 Method 8021 and *(8240)	0.7 *(0.7)		*	*	*	*	---	---	
1,1-Dichloropropene	March 5, 1993	SW846 Method 8240	0.5	3.8					---	---	
Bis(2-ethylhexyl)phthalate	March 5,1993	SW846 Method 8270	2		20				---	---	
Xylenes, Total	March 5, 1993	SW846 Method 8021	0.4					1	0.4	10	
4,4'-DDD	March 5, 1993	SW846 Method 8080	0.1					0.1	---	---	

Note: All Concentrations are in ppb (ug/L) (other footnotes located on page 4)

TABLE 4 (CON'T)
WATAUGA COUNTY LANDFILL GROUNDWATER
ORGANIC CONSTITUENTS DETECTED
DECEMBER 11, 1990, NOVEMBER 16-18, 1992 AND MARCH 5, 1993 SAMPLING EVENTS

Analyte	Date Sampled	Analytical Method	MDL	MW-1	MW-2	MW-3	MW-4	PZ-24	NCS	MCL	TRIP
Bromodichloromethane	December 11, 1990	SW846 Method 8240	5					---	---	100	
	November 16-18, 1992	SW846 Method 8010	1						---	100	
	March 5, 1993	EPA Method 502.2	0.3		0.6				---	100	
Carbon Tetrachloride	December 11, 1990	SW846 Method 8240	5					---	0.3	5	
	November 16-18, 1992	SW846 Method 8010	1						0.3	5	
	March 5, 1993	EPA Method 502.2	0.1			0.2	0.2	0.3	0.3	5	
	March 5, 1993	SW846 Method 8021	0.1						0.3	5	
	March 5, 1993	SW846 Method 8021	0.3						0.38	5	
1,2-Dichloroethane	December 11, 1990	SW846 Method 8240	5					---	0.38	5	
	November 16-18, 1992	SW846 Method 8010	1			1			0.38	5	
	March 5,1993	EPA Method 502.2	0.3		0.3				0.38	5	
	March 5, 1993	SW846 Method 8021 and *(8240)	0.3 *(0.3)		*	*		*	0.38	5	

EPA SW-846 Methods 8011, 8030, 8040, 8090, 8120, 8150, and 8310 were Also Performed on Samples Collected on March 5, 1993, Resulting in No Analytes Detected.

MDL Analytical Method Detection Limit
NCS North Carolina Water Quality Standard (DEHNR: 15A NCAC 2L .0202)
MCL EPA Primary Drinking Water Standard Maximum Contaminant Level

December 11, 1990 Sampling Event - Conducted by Engineering Tectonics and split-sampled with the NCDEHNR Solid Waste Section - Analysis performed by the North Carolina State Laboratory of Public Health.

November 16-18, 1993 and March 5, 1993 Sampling Event - Conducted by Draper Aden Associates - Analysis performed by Central Virginia Laboratories and Consultants, Inc. (CVLC).

EPA Metho 502.2 Co-elutes compounds cis-1,2-Dichloroethene and 2,2-Dichloropropane

J denotes estimated result
[1] denotes proposed NCS
* denotes where indicated, method also utilized an analyte not detected

Note: All Concentrations are in ppb (g/L)

2.9.1 September 10, 1992 Groundwater Sampling Event

To evaluate the potential influence of the existing landfill on groundwater quality beneath the Bolick site, two groundwater sampling events were initially conducted by Draper Aden Associates in September and November of 1992.

The September, 1992 groundwater sampling event was performed on the four monitoring well network of the existing landfill, MW-1, MW-2, MW-3, and MW-4, and the three grouted piezometers, PZ-19, PZ-24, and PZ-25 (i.e. proposed monitoring wells MW-5, MW-6, and MW-7), located along the original topographic divide between the Bolick site and the active landfill. Groundwater samples collected during the September sampling event were analyzed for all the inorganic and indicator parameters required for routine, annual groundwater analysis by the North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities.

The September, 1992 groundwater sampling event revealed levels of several metals throughout the seven monitoring points sampled, including the upgradient well MW-1. Three metals, Cadmium, Mercury, and Zinc, were found consistently above the Federal Groundwater Protection Level. Barium was found at levels approaching the Federal Groundwater Protection Level in the three grouted piezometers located between the Bolick site and the existing landfill. Total Organic Halides (TOX) was also found at levels of concern in the three grouted piezometers and in MW-3, located below the Bolick site.

Elevated levels of many parameters, particularly TOX, were observed in the groundwater along the ridge above the Bolick site, in wells PZ-19, PZ-24, and PZ-25, (i.e. proposed monitoring wells MW-5, MW-6, and MW-7) and in the drainage below the Bolick site at MW-3. This suggested that flow may be occurring from the existing landfill towards the Bolick site. The November groundwater sampling event was designed to identify and characterize the lateral and vertical extent of organic compounds contributing to the elevated TOX levels and to confirm and characterize levels of five metals (Barium, Cadmium, Manganese, Mercury, and Zinc).

2.9.2 November 18, 1992 Groundwater Sampling Event

The November, 1992, sampling event was performed on the seven ungrouted piezometers installed at the Bolick site in addition to the seven monitoring points sampled in September. Groundwater samples collected during the November sampling event were analyzed for Total Organic Halides (TOX), various volatile halogenated organic compounds (SW-846 Method 8010), and five metals (Barium, Cadmium, Manganese, Mercury, and Zinc). QA/QC practices followed both in the field and in lab for the September and November of 1992 sampling and analysis were conducted in substantial accordance with Level I QA/QC as defined in the attached Sampling and Analysis Plan (SAP).

The November, 1992, groundwater sampling event identified 13 volatile halogenated organic compounds distributed throughout the Bolick site. Ten volatile halogenated organic compounds were found above the associated North Carolina Groundwater Quality Standard (NCS). Trichloroethene was found at five monitoring locations and was analyzed to be at a level 40 times the North Carolina Groundwater Quality Standard at the monitoring location, PZ-24 (i.e.: proposed MW-6). Methylene Chloride was found at every monitoring location on the Bolick site, 11 monitoring locations, in all cases above the North Carolina Groundwater Quality Standard. Several other organics detected above applicable groundwater quality standards are delineated in Table 4.

The analyses for five metals (Barium, Cadmium, Manganese, Mercury, and Zinc) performed for the November groundwater sampling event revealed that the elevated levels of Cadmium and Mercury resulting from the September sampling and analysis were likely the result of low analytical lab QA/QC procedures for trace level detection. The November resampling and analyses for Cadmium revealed levels below, at, or near the detection level for all 14 monitoring locations. The September sampling and analysis for Cadmium was suspect since the second highest Cadmium level had occurred in the upgradient monitoring well (MW-1). Similarly, the November resampling and analyses for Mercury also revealed levels below, at, or near the detection level for all 14 monitoring locations. One of the higher levels of Mercury, 0.001 mg/L, was detected in the Trip Blank for that event. The Federal Groundwater Protection Levels for Cadmium and Mercury are 0.0004 mg/L and 0.00005 mg/L, respectively. Analytical results obtained at these low levels are often not reproducible and therefore must be thoroughly reviewed before being accepted with any confidence.

The resampling and analyses for Barium and Zinc confirmed the elevated levels detected from the September sampling and analyses. Barium was again found at levels approaching the Federal Groundwater Protection Level in the three grouted piezometers located between the Bolick site and the existing landfill. Barium was also analyzed to be at a level 2.4 times the Federal Groundwater Protection Level at piezometer PZ-17, located in the center of the Bolick site. Zinc was found above the Federal Groundwater Protection level in six monitoring points, exceeding the Federal Groundwater Protection Level by a factor of eight at piezometer PZ-17.

The fourteen monitoring points sampled and analyzed during the November sampling event were ranked according to the presence and levels of various halogenated organic compounds and metals to delineate the extent of the contaminant plume moving across the Bolick site. The contamination ranking scheme for the fourteen monitoring points employed a weighted value of one for any volatile halogenated organic compound or Barium and Zinc detected above the North Carolina Groundwater Quality Standard. The contamination ranking delineated a contaminant plume entering the Bolick site along the center of the original topographic divide separating the Bolick site from the existing landfill in the vicinity of PZ-24. The contaminant plume appears to migrate along the central drainage of the Bolick site in the vicinity of PZ-17. The contaminant plume displays the highest concentrations directly upgradient and downgradient of the existing sediment pond in the vicinity of PZ-13 and MW-3, which may act as a localized drainage sink.

Figure 8 delineates the contaminant ranking scheme determined from the November, 1992 analytical results and provides a graphical presentation of relative concerns of impact to groundwater across the Bolick site. The select analytical results of the fourteen volatile halogenated organic compounds, and Barium and Zinc from the November sampling event of the fourteen monitoring points utilized in the contamination ranking are contained in the table displayed on Figure 8. Also contained in this data summary table is the Federal Groundwater

Protection Level and North Carolina Groundwater Quality Standard for the select parameters. A complete presentation of all inorganic and indicator groundwater quality analytical results collected to date at the Watauga County Landfill is presented in Table 3. A complete presentation of all organic groundwater analytical results collected for the four wells comprising Watauga County Landfill Monitoring Well Network and the grouted piezometer, PZ-24 (i.e.: proposed MW-6), is presented in Table 4.

2.9.3 March 5, 1993 Sampling Event

Based on data collected at the landfill between September 1992, and February, 1993, several concerns with regard to potential impact of the existing landfill on local groundwater were noted in the Bolick Site Investigation report. In particular the November sampling event resulted in two metals, Barium and Zinc, and several chlorinated organic compounds detected at levels of concern within and at the compliance boundary of the landfill site, including the Bolick property. Levels were found consistently above background and applicable North Carolina Groundwater Quality Standards.

On March 3, 1993, DAA and Watauga County representatives met with the State Solid Waste Management officials to discuss the results of the September and November sampling events and associated aquifer flow testing. The Bolick Site Investigation report provided data on groundwater flow directions and rates which indicated the possibility of related groundwater contamination outside the property boundary of the Watauga County landfill site.

On March 5, 1993, DAA, under the direction of Watauga County, sampled twelve drinking water wells in the vicinity of the landfill. On the same date, March 5, 1993, the current Watauga County Landfill Monitoring Well Network, MW-1, MW-2, MW-3, and MW-4, and the grouted Piezometer, PZ-24 (i.e.: proposed MW-6) was also sampled. The sampling of the landfill provided a comparable data set for use in investigating and predicting the extent of contaminant transport and migration. QA/QC Level I of the SAP was utilized in collection of EPA Subtitle D Appendix II Assessment parameters.

The March 5, 1993, groundwater sampling event essentially confirmed the results obtained from the November, 1992 groundwater sampling event. The thirteen (13) volatile halogenated organic compounds detected in the November, 1992, sampling event were again detected in the March 5, 1993, groundwater sampling event at generally similar locations and concentrations.

The March 5, 1993, sampling event detected seven (7) additional volatile halogenated organic compounds and three (3) semi-volatile organic compounds. The detection of additional compounds resulted primarily from the additional analyses performed for the March, 1993, sampling event.

The organic analysis performed for the November, 1992, groundwater sampling event utilized SW846 Method 8010 and analyzed for 29 chlorinated volatile organics. No semi-volatile organic analysis was performed on the November, 1992, groundwater sampling event.

The March, 1993, groundwater sampling event utilized eleven (11) SW846 Methods to analyze for 213 constituents identified in the "Appendix II List of Hazardous Inorganic and Organic Constituents" contained in 40 CFR Part 258 (Subtitle D). In addition to the 213 constituents analyzed utilizing EPA SW846 Methods, EPA Methods 502.2 (volatiles) and 525.1 (semi-volatiles) were also employed in the March, 1993 sampling event. EPA Methods 502.2 and 525.1 are commonly employed for drinking water analysis and were utilized for the landfill groundwater sampling event to provide a data set for comparing the landfill sampling results with the residential and business potable well sampling and analysis results.

The seven (7) additional volatile organic compounds detected as a result of the extensive March 5, 1993 groundwater analysis were comprised of four (4) compounds that are not included on the SW846 Method 8010 parameter list and three (3) compounds originally included but not detected utilizing SW846 Method 8010. Two of the additional volatile organic compounds not analyzed for in the November, 1992 analysis (SW846 Method 8010) cis-1,2-Dichloroethene and Benzene, were detected at significant levels as a result of the March, 1993 analysis (SW846 Method 8021 and EPA Method 502.2). A complete presentation of all organic groundwater analytical results collected to date for the four wells comprising the existing Watauga County Landfill Monitoring Well Network and the grouted piezometer, PZ-24 (i.e.: proposed MW-6) is presented in Table 4.

2.10 RESIDENTIAL AND BUSINESS POTABLE WELL SAMPLING AND ANALYSIS RESULTS

2.10.1 March 5, 1993 DAA Sampling Event

On March 5, 1993, DAA sampled twelve drinking water wells in the vicinity of the Watauga County Landfill.

<u>Selection Criteria</u>

The initial domestic and commercial use potable water well sampling event was developed and conducted by Draper Aden Associates at the direction of Watauga County with the oversight and approval of State officials to protect the public health and welfare. The locations of all the residences and businesses are presented on the Vicinity Map (Figure 3). A summary of the results of all volatile and semi-volatile analysis conducted on residential and business water wells is presented in Table 5. The decision criteria for selecting sampling locations was based on the potential for a location's groundwater to be impacted by the landfill. Various flow path directions were considered in the initial assessment to account for unanticipated fracture flow conditions. Three general areas near the landfill were identified as potentially impacted by the volatile organic compounds detected in the groundwater beneath the landfill property boundaries.

Based on information compiled from the current groundwater monitoring network, the area directly downgradient and east of the Bolick site was considered to have the highest potential to be impacted. Three residences and four businesses were identified in the area downgradient of the Bolick site and all were included in the initial sampling event. These three

TABLE 5A
RESIDENTIAL WELL TESTING - WATAUGA COUNTY, NC
RESULTS OF VOLATILE AND SEMI-VOLATILE ANALYSIS

CONSTITUENT	MARCH 5, 1993[1]	MARCH 18, 1993[1]	MARCH 24, 1993[1]	June 23, 1993[2]	NCS	MCL
Carroll Residence (12)						
Benzene	2.1	1.7		1.9	1.0	5
Chloroethane	173.4	74.5			---	---
Chloromethane		14.8			---	---
Dichlorodifluoromethane	30.6				0.19	---
1,1-Dichloroethane	20.9	17.4			700	---
1,1-Dichloroethene	4.1	1.5			7	7
cis-1,2-Dichloroethene[#]	1.2	0.9		<1.0	70	70
2,2-Dichloropropane[#]	1.2	0.9			---	---
4-Isopropyltoluene		0.2	NS		---	---
Isopropylbenzene	0.6				---	---
Methylene Chloride		43.0[XT]		138.2	5	5
Styrene	2.8	0.5			0.014	100
Tert-Butyl Methyl Ether				2.4	200	---
Tetrachloroethene	5.4[X]	4.7		4.2	0.7	5
Toluene		0.6[T]			1000	1000
1,1,1-Trichloroethane	19.7	25.7		29.4	200	200
Trichloroethene	7.0[X]	5.5[X]		7.0	2.8	5
Trichlorofluoromethane	37.1	20.2			2100	---
Vinyl Chloride	1.7[T]				0.015	2
p and m-Xylene				<1.0	400	10,000
o-Xylene		3.4		2.9	400	10,000
Nissan-Mazda Dealership (4)						
Carbon Tetrachloride	0.2				0.3	5
Chloroethane	19.1				---	---
Dichlorodifluoromethane	8.2		8.7		0.19	---
1,1-Dichloroethane	98.5		63.1		700	---
1,2-Dichloroethane			0.5		0.38	---
1,1-Dichloroethene	5.4		3.7		7	7
cis-1,2-Dichloroethene[#]	22.2	NS	13.0		70	70
1,2-Dichloropropane	0.5		0.3	NS	0.56	5
2,2-Dichloropropane[#]	22.2		13.0		---	---
Tetrachloroethene	21.8[X]		28.1[X]		0.7	5
Toluene			0.8[T]		1000	1000
1,1,1-Trichloroethane	14.7		19.3		200	200
Trichloroethene	11.2[X]		9.1[X]		2.8	5
Trichlorofluoromethane	0.4				2100	---
o-Xylene			0.5[T]		400	10,000

NOTE: All concentrations are in ppb (ug/L). (Other footnotes located on page 3)

TABLE 5A (CONT.)

CONSTITUENT	MARCH 5, 1993[1]	MARCH 18, 1993[1]	MARCH 23, 1993[2]	MAY 11, 1993[2]	June 23, 1993[2]	NCS	MCL
Blue Ridge Electric Membership Company - (BREMCO) (5)							
1,1-Dichloroethane	0.7	NS	NS	NS	NS	700	---
Naphthalene	0.6					---	---
1,1,1-Trichlorothane	6.2^E					200	200
Trichloroethene	0.5					2.8	5
Bolick rental residence (2)							
tert-Butylbenzene	1.1	NS	NS	NS	NS	---	---
Isopropylbenzene	0.7					---	---
Trichloroethene	0.5					2.8	5
1,3,5-Trimethylbenzene	0.7					---	---
Perry residence (11)							
Dichlorodifluoromethane	2.5	NS	NS	NS	ND	0.19	---
Naphthalene	0.7					---	---
Chloromethane	$<9^E$					---	---
Methylene Chloride	$<0.6^E$					5	5
Shared Well #1 (8 Houses) (13)							
sec-Butylbenzene	NS	0.2	NS	ND	NS	---	---
Carbon Tetrachloride		0.1				0.3	5
Methylene Chloride		1.5				5	5
alpha-Chlordane		0.4				0.027	2
gamma-Chlordane		0.3				0.027	2
Shared Well #2 (4 Houses) (14)							
1,4-Dichlorobenzene	NS	0.5	NS	NS	NS	1.8	---
Simko residence (20)							
Chloroform	NS	NS	<1.0	NS	NS	0.19	5
1,1,1-Trichloroethane			trace			200	200
Johnson residence (32)							
Chloroform	NS	NS	NS	trace	NS	0.19	5
Ward residence (24)							
Methylene Chloride	NS	NS	NS	3.2		5	5
1,1,1-Trichloroethane				<1.0	<1.0	200	200
Trichloroethene				trace	trace	2.8	5
Tetrachloroethene					trace	0.7	5
McLean residence (26)							
Chloroform	NS	NS	NS	NS	<1.0	0.9	5

TABLE 5B (Cont.)
RESIDENTIAL WELL TESTING - WATAUGA COUNTY, NC
WELLS SHOWING NO DETECTED ORGANIC COMPOUNDS

SAMPLING LOCATION	SAMPLING DATES
Colene Bolick residence (1)	March 5, 1993[1]
Roten residence (3)	March 5, 1993[1]
Hollar and Green Produce (6)	March 5, 1993[1]
Vannoy residence (8)	March 5, 1993[1]
Chevrolet Dealership (7)	March 5, 1993[1]
Martin High Country Rentals #1 (10)	March 5, 1993[1]
Martin High Country Rentals #2 (10)	March 5, 1993[1]
Greer residence (15)	March 18, 1993[1]
Williamson residence (16)	March 18, 1993[1]
Suddreth residence (17)	March 18, 1993[1]
Taylor residence (18)	March 18, 1993[1]
Hodges resdence (19)	March 18, 1993[1]
Findt residence (21)	March 23, 1993[2]
Rusher residence (22)	March 23, 1993[2]
Younce residence (25)	May 11, 1993[2]
Medlin residence (27)	June 23, 1993[2]
Rector residence (28)	June 23, 1993[2]
Robinson residence (29)	June 23, 1993[2]

'ABLE 5A AND 5B NOTES:

[1]Laboratory analysis performed by Central Virginia Laboratories and Consultants (CVLC) utilizing EPA Methods 502.2 (Volatiles) and 525.1 (Semi-Volatiles)
[2]Laboratory Analysis performed by NCDEHNR Division of Laboratory Services utilizing EPA Method 502.2 (Volatiles)
The sampled well reference number as presented on the Vicinity Map (Figure 3) is denoted in parentheses following the sampling location name.
# denotes compound co-elutes
ND denotes no compounds detected for entire analytical scan
NS denotes not sampled on that date
T denotes found in Trip Blank
E denotes estimated result
X denotes above MCL

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residences and businesses are listed below with an associated well reference number as presented on the Vicinity Map (Figure 3):

- Bolick residence (1)
- Bolick rental residence (2)
- Roten residence (3)
- Nissan-Mazda Dealership (4)
- Blue Ridge Electric Membership Company (BREMCO) (5)
- Hollar and Green Produce (6)
- Chevrolet Dealership (7)

The area downgradient of the existing Watauga County Landfill along Rocky Branch was also considered to be potentially impacted based on information compiled from two monitoring wells located next to a tributary of Rocky Branch at the landfill property boundary. A trailer park and diner served by a community water supply consisting of two wells and residence and furniture store jointly served by one well were identified directly downstream and adjacent to the surface drainage and are listed below with an associated well reference number as presented on the Vicinity Map (Figure 3):

- Vannoy residence and Furniture Factory Outlet (one well)(8)
- Martin High Country Rentals and Dee's Diner (community water supply utilizing two wells) (9 and 10)

The above referenced three wells were sampled independently during the initial sampling event.

The possible influence of complex fracture systems working in combination with mound effects which may be occurring within the waste disposal area made it appropriate to investigate potential impacts in the apparent upgradient area located to the south directly adjacent to the landfill. The subdivision, Rocky Mountain Heights, containing over 50 houses, is located in this area adjacent to the landfill. Two residences bordering the landfill property immediately adjacent to the fill area were selected for the initial sampling event and are listed below with an associated well reference number as presented on the Vicinity Map (Figure 3).

- Perry residence (11)
- Carroll residence (12)

Sampling Methodology

Businesses and residences selected for the initial sampling event were notified by the County prior to sampling. An official of the County, Mr. Mark Combs, Solid Waste Director, and Draper Aden Associates' sampling technician, Mr. Jeff Smith, Project Geologist, visited each sampling location on the morning of the sampling event on March 5, 1993 to deliver letters of notification. When knowledgeable sources were available, inquiries were made to ascertain the location, depth, date of installation, use, and design (i.e.: filters, holding tanks, etc.) of the selected well. In many instances well information was not available prior to sampling.

Efforts were implemented to collect samples from the potable water well systems as close to the well head as possible to avoid extraneous contamination sources. In addition, well systems were purged prior to sample collection to insure that sampled well water was not influenced by prolonged contact with plumbing systems. During purging, pH was monitored to indicate stabilization of groundwater quality. Upon stabilization of pH, well water samples were collected.

Latex gloves were worn during the sample collection procedure. Several minutes before filling the pre-labeled sample collection jars prepared by Central Virginia Laboratories and Consultants, Lynchburg, Virginia, the discharge rate of the well system was lowered to diminish volatilization. Sample jars were filled completely with water from the potable well systems and immediately placed in a cooler on ice.

Analysis Results

A general summary of the initial residential and business potable water well sampling and analysis results follows. A table summary of the analysis results of all residential and business potable well testing conducted to date is contained in Table 5.

No levels above the laboratory detection limit were detected in 7 of the 12 residential wells tested. For these locations, no evidence of degradation to groundwater quality was found at this time, and the groundwater was found acceptable for all uses. Two potable wells, at the Carroll residence and the Nissan Mazda Dealership, appear to have been impacted by the presence of volatile organic compounds and the N.C. State Epidemiologist recommended the well water should not be used for consumption, or prolonged bathing, at this time. Resampling was recommended. Low levels of volatiles were detected at BREMCO, the Perry residence and the Bolick rental residence. Continued use, however, is acceptable at this time.

Twelve (12) well constituents were detected above laboratory detection limits in the Nissan-Mazda Dealership (well reference no. 4). Only seven (7) constituents had associated EPA Maximum Contaminant Level (MCLs) for evaluation purposes. Laboratory results indicated Trichloroethene and Tetrachloroethene exceeded EPA MCLs. Ten (10) constituents had associated North Carolina Groundwater Quality Standards (NCS). Laboratory results indicated Dichlorodifluoromethane in addition to Trichloroethene and Tetrachloroethene exceeded associated NCSs.

Fourteen (14) organic constituents were detected above laboratory detection limits in the Carroll residence well (well reference no. 12). Only eight (8) constituents had associated MCLs for evaluation purposes. Laboratory results indicated Trichloroethene and Tetrachloroethene exceeded EPA MCLs. Twelve (12) constituents had associated NCSs. Laboratory results indicated five (5) constituents (Styrene, Benzene, and Dichlorodifluoromethane in addition to Tricholoroethane and Tetrachloroethane) exceeded associated NCSs.

Four (4) organic constituents were detected above laboratory detection limits in the Blue Ridge Electric Membership Company (BREMCO) well (well reference no. 5) with MCLs applicable to only two (2) constituents and the NCSs applicable to three (3) constituents.

Laboratory results were well below applicable MCLs and NCSs. It should be noted that the result for 1,1,1-Trichloroethane (6.2 ppb) was estimated due to poor recovery.

Four (4) organic constituents were detected just above laboratory detection limits in the Perry residence well (well reference no. 11). Low levels detected should not pose health risks upon continued consumption. It should be noted that the result for Methylene Chloride (<0.6 ppb) and Chloromethane (<9.0 ppb) were estimated due to poor recovery and may not represent actual constituents present. The estimated level for Methylene Chloride (5 ppb) is well below the associated MCL and NCS. Chloromethane does not have an established MCL or NCS.

Four (4) organic constituents were detected just above laboratory detection limits in the Bolick rental residence well (well reference no. 2). Three (3) compounds detected are Benzene derivatives and unlikely related to groundwater contamination beneath the landfill. Trichloroethene was detected at a level well below the applicable MCL and NCS.

2.10.2 March 18, 1993 DAA Sampling Event

The March 18, 1993, residential and business potable water well sampling event was conducted to confirm and further investigate trends observed in results of the initial March 5, 1993, sampling event. The eight (8) sampling locations were selected based on a preliminary risk analysis conducted from the results of the initial March 5, 1993, sampling event. These eight (8) sampling locations are presented on the Vicinity Map (Figure 3) and are denoted by the sampled well reference numbers 12 through 19. Sampling and Analysis protocol detailed for the March 5, 1993 was duplicated for the March 18, 1993 sampling event. The March 18, 1993 analytical results are included in the summary table of all residential and business potable water well testing conducted to date (Table 5).

The Carroll residence well (well reference no. 12) was resampled during the March 18, 1993 sampling event to confirm results obtained from the initial sampling conducted on March 5, 1993. The March 18, 1993 Carroll residence well water analysis generally confirmed the analytical results obtained from the initial sampling event with the exception of the detection of three BTEX components (Toluene, 4-Isopropyltoluene, and O-Xylene) at low levels, and the absence (non-detection) of two chlorinated volatile organics (Vinyl Chloride and Dichlorodifluoromethane) and Isopropylbenzene. The presence of Toluene is likely a false detect since Toluene was also detected at a similar level in the Trip Blank.

Methylene Chloride was detected in the March 18, 1993 sampling of the Carroll residence well at levels considerably above the NCS and EPA MCL. Methylene Chloride was also detected in the accompanying Trip Blank and was not detected in the March 5, 1993 sampling of the Carroll residence well. The two compounds identified in the March 5, 1993 sampling of the Carroll residence well at levels above the EPA MCL (Tetrachloroethene and Trichloroethene) were again detected at levels approaching and above, respectively, the EPA MCL.

Two (2) of the additional residential wells tested (denoted with sampled well reference numbers 13 and 14 on the Vicinity Map) detected low levels of several volatile and semi-volatile organic compounds. All organic levels detected are below applicable NCSs and EPA MCLs except two Chlordane compounds (a Termite insecticide) which were detected above the NCS but below the EPA MCL in Shared Well #1 (well reference no. 13).

The analysis of the other five (5) additional residential wells tested on March 18, 1993 (well reference numbers 15 through 19) did not detect any volatile (EPA Method 502.2) or semi-volatile (EPA Method 525.1) organic compounds.

2.10.3 March 23, 1993 Appalachian District Health Department Sampling Event

The March 23, 1993 sampling event was conducted by the Appalachian District Health Department and analysis was performed by the North Carolina State Laboratory of Public Health. The March 23, 1993, sampling represents the initiation of a cooperative effort between Watauga County and the Appalachian District of Health Department to conduct an ongoing risk investigation of potential contaminant migration pathways neighboring the landfill site. Analytical results can be found in the summary table (Table 5).

The March 23, 1993 sampling event was performed on three (3) additional residential wells within the Rocky Mountain Heights subdivision and analyzed for volatiles only (EPA Method 502.2). No volatile compounds were detected in two (2) of the residential wells (well reference no. 21 and no. 22). Low, trace levels of two (2) chlorinated volatile compounds (1,1,1-Trichloroethane and Chloroform) were detected in the Simko well; (well reference no. 20).

2.10.4 March 24, 1993 DAA Sampling Event

The March 24, 1993, sampling event was conducted on the Nissan-Mazda Dealership water well (well reference no. 4) for the purpose of confirming results obtained from the March 5, 1993, sampling event. The sampling was conducted by the Appalachian District Health Department and analysis (EPA Method 502.2) was conducted by Central Virginia Laboratories and Consultants, Inc. (CVLC). CVLC had conducted analysis for all previous site sampling events performed by DAA since September, 1992. Analytical results can be found in the summary table (Table 5).

The March 24, 1993, analysis results of the Nissan-mazda Dealership are similar to the March 5, 1993, analysis results with the exception of the detection of two BTEX components (Toluene and o-Xylene) at low levels and the absence (non-detection) of three chlorinated volatile organics (Carbon Tetrachloride, Chloroethane, and Trichlorofluoromethane). The presence of Toluene and o-Xylene are likely false detects as these compounds were also detected at similar levels in the accompanying Trip Blank.

The two compounds identified in the March 5, 1993 sampling at levels above the EPA MCL (Tetrachlorothene and Trichloroethene) were again detected above the MCL.

2.10.5 May 11, 1993 Appalachian District Health Department Sampling Event

The May 11, 1993, sampling event was conducted by the Appalachian District Health Department and analysis (EPA Method 502.2) was performed by the North Carolina State

Laboratory of Public Health. A DAA representative participated in the sampling to ensure the standard protocols established in the initial March 5, 1993 residential and business well sampling were observed.

Four (4) residential wells within the Rocky Mountain Heights Subdivision were sampled, including one well originally sampled on March 18, 1993. The resampled well (well reference no. 13) is shared by eight (8) residences and the March 18, 1993 analysis detected two Chlordane components (Termite insecticide) above the NCS. Resampling was performed at the request of the North Carolina State Epidemiologist to confirm and further investigate the initial Chlordane levels detected.

The analytical results of the resampled shared well detected no volatile organic compounds suggesting that 1) the two chlordane components observed in the initial sampling may be a transient rather than persistent contamination problem and 2) the two chlorinated organics and one benzene derivative detected initially at low to trace levels may also not be persistent, widespread contaminants of the well system.

The analytical results obtained from the May 11, 1993 sampling of the Ward residence well (well reference no. 24) detected two chlorinated organic compounds (1,1-Trichloroethane and Trichloethene) at trace levels and Methylene Chloride at a level (3.2 ppb) approaching the NCS and MCL (5 ppb).

Chloroform, a common transformation product resulting from the chlorination of well systems, was detected in the Johnson residence well (well reference no. 23) sampled on May 11, 1993.

No volatile organic compounds were detected in the other residential well, the Younce well (well reference no. 25) sampled on May 11, 1993. Analytical results for all residential and business potable water well testing to date is presented in Table 5.

2.10.6 June 23, 1993 Appalachian District Health Department Sampling Event

The June 23, 1993 sampling event was conducted by the Appalachian District Health Department and analysis (EPA Method 502.2) was performed by the North Carolina State Laboratory of Public Health. Seven (7) residential wells within the Rock Mountain Heights Subdivision were sampled including three (3) wells previously sampled.

The resampling of the two (2) previously sampled wells was performed at the request of the North Carolina State Epidemiologist. One well requested resampled was the Carroll residence well (well reference no. 12) which had been sampled twice before on March 5, 1993 and March 18, 1993. The Carroll residence well analytical results had repeatedly detected several chlorinated organic compounds above respective NCSs and MCLs. The other requested resampled well was the Ward residence well (well reference no. 24). The previous sampling of the Ward residence well performed on May 11, 1993 had detected Methylene Chloride at a level (3.2 ppb) approaching the NCS (5 ppb) and MCL (5 ppb).

The June 23, 1993 Carroll residence well analysis generally confirmed the analytical results obtained for the primary organic constituents detected from the two (2) previous sampling events performed on March 5, 1993 and March 18, 1993 with the exception of the absence (non-detection) of many of the BTEX components (Toluene, 4-Isopropyl toluene, and Isopropylbenzene) and Chlorinated volatile organics (Chloroethane, Chloromethane, Dichlorodifluoromethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 2,2-Dichloropropane, Trichlorofluoromethane, and Vinyl Chloride) and Styene. Several of these previously detected compounds (Chloroethane, Dichlorodifluoromethane, 1,1-Dichloroethane, and Trichlorofluoromethane) had been previously detected at significant levels. Analysis for the previous two (2) sampling events was performed by Central Virginia Laboratories and Consultants, Inc. (CVLC). The disparities between sampling event data sets presented above have yet to be resolved or qualified in conjunction with the QAPP designed for the Assessment Plan.

The June 23, 1993 Ward residence well analysis did not detect Methylene Chloride which had been previously detected at a level (3.2 ppb) approaching the NCS (5.0 ppb) and MCL (5.0 ppb). The other two Chlorinated organic compounds (1,1,1-Trichloroethane and Trichloroethane) detected at trace levels from the previous sampling and analysis performed on May 11, 1993 were again detected at trace levels. An additional Chlorinated organic compound (Tetrachloroethene) was also detected at trace levels as a result of the June 23, 1993 sampling event.

Chloroform, a common transformation product resulting from the chlorination of well systems, was detected in the McLean residence well (well reference no. 26). Chloroform has also been detected in other neighboring residence wells (Simko residence well, well reference no. 20 and Johnson residence well, well reference no. 23). Chloroform concentration levels detected have been reported by the N.C. State Laboratory of Public Health both as trace and less than 1.0 ppb. The MCL for Chloroform is 5.0 ppb and the NCS is 0.19 ppb.

The Perry residence well (well reference no. 11) was also resampled on June 23, 1993. The Perry residence well was originally sampled on March 5, 1993 and the analysis had detected 4 organic compounds (Dichlorodifluoromethane, Naphthalene, Chloromethane, and Methylene Chloride). These organic compounds were detected at low levels although the level detected for Dichlorodifluoromethane (2.5 ppb) was above the NCS (0.19). The June 23, 1993 sampling and analysis resulted in no volatile organic compounds detected. The analysis of the other three (3) residential wells tested on June 23, 1993 (well reference numbers 27 through 29) also did not detect any volatile organic compounds.

III. SITE DYNAMICS

3.1 INITIAL INVESTIGATION

This section discusses the initial investigations conducted during the development of this Assessment work plan to better understand the site dynamics. To the benefit of this plan, several critical areas of typical investigation are already well delineated. The existing data presented in Section II is utilized to develop a conceptual site model that describes the site dynamics. This section concludes with a preliminary exposure assessment that attempts to provide an understanding of the dynamics between the site and its environs including potential receptors. The understanding of site dynamics provides the foundation for the Assessment Plan work tasks presented in the following Section IV.

3.1.1 Site Boundary and Feature Delineation

Draper Aden Associates surveyed the site boundaries and features and utilized an aerial topographic survey to develop a site map. During the Bolick site investigation all monitoring wells and piezometers were additionally surveyed and combined with the previous site map. This information is presented in the enclosed Site Map (Figure 2).

The Site Map depicts the location of all structures (i.e.: baling facility, scale house, maintenance facility, dog pound, etc); roads; power and water lines; monitoring wells and piezometers; as well as limits of waste disposal. Additionally, the site map depicts surface features including topographic, drainage, and vegetation features. The site map is presented at a scale of 1"=10' with a ten (10) foot topographic interval.

The vicinity map (Figure 3) depicts an area slightly greater than one (1) square mile surrounding the landfill site. The vicinity map depicts many of the features presented on the site map including structures, roads, and other surface features. For purposes of risk assessment, particular emphasis is given to presenting all residences, drinking water wells, and public water supply sources on the vicinity map. Information for the vicinity map was compiled from a variety of sources including USGS topographic maps, Watauga County tax maps, aerial survey photographs, and site inspections. The vicinity map is presented at an approximate scale of 1 inch = 600 ft. with a forty (40) foot topographic interval.

3.1.2 Present Site Conditions Evaluation

The evaluation of present site conditions was compiled from reviews of recent NCDEHNR Solid Waste Section inspection reports, discussions with Mark Combs, Sanitation Supervisor, and visual inspections. The site evaluation emphasized current waste composition and current cover characteristics. Particular attention was given to the effects of present waste and cover conditions on leachate and landfill gas generation.

The present site condition evaluation indicates that current site activities are not contributing substantially to leachate and landfill gas generation. Leachate generation and subsequent effects on groundwater and surface water quality are primarily the result of past substandard disposal practices and development decisions discussed in Section II.

3.1.3 Site Drainage Patterns Evaluation

Reviews of recent NCDEHNR Solid Waste Section inspection reports, discussions with Mark Combs, Sanitation Supervisor, and visual inspections reveal that runoff pathways within the waste are currently problematic immediately north of the power easement as depicted on the Site Map (Figure 2). Remediation of the surface drainage in this area of the hill has been conducted by installing and maintaining suitable drainage structures.

Three (3) sediment ponds are currently located in the drainage immediately below the waste disposal area. The ponds appear to be adequately maintained for the purpose of temporarily retaining surface runoff and precipitating sediment and metal ions as well as volatilizing organic compounds. A sediment pond is also located below the Bolick site. The Bolick site sediment pond does not receive direct surface runoff from the fill area, but appears to be hydraulically connected to the groundwater. The groundwater in turn appears to be hydraulically connected to the fill area.

3.1.4 Leachate and Surface Water Evaluation

Volatile organic analysis was conducted on "leachate samples" collected from the spring capture system installed beneath the fill area on March 8, 1989, and December 11, 1990 and was conducted on stream samples collected on May 12, 1990. Sampling for these events was conducted by the North Carolina Solid Waste Section and analysis was performed by the North Carolina State Laboratory of Public Health. The volatile organic analysis results indicate sixteen (16) volatile organic constituents that are likely contributing to the high TOX results obtained in previous sampling events.

Review of the spring capture outfall (i.e. leachate) analysis summary (Table 1) reveals no occurrence of either excessive concentrations of inorganic constituents or high levels of indicator parameters. Comparison of these historical leachate characterizations with the EPA Summary of Leachate Characteristics (EPA/530/SW-87/028A, October 1987) indicates the leachate "strength" to actually be below levels typically found in municipal solid waste landfill leachate. Residence time, total volume, and dilution occuring in the spring outfall are likely resulting in lower concentrations observed at sampled leachate seep sampling points.

Dilution effects expected to be observed at the stream are often not apparent. Review of the stream analysis summary indicates elevated concentrations of inorganic concentrations and elevated levels of indicator parameters. The non-dilution phenomena is most prevalent for the indicator parameters: Conductivity, COD, and TOX, and the water quality parameters; Chloride, Nitrate, Sulphates, Iron, Manganese, and Zinc. Of particular note are the stream analysis TOX results obtained on May 29, 1990 and December 11, 1990 of 0.077 mg/L and 0.066 mg/L, respectively.

The volatile organic constituents detected in the leachate are at much lower concentrations than would be expected given the concentrations observed in the groundwater (discussed in Sections 2.9 and 2.10). Dilution of the leachate and volatilization of certain constituents in the aerobic conditions experienced along certain surface seeps may be contributing to the lower DNAPL organic constituent concentration levels observed in the sampled leachate. Attempts to sample leachate buried deep within the fill may produce additional useful information concerning volatile organic concentrations of leachate infiltrating the fracture aquifer systems. Sources of groundwater contamination other than the landfill should also continue to be investigated.

The reason for the apparent contradictory relationship between leachate and stream water quality may result from the cumulative effects of a variety of non-point discharges originating from the landfill site including natural variation due to on and off-site geology which itself is a significant source of noted metals. The improper management practices conducted at the landfill prior to 1984 discussed in Section 2.6, (i.e.: improper drainage, improper cover, erosion, numerous leachate seeps, siltation, etc.) likely resulted in low point impacts but a cumulatively high general impact on the stream below the site. The objective of the leachate investigation conducted during the landfill assessment investigation will be to clarify the relative strengths occurring within various areas of the landfill and predict potential leachate pathways.

3.1.5 Landfill Gas Evaluation

Several gases are typically generated by decomposition of organic materials in a landfill. The composition, quantity, and generation roles of the gases depend on such factors as refuse quantity and composition, refuse placement characteristics, landfill depth, refuse moisture content, and amount of oxygen present. During early stages of decomposition, waste undergoes aerobic decomposition, and the principle gas generated is carbon dioxide. Once free oxygen is depleted, the waste decomposition becomes anaerobic, and dominate gas generation also includes methane.

The evaluation of existing data conducted for the waste and cover characterization have been utilized for the landfill gas evaluation. Potential conditions presented by past and present waste disposal and cover practices were explored but no formal testing of the surface or subsurface gas conditions were conducted. As such, the potential exists for substantial gas generation at the landfill, considering the combination of extensive fill and varied water infiltration sources. The recently disposed waste residing near the surface of the fill has received sufficient cover to suppress and contain considerable gases generated in the older saturated waste residing deeper in the fill.

3.1.6 Waste and Cover Evaluation

The waste, cover and compaction characteristics are heavily dependent on the age of the waste disposal units. The chronologic delineation of phases of waste disposal for individual units or general areas of the fill provides an effective method for anticipating waste composition, compaction, and cover characteristics. Section 2.4 provides a chronology summary of the waste disposal and cover practices as indicated by the evaluation of available existing information. The resultant cap and cover characterization forms the basis of the following waste and cover evaluation.

According to Mark Combs, Watauga County Sanitation Supervisor, the basic footprint of the sanitary debris fill area has not expanded north of the powerline easement since Watauga County began managing the landfill in 1984. During the years from 1978 to 1984, when the landfill was operated by the Town of Boone, the footprint of waste disposal basically covered the area north of the powerline easement currently utilized for sanitary waste disposal with the exception of several hundred feet in the western area of the landfill adjacent to the maintenance office. In 1984, after maintaining an even grade with the maintenance building for approximately 800 feet, the waste disposal's vertical lift sloped down to the demolition/debris fill area and the sediment pond.

The western area of the landfill was utilized beginning around 1980. Since 1984, expansion of the sanitary fill area north of the powerline easement has added as much as 40-feet of waste to the previously existing vertical lift. Beginning in 1992, the County began utilizing a bailer to compress the waste into compact bails. The bails currently cover a majority of the original footprint extending from the maintenance office in the western portion of the landfill to approximately 800 feet to the beginning of the slope of the fill area.

The closed demolition area, located northeast of the sanitary fill area, was operated from approximately 1984 to 1986. The existing demolition/debris fill area is located immediately north of the powerline easement and east of the sanitary fill area and has been operated from 1986 to the present.

The area to the south of the powerline easement was utilized as a sanitary fill area between 1987 and early 1989. 15-20 feet of earth was excavated in the easternmost section of this fill area and approximately 40 feet of earth was excavated in the westernmost section to allow for approximately 60 feet of waste to be disposed. Disposal began in the eastern section and progressed to the western section.

3.1.7 Geotechnical Investigation

During the Bolick site investigation, twelve soil borings were drilled at the site to determine the nature and occurrence of available soil materials. The weathering of bedrock underlying the Bolick site has produced approximately 20-feet of micaceous silty sands and sandy silts above bedrock. A summary of the Bolick site soil borings is presented in Table 6.

Auger refusal depths obtained from the boring program were utilized to determine depth to bedrock on the Bolick site. A bedrock elevation map of the Bolick site determined from auger refusal depths is presented in Figure 9.

A bulk sample representative of the most common material available, was obtained from boring B-23, from 5.0 feet to 10.0 feet and was analyzed by Engineering Tectonics for the following:

- Natural Moisture
- Proctor
- Grain Size
- Atterberg Limits
- Consolidation
- Triaxial Shear
- CBR
- Permeability (Remolded at optimum moisture)

The soil analysis results are summarized in Table 7.

TABLE 6

Watauga County Landfill, Bolick Site
Soil Boring Summary

All measurements are in feet and elevations are in feet above sea level.

Boring No.	Ground Elev.	Auger Refusal Depth	Auger Refusal Elev.	Sampling Summary	Piezometer/ Well
B-13	3195.05	26.0	3169.1	BS[1]	Yes
B-14	3214.80	26.0	3188.8	BS[1]	Yes
B-15	3232.00	24.0	3208.0	BS[1]	No
B-16	3254.29	9.5	3244.8	BS[1]	No
B-17	3217.62	20.5	3197.1	BS[1] ST 17A (7.0'-10.0') ST 17B (7.0'-10.0')	Yes
B-18	3233.60	26.0[3]	3207.6	BS[1] C30.0'-50.0'	Yes
B-18A	3233.95	25.0	3209.0		Yes
B-19	3263.81	21.0[2]	3242.8[2]		Yes (grouted)
B-20	3235*	abandoned			No
B-21	3269.58	abandoned		Encountered fill	No
B-22	3205.60	26.0	3179.6	BS[1]	Yes
B-23	3221.74	16.0[3]	3205.7	BS 5.0'-10.0' C 17.0'-36.5'	Yes
B-24	3262.55	21.0[2]	3241.6[2]		Yes (grouted)
B-25	3270.56	19.0[2]	3251.6[2]		Yes (grouted)

[1] The soil boring program included split-spoon sampling at 5-foot intervals for the first 10 feet, and continuous split-spoon sampling for the next 20 feet of penetration or until auger refusal or saturated conditions (groundwater) were encountered.
[2] Air rotary drilling utilized a hydraulic hammer rather than a hollow stem auger. Auger refusal depths and elevations noted for B-19, B-24, and B-25 refer to depth bedrock was encountered.
[3] For B-18 and B-23, tri-cone drilling was used for the interval from auger refusal to coring.

Borings surveyed by Draper Aden Associates on September 10, 1992.
*approximate, not surveyed (inferred from topographic map)

BS - Bulk sample
ST - Shelby tube
C - Core

Drawing Under Seperate Cover

Drawing Under Seperate Cover

TABLE 7
SOIL LABORATORY TEST RESULTS

	REMOLDED SAMPLE B-23	UNDISTURBED SAMPLE B-17
DEPTH	5.0 feet - 10.0 feet	7.0 feet - 9.5 feet
NATURAL MOISTURE %	29%	34.3%
OPTIMUM MOISTURE %	27.3%	---
LIQUID LIMIT	35	47
PLASTIC LIMIT	NP	38
PERMEABILITY	2.42 X 10^{-6} cm/s	3.42 x 10^{-7} cm/s
TUBE DENSITY	---	117.6 PCF
MAXIMUM DRT DENSITY	91.8 PCF	---
% COMPACTION	95.2%	---

The bulk sample laboratory test results quantify the character of the site soils for use as daily cover and suitability for use in a compacted liner. The liquid limit and plastic limit are used to calculate the plastic index for the soil which indicates its degree of plasticity under natural conditions. The plastic index calculated for the bulk sample collected indicates this soil to be non-plastic. Non-plastic soils have little or no cohesion and cannot be compacted to achieve a high density and low permeability. The natural moisture (%) and optimum moisture (%) are used to determine how the soils must be treated to be compacted to its maximum density. The remolded permeability of the bulk sampled was conducted at a compaction of 95.2% maximum density. The remolded permeability at optimum moisture (%) for the representative soil sample obtained from boring B-23 (2.42 x 10^{-6} cm/sec) is greater than the maximum allowable permeability. It will therefore be necessary to augment the on site soils to meet the 1 x 10^{-7} cm/sec clay liner permeability requirements.

Bulk samples obtained from each of the eight borings drilled with the hollow-stem auger have been analyzed by Colloid Environmental Technologies (CETCO) for soil augmentability. The soil augmentation testing provided an indication of the amount of bentonite clay necessary to mix with the existing soils to meet clay liner permeability requirements. To attain a permeability coefficient of 1 x 10^{-7} cm/sec., the analysis by CETCO recommends an average application rate of 5.8 lbs/sq. ft. bentonite clay to a six inch thick liner layer (compacted at optimum moisture to a minimum of 90% of Standard Proctor.

Shelby tubes (i.e. undisturbed samples) were collected immediately adjacent to boring B-17, located halfway along this central drainage of the Bolick site, at a depth one foot above the water table from 7.0 feet to 9.5 feet. The following soil analyses were performed on these shelby tubes by Engineering Tectonics:

- Tube Density
- Natural Moisture
- Grain Size
- Atterberg Limits
- Consolidation
- Triaxial Shear
- CBR
- Permeability (undisturbed)

The shelby tube soil analysis results are summarized in Table 7.

The shelby tube soil analysis laboratory test results quantify the in-situ character of the soil. The permeability determined from the Shelby tube indicated the rate at which fluids will travel through the portion of the vadose zone composed of undisturbed soil.

3.1.8 Hydrogeologic Investigation

3.1.8.1 Aquifer Flow Characterization

During the Bolick site investigation, a variety of aquifer tests were performed on the network of monitoring wells and piezometers at the Watauga County landfill property. For the purpose of attaining a comparative data set, the aquifer test results were utilized to establish the hydraulic conductivity of the groundwater at these various points.

A summary of the aquifer test results is contained in Table 9. A summary of completion data for monitoring wells is contained in Table 2 and a summary of all piezometers is contained in Table 8. The information derived from the aquifer tests is utilized to support the presence of preferential flow regimes that appear to exist at the site.

Aquifer Tests

Slug tests were performed on soil piezometers (PZ-13, PZ-14, PZ-17, PZ-18A, and PZ-22) within groundwater above bedrock, two piezometers (PZ-18 and PZ-23) within cored bedrock, and three proposed monitoring wells (MW-5, MW-6, and MW-7) within the air rotary drilled bedrock along the divide between the Bolick site and the landfill. Slug tests were performed to calculate the hydraulic conductivity of these various aquifer locations. The hydraulic conductivity (K) within the soil aquifer was calculated from slug test data obtained from the five piezometers with groundwater above bedrock utilizing the Bouwer and Rice slug test method (Bouwer, 1989). The transmissivity (T) and storage coefficient (S) was calculated from the slug test data from the two piezometers within the cored bedrock and the three monitoring wells within the air rotary drilled bedrock along the topographic divide utilizing the Cooper-Bredehoeft-Papadopulos slug test method (Cooper, et al, 1967). The hydraulic conductivity (K) was then calculated from the transmissivity (T) by dividing the transmissivity by the well screen length utilized in the test method calculations.

Pump and recovery tests were performed on the set of nested piezometers (PZ-18 and PZ-18A), the set of nested monitoring wells (MW-2 and MW-4), MW-1 and MW-3, and the three proposed monitoring wells within the bedrock along the topographic divide between the Bolick

TABLE 8

Watauga County Landfill, Bolick Site
Summary of Piezometers

All measurements are in feet and elevations are in feet above sea level.

Piezometer No.	Ground Elev.	PVC Casing Elev.	SWL* Elevation	SWL*	Total Depth**	Screen Length Depth Interval**	Filter Packing Depth Interval**	Annular Seal Depth Interval**	Completed in Soil or Bedrock
PZ-13	3195.05	3198.33	3185.51	12.82	26.0	26.0-21.0	26.0-19.0	19.0-17.0	Soil
PZ-14	3214.80	3217.80	3200.05	17.75	25.5	25.5-20.5	25.5-18.5	18.5-16.5	Soil
PZ-17	3217.62	3220.79	3205.61	15.18	20.5	20.5-15.5	20.5-13.5	13.5-11.5	Soil
PZ-18	3233.60	3236.02	3222.06	13.96	50.0	50.0-35.0	50.0-33.0	33.0-28.0	Bedrock
PZ-18A	3233.95	3236.86	3222.83	14.03	25.0	25.0-20.0	25.0-18.0	18.0-16.0	Soil
PZ-19	3263.81	3266.86	3216.11	50.75	73.0	73.0-63.0	73.0-61.0	61.0-59.0	Bedrock
PZ-22	3205.60	3208.84	3195.54	13.30	26.0	26.0-21.0	26.0-19.0	19.0-17.0	Soil
PZ-23	3221.74	3225.27	3200.74	24.53	36.5	36.5-31.5	36.5-28.5	28.5-17.0	Bedrock
PZ-24	3262.55	3265.15	3223.19	41.96	58.0	58.0-48.0	58.0-46.0	46.0-44.0	Bedrock
PZ-25	3270.56	3273.61	3246.46	27.15	50.0	50.0-40.0	50.0-38.0	38.0-36.0	Bedrock

*As recorded from top of PVC on September 8, 1992
**As recorded from ground elevation

Note: Piezometers PZ-19, PZ-24 and PZ-25 were grouted (5% bentonite) to surface above the annular seal and are currently proposed plume assessment moitoring wells MW-5, MW-6, and MW-7, respectively.

Survey by Draper Aden Associates, September 10, 1992.

TABLE 9

Watagua County Landfill and Bolick Site
Aquifer Flow Characterization Summary

All measurements are in feet

Observation Well	Screen Length Depth Interval	Completed in Soil or Bedrock	Bower - Rice Slug Test (unconfined)	Cooper, Bredehoeft, Papadopulos Slug Test (confined)	Theis Recovery Test
PZ-13	26.0 - 21.0	Soil	K = 8.0222 ft/day		
PZ-14	25.5 - 20.5	Soil	K = 7.4557 ft/day		
PZ-17	20.5 - 15.5	Soil	K = 5.585 ft/day		
PZ-18	50.0 - 35.0	Bedrock		T = 10.368 ft^2/day K = 0.610 ft/day	
PZ-18A	25.0 - 20.0	Soil	K = 0.165 ft/day		
PZ-19 (proposed MW-5)	73.0 - 63.0	Bedrock		T = 5.184 ft^2/day K = 0.432 ft/day	T = 1.28 ft^2/day K = .1449 ft/day
PZ-22	26.0 - 21.0	Soil	K = 0.089 ft/day		
PZ-23	36.5 - 31.5	Bedrock		T = 3.456 ft^2/day K = 432 ft/day	
PZ-24 (proposed MW-6)	58.0 - 48.0	Bedrock		T = 6.048 ft^2/day K = 504 ft/day	T = 1.872 ft^2/day K = 0.156 ft/day
PZ-25 (proposed MW-7)	50.0 - 40.0	Bedrock		T = 0.0086 ft^2/day K = .0007 ft/day	T = 0.662 ft^2/day K = 0.055 ft/day
MW-1	80.0 - 70.0	Bedrock			T = 27.36 ft^2/day K = 0.739 ft/day
MW-2	180.0 - 170.0	Bedrock			T = 6.624 ft^2/day K = 0.390 ft/day
MW-3	32.0 - 22.0	Soil			T = 116.64 ft^2/day K = 9.72 ft/day
MW-4	42.0 - 32.0	Soil			T = 112.32 ft^2/day K = 10.21 ft/day

K - Hydraulic Conductivity *** As recorded from ground elevation**
T - Transmissivity

site and the landfill (MW-5, MW-6, and MW-7) to determine the nature of flow in and between these various aquifer depths. The transmissivity (T) and storage coefficient (S) were calculated from the recovery data utilizing the Theis recovery method (Theis, 1935). The hydraulic conductivity (K) was then calculated from the transmissivity (T) by dividing the transmissivity by the well screen length utilized in the test method calculations.

During pumping of the deeper well or piezometer of the nested sets, the water level of the shallow well or piezometer was monitored to provide an indication of the degree of vertical integration occurring within the groundwater fracture system.

The conventional well-flow equations utilized for defining fracture flow (i.e. Cooper-Bredehoeft-Papadopulos slug test method and the Theis recovery method) were developed for homogeneous and isotropic aquifers, and therefore may not describe fracture flow adequately. Weaknesses involved with aquifer property test methods for fracture flow creates difficulties for creating fracture data sets to compare with the flow properties occurring within the soil aquifer. Since assumptions regarding homogenous and isotropic conditions required for the Theis recovery method and the Cooper-Bredehoeft-Papadopulos slug test method do not hold in the fracture system, the resultant calculated hydraulic conductivities provide only a relative indication of the flow properties of the fracture system. The two confined flow test methods utilized were chosen because methods of describing fracture flow generally assume the aquifer is confined (Kruseman and de Ridder, 1989).

These confined flow test methods were utilized primarily for comparative purposes since true fracture flow test methods will require prolonged (>2 days) pumping of the well and the monitoring of several nearby nested well sets that also access the same fracture system. The results obtained from these expensive flow tests can be interpreted rather subjectively since it is necessary for the tests to make certain assumptions regarding fracture symmetry and the global geometry of the fracture system that may or may not hold true. Prolonged, nested well pump tests may prove to be beneficial and cost effective after more information is attained during the plume assessment.

The information obtained from the aquifer testing is used in the following discussion to define the rate and nature of flow within the fractures and in the soil at variable locations and depths across the existing Watauga County Landfill and the adjacent Bolick site.

Aquifer Test Results

The recovery tests performed on the monitoring wells reflect a general trend of decreasing hydraulic conductivity with depth. The hydraulic conductivities of the two shallow monitoring wells, MW-3 and MW-4 (completed at total depths of 42.0' and 32.0', respectively) are substantially greater than the two deeper monitoring wells, MW-1 and MW-2 (completed at total depths of 80.0' and 180.0', respectively). The substantial difference in the hydraulic conductivities between the two shallow and two deep monitoring wells reflect the fact that the two shallow wells are completed in soil rather than fractures within bedrock.

The difference in the hydraulic conductivities between the two deep monitoring wells, MW-1 and MW-2, is indicative of the general trend of decreasing permeability with depth within the bedrock fractures. MW-1, completed at a depth of 80.0', is over four times as transmissive as MW-2, completed at a depth of 180.0'. Without taking fracture depth into consideration, the fracture zone accessed by MW-2 would be expected to be more transmissive than MW-1 rather than less transmissive. MW-2 is located in the major drainage of the active landfill where the underlying zone of fracture concentration would be expected to be found. MW-1 is located in the saddle of the ridge above the active landfill where fracture concentration would be expected to be less. The drillers well log for MW-1 only describes a 2 foot zone of 'decomposed granite' at a depth of 50 feet, but constructed the filter pack from 85.0 to 48.0. The possibility exists that less obvious fractures exist within the filter pack that are not detailed in the driller's log.

The set of nested monitoring wells, MW-2 and MW-4, was observed to determine the interconnectedness of the surficial saprolite aquifer and the deep fracture system aquifer at this location. During the recovery test for MW-2, 512 gallons were removed from the deep fracture system over a two hour period. The water level in the adjacent shallow well, MW-4, was observed to detect any loss of groundwater in the shallow soil aquifer to the deeper fracture system. No change in the water level of MW-4 was observed. Therefore, no apparent connection was observed between the deep fracture system accessed by MW-2 and the shallow soil aquifer accessed by MW-4.

The recovery tests performed on the three piezometers (PZ-19, PX-24, and PZ-25) proposed as monitoring wells, MW-5, MW-6 and MW-7, (discussed in Section 4.3.5) located along the original topographic divide separating the Bolick site from the fill area, indicate that the fracture system supplying groundwater to upper bedrock within this divide is far less transmissive than the fracture systems accessed by MW-2, located in the drainage of the landfill, and MW-1, located in the saddle of ridge above the landfill. The fracture system located at the toe of the southwestern knob accessed by MW-7 is the least transmissive of all the fractures accessed on site. During the recovery test of MW-7, 24 feet of water was initially removed and only 1.2 feet returned after a 24 hour period.

Slug tests were also performed on the three proposed monitoring wells located along the divide to provide additional data to compare with the results of the recovery tests. The low recovery rates of these wells warranted the slug tests to substantiate the general transmissivity trends observed. In addition to these three wells, slug tests were also performed on the two piezometers accessing bedrock lower on the Bolick site, PZ-18 and PZ-23.

The results of the slug tests performed within the fractures of the bedrock underlying the Bolick site indicate relatively similar hydraulic conductivities. The slug test results reflect that far less transmissive fractures are accessed within the bedrock underlying the Bolick site than the fracture accessed by MW-1 and MW-2, underlying the active landfill. These transmissivity results may reflect a surface manifestation of the underlying zones of fracture concentration. The surface topography is often indicative of underlying zones of increased weathering, solutioning, and permeability resulting from fracture concentrations. In comparison, the Bolick site is gently sloping whereas the existing landfill is in a steeply sloping drainage.

The set of nested piezometers, PZ-18 and PZ-18A, was observed to determine the interconnectedness of the surficial saprolite aquifer and the shallow fracture system aquifer at this location. The piezometer accessing the bedrock, PZ-18, was pumped dry over a period of 30 minutes and the water level in the piezometer accessing the saprolite, PZ-18A, was observed to detect any loss of groundwater in the shallow soil aquifer to the shallow fracture system. Only a minor change in the water level of PZ-18A, Δ .03 feet, was observed. Therefore, only a slight connection was apparent at this location between the shallow fracture system and the surficial saprolite aquifer.

The results of the slug tests performed within the soil aquifer underneath the Bolick site indicate a wide range of hydraulic conductivities are distributed throughout the soils on site. The hydraulic conductivities calculated from piezometers, PZ-14 and PZ-17, located in drainages of the Bolick site, are similar to the transmissivities calculated from the two shallow monitoring wells, MW-3 and MW-4, also accessing surficial drainages in the unconfined soil aquifer. The hydraulic conductivities calculated from piezometers, PZ-18A and PZ-22, located in the northern drainage of the site reflect substantially less movement of water. The hydraulic conductivities calculated from the unconfined soil aquifer slug test results have been combined with potentiometric flow gradients to calculate specific discharges of specific soil aquifer flow paths. These specific discharges discussed in the following section and the potentiometric surface reflect that groundwater from the deeper bedrock aquifer that is discharged above bedrock beneath the Bolick site generally migrates towards the existing sediment pond.

<u>Specific Discharge</u>

The hydraulic conductivity and hydraulic gradient was estimated from the ratio of the change in hydraulic head between two well points and the distance separating the well points. The estimated hydraulic conductivity and hydraulic gradient were used in Darcy's equation to calculate the specific discharge of groundwater through three primary flow paths in the soil aquifer underlying the Bolick site.

Darcy's equation is written as: $q = K \times i$ where q is the specific discharge, or Darcy flux, K is the averaged hydraulic conductivity, and i is the hydraulic gradient between two well points. The hydraulic conductivity was calculated from slug test data for each well point as detailed in the previous section. The hydraulic gradient was estimated by calculating the ratio of the change in static water level (i.e. total hydraulic head) between two wells, h_2-h_1, and the approximate linear distance separating the well points, L_2-L_1, to give $i = (h_2-h_1)/(L_2-L_1)$.

Darcy's law approximates laminar groundwater flow through a porous medium and is valid only within a range of Reynolds numbers from 1 to 10 (Freeze and Cherry, 1979). For this study Reynolds numbers for the soil aquifer underlying the bolick Site were not calculated because the actual size of the planar and/or granular pores within the aquifer are not known. However, Darcy's law is assumed to be a good approximation for groundwater flux through the surficial soil aquifer underlying the Bolick site since groundwater production zones within gneiss saprolitic soils typically make for thin sheet-like laminar flow paths, and hydraulic conductivity and hydraulic gradients across the site are less than unity, providing for a small Reynolds number.

The Darcy flux of groundwater through the soil aquifer was calculated for three primary groundwater flow paths through the Bolick site. The following figure illustrates the locations of the three primary groundwater flow paths and the respective piezometers utilized to determine the specific discharge or Darcy flux. The following table, lists the Darcy flux calculations for the various soil groundwater flow regimes.

Flow Path	(h_2-h_1)(feet)	L_2-L_1(feet)	q(ft/day)
PZ-14 to PZ-13	14.54	234'	0.48
PZ-17-PZ-13	20.10	281'	0.49
PZ-18A to PZ-22	27.28	500'	0.0069

The calculated specific discharges of the three primary flow paths in the soil aquifer at the Bolick Site illustrate how the preferential flow regimes mimic existing surficial drainage patterns. PZ-13, the well head providing the fastest calculated hydraulic conductivity, is located at the confluence of two main drainages. PZ-14 and PZ-17 are located roughly 250 feet up gradient of these two main drainages. Both of the flow paths represented by these piezometers have similar high specific discharges although the central flow path containing PZ-17 is the faster of the two. Alternatively, the specific discharge of the flow path represented by PZ-18A and PZ-22 is negligible in comparison. The flow path represented by PZ-18A and PZ-22 is situated in an excavated trench that attempts to reroute surficial flow away from a sediment pond located below PZ-13. The soil aquifer underlying the excavated trench has likely not developed porous and permeable characteristics that evolve beneath natural drainages resulting in much slower hydraulic conductivities and specific discharges.

The calculated specific discharges of the three primary flow paths correlate well with the distributions of contaminants illustrated by the Bolick Site Groundwater Contaminant Plume Map (Figure 9). The contaminant plume's highest contaminant concentrations are distributed between the two main drainages and the concentrations diminish laterally to either side of these drainages.

It should be pointed out that the calculated specific discharges reported for the soil aquifer are not meant to represent conditions existing within the fracture system. Accurate documentation of the rate of flow existing within the fracture system will require the use of true fracture flow test methods with nested well and prolonged pumping (>2 days) of the aquifer. To proper interpretation, these fracture system pump test methods also require accurate characterization of individual fracture symmetry and the global geometry of the fracture network as well as accurate placement of individual wells.

The results from the conventional well-flow equations utilized for representing fracture flow rates (i.e. Cooper, Bredehoeft, Papadopulos slug test method and Theis Recovery Method) were developed for homogenous and isotropic aquifers and therefore may not describe fracture flow adequately. As described previously, the confined flow test methods were utilized primarily for comparison purposes and as such display the wide range of transmissivities existing within the fracture systems accessed by the seven bedrock well points at the Bolick site and Watauga County Landfill.

A review of well records for nearby domestic water wells within the bedrock fracture system as well as scientific literature review and fracture systems encountered at the site's well locations indicate the potential for a wide range of hydraulically conductive fractures to exist beneath and surrounding the Bolick site.

Aquifer Flow Summary

In summarizing, a conservative estimate of the discharge rates of mobile groundwater at the site likely range from 0.01 ft/day upwards to 10 ft/day. The faster discharge rates are documented to occur in the soil aquifer beneath the central drainage of the Bolick site.

Summarizing flow characteristics at the site, the following conclusions are obtained:

1. Groundwater is found within a locally confined fractured bedrock aquifer system, and, at lower topographic areas of the sites, within the soil zone above bedrock.

2. There is apparent hydraulic connection between the existing landfill site and the Bolick site, potentially influenced by mounding within the existing fill and deeper fracture flow orientations within the bedrock.

3. Based on research provided by Zurawski (1978), values for hydraulic conductivity within the Cranberry-Mine Layered Gneiss bedrock observed beneath the Watauga County Landfill property potentially range between 1 and 100 ft/day.

4. Depending on location at the site, discharge rates of groundwater appear to range between less than 0.01 ft/day, occurring in smaller possibly discontinuous fractures and less hydraulically evolved soil drainages, and up to 10 ft/day in areas of preferential flow influenced by larger fractures and relatively faster flow paths observed within the surficial soil zone aquifers developed beneath topographic drainages.

3.1.8.2 Preliminary Fracture Study

The application of predictive contaminant transport models in fracture rock systems is hampered by the overwhelming difficulties encountered in fracture system characterization. Data collection is essential and lays the foundation for modeling the behavior of a site. Before modeling the fracture system and before being able to make even simple assumptions regarding site specific fracture flow rates immediately surrounding individual well heads, several important characteristics must first be described (EPA/540/4-89/004. August 1989).

Realizing an accurate and comprehensive fracture system characterization is essential before effective modeling of the fracture system, the initial objective of the preliminary fracture study was to document all available information regarding the mineral lineation, layering, and foliation trends within the host bedrock. Attempts were then made to relate the trends and orientations of mineral lineation, layering, and foliation to the nature of the discontinuities within the host bedrock.

Layering within the mixed rocks has been produced by shearing of the migmatitic layering found in the underlying Cranberry Gneiss. The most strikingly layered rocks are the most sheared and less sheared rocks are generally more granitic and have a migmatitic aspect (Bryant and Reed, 1970) The mixed rocks appear to be a gradation zone between migmatitic Cranberry Gneiss and the overlying schist, gneiss, and amphibolite and as such reflect characteristics of both.

Lineation within the host bedrock is predominately formed by alignment of minerals and mineral aggregates and by elongated porphyclasts and boundings. This lineation was formed during synkinematic recrystallization (Bryant and Reed, 1970). Lineation generally trends northwest although the gradational character of the contact zone represented by the "mixed rocks" has resulted in a slightly variable or wavy lineation trend. The fracture analysis conducted for the remedial investigation will explore whether the lineation trends mimic and are reflective of topographic features.

Foliation, marked by aligned micas, tabular quartz-feldspar laminae, and planar arrangement of amphiboles, is well developed in most of the rocks of the Blue Ridge Thrust sheet. In the Cranberry Gneiss, foliation is cataclastic and is formed primarily by planar orientation of micaceous minerals. In most of the technically overlying mica schist, gneiss, and amphibolite, cataclastic effects are lacking, and foliation apparently formed during synclinematic recrystallization. (Bryant and Reed, 1970) Foliation generally trends northwest similar to lineation.

Cracks, fissures, fractures, joints, and shear zones within the regional bedrock interconnect to form the fracture system. The global geometry of the fracture system appears to possess both continuous and discontinuous zones. The continuous fracture zones primarily consist of conductive fractures that are very long compared to the region under study. The discontinuous fracture zones consist of dead end fractures, isolated fractures, and less conductive fracture zones. Preferential groundwater flow regimes occurring within these fracture systems appear to be characterized by topographic drainage features and the occurrence of springs.

Contaminant transport rates and distances indicated by residential and business potable well sampling and analysis results suggest that certain well heads likely access very continuous and conductive fractures and other well heads may access dead end or isolated fracture zones. The five on-site shallow (upper twenty (20) feet) bedrock piezometers also display a variety of both flow and contaminant transport characteristics that suggest the existence of both continuous and discontinuous zones within the host bedrock fracture system.

Local well drillers logs describe the formation materials as granite and shale. The "shale" intervals represent the layers of mica schist within the shear zones that host the monitoring of the groundwater production zones accessed most often by water production wells. Occasionally groundwater production is encountered in intervals described in the drillers logs as granite and white quartz, decomposed granite, or white flint. These groundwater production intervals likely represent either cracks, fissures, fractures, and/or joints within the host bedrock. Driller's logs indicate that these crack, fissure, fracture, and joint groundwater protection zones have been shown to be capable of producing considerable groundwater.

Groundwater production zones within cracks, fissures, fractures, and/or joints have also been observed in rock cores obtained from the upper twenty (20) feet of bedrock at two (2) piezometer locations within the Bolick site. Groundwater production in the fractures observed indicate that the size, orientation, location, and effective aperture of the discontinuities within the fracture system can be expected to vary considerably. Groundwater production zones were found in the upper twenty feet of bedrock in all five of the bedrock borings conducted on the Bolick site in August of 1992. Variability of recharge rates indicated by the initial Bolick site investigation aquifer flow characterization, (presented in Section 3.1.8.1 and summarized in Table 9), also indicate that the discontinuities within the fracture system can be expected to vary considerably.

The flow rates within specific discontinuities at site specific locations can be expected to depend on a variety of factors including the degree of interconnectedness, the frequency within single planes, the density per unit volume of rock, the effective aperture, and orientation and location in relation to gradient and relation to other discontinuities. Preliminary fracture analysis indicates that general approximations of these factors may be related to metamorphic grade contrasts and to general physiographic expressions, in and surrounding the site.

3.2 POTABLE WATER RESOURCES

3.2.1. Nearest Downstream Surface Water Intake

The Watauga County Landfill watershed drains into the South Fork of the New River, which flows north into Ashe and Alleghany Counties in North Carolina and continues into Grayson County in Virginia. The nearest existing downstream surface water intake is located in Grayson County, Virginia, several counties away from the influence of Watauga County Landfill watershed. The nearest proposed downstream surface water intake is located in Ashe County, North Carolina.

3.2.2. Potable Water Wells Within One Half Mile

The bedrock fracture system aquifer is the major source of potable water in the vicinity of the landfill. Approximately 100 residences, including 2 trailer parks and six businesses, are currently located within one half mile of the site. Although the Town of Boone's public water and sewer systems were extended across the South Fork of the New River in February, 1993, and connections are planned for the Bailing Facility at the landfill and the Nissan-Mazda Dealership, no other business or residential connections have been initiated for the systems.

In June of 1993, an intern with Appalachian District Health Department conducted a house to house potable water well survey determining well head locations and uses of all the potable water wells within one half mile of the site. It was determined that sixty (60) domestic water wells utilized groundwater resources within a one half-mile radius of the landfill.

Well heads were inspected and information concerning total depth and water production zone depth(s) collected. Well information was compiled from the well plates, well records, and discussions with the local well driller, Dewey Wright Well and Pump Company, Inc. The Regional Site Map (Figure 3) depicts the locations of all appropriate features and structures within a one half-mile radius of the landfill including all residences and well heads.

3.3 CONCEPTUAL SITE MODEL

Figure 7 summarizes the preliminary conceptual site model for the site generated from initial investigations. The preliminary conceptual site model illustrates relevant features within approximately 2,000 feet of the area. Initial investigations have considered the area depicted in the conceptual site model for assessing potential exposure pathways.

The domain of the soil aquifer potentially influenced by the waste disposal area is illustrated by the shaded area as depicted in the legend. Direct impact to the soil aquifer via leachate seeps and surface runoff may only occur north of the waste disposal area in the same drainage basin. The soil aquifers located within and below the Bolick site and the Rocky Mountain Heights Subdivision may only be impacted by the waste disposal area via recharge from the fracture system aquifer. It should be noted that impact to the Rocky Mountain Heights Subdivision by the waste disposal area via recharge from the fracture system aquifer must overcome the potentiometric gradient presented by the inferred potentiometric divide located at the ridge between the Rocky Mountain Heights Subdivision and the waste disposal area. Further investigation into the fracture systems' drainage pattern at this location will be necessary to substantiate any potential influence the landfill may have in impacting the Rocky Mountain Heights Subdivision.

The preliminary determinations of fracture traces in the area are illustrated by bold lines as depicted in the legend. A network of smaller conduits contribute flow to and receive flow from these larger "trunk" conduits represented by the preliminary fracture traces.

All existing businesses, residences, and mobile homes, within the vicinity of the site as illustrated by the conceptual site model, are depicted as defined by the legend and figure attributes. All existing monitoring wells, proposed monitoring wells, and potable water wells with sampled well reference number, within the vicinity of the site as illustrated by the conceptual site model, are also depicted as defined by the legend.

3.4 PRELIMINARY EXPOSURE ASSESSMENT

In order to adequately define the preliminary remediation goals, potential exposure pathways are first identified. The following exposure assessment begins by identifying the occurrence and concentrations of contaminants detected in the groundwater at the site and continues by comparing observed contaminant behavior within various exposure pathways with contaminant physical properties. Components of the exposure pathway explored include potential contaminant sources, release mechanisms, and the transport, migration, and fate of the contaminants.

The next step in the exposure assessment is a risk assessment. Section 4.6 defines the protocol to be followed during the Assessment Work Plan for assessing of risks to human health or the environment posed by contaminant exposure.

3.4.1 Constituents Detected at the Site

The organic compounds detected in the groundwater at Watauga County Landfill are primarily dense Chlorinated solvents. The solvents have little affinity for soils and are seldom a problem in surface water because of their volatility. (EPA/600/8-83/019. May 1983). Metals concentrations detected in the groundwater are generally low or are below the analytical method detection limit, although several metals, Cadmium and Iron in particular, have been observed at levels above those established by the EPA MCL and the Secondary MCL, respectively.

Metal concentrations observed during the Assessment monitoring program will be evaluated to determine if groundwater resources are being adversely impacted by sources not directly related to the aquifer medium. The Groundwater and Surface Water Monitoring Program (SAP - Appendix I) included as an attachment to the Watauga County Assessment Plan describes the metal analysis to be conducted as part of the Assessment Plan. Cadmium, Iron, Barium, and Mercury will initially be included in the target analyte list for the first year of Assessment monitoring. Subsequent to complete annual Appendix II analyses conducted on the 'core' plume assessment monitoring well network appropriate revisions to the target analyte list will be made.

A descriptive summary of constituents detected as a result of prior sampling and analysis is contained in the Evaluation of Existing Data (Section II). Tables presenting data summaries of landfill well groundwater, potable well water, stream, and leachate analyses are also contained within Section II. The following section explores in greater detail the organic constituents detected at the site.

The Groundwater and Surface Water Monitoring Program (Appendix I) included as an attachment describes the organic analysis to be conducted as part of the Assessment Plan. The following twelve "primary detected organic compounds" and also denoted in Tables 4 and 4A - SAP will initially be included in the target analyte list for the first year of Assessment monitoring, as well as other organic analytes provided by the necessary methods. Subsequent to complete annual Appendix II analyses conducted on the 'core' plume assessment monitoring well network, appropriate revisions to the target analyte list will be made.

<u>Primary Detected Organic Compounds</u>

The organic compounds detected at significant levels in virtually all downgradient groundwater monitoring wells, listed by order of decreasing occurrence and concentration are:

Parameters detected at significant levels in virtually all downgradient monitoring wells	Highest concentration reported (ppb)	NCS/MCL (ppb, ug/L)	Location of highest concentration
1,1,1-Trichloroethane (1,1,1-TCA)	1646	200/200	MW-2
1,1-Dichloroethene, *1,1-Dichloroethylene* (1,1-DCE)	232	7/7	MW-2
1,1-Dichlorethane (1,1-DCA)	250	700 (proposed)/--	MW-3
cis-1,2-Dichloroethene, cis-1,2-*Dichloroethylene* (cis-1,2-DCE)	225	70/70	MW-6
Tetrachloroethene, *tetrachloroethylene, perchloroethylene* (PCE)	39	0.7/5	MW-3
Trichloroethene, *trichloroethylene* (TCE)	110	2.8/5	MW-6

All of the constituents listed above were detected above associated EPA Maximum Contaminant Levels (MCL) and the North Carolina Groundwater Quality Standards (NCS) in one or more site groundwater monitoring wells (except for 1,1-DCA which does not have an established MCL or NCS).

All of the constituents listed above were detected above associated EPA Maximum Contaminant Levels (MCL) and the North Carolina Groundwater Quality Standards (NCS) in one or more site groundwater monitoring wells (except for 1,1-DCA which does not have an established MCL or NCS). All of the compounds listed above were also detected in two of the potable water wells neighboring the site (i.e.: Nissan-Mazda and Carroll residence wells). PCE and TCE were also detected above associated MCLs and NCSs in these two potable water wells. 1,1,1-TCA, 1,1-DCE, PCE, and TCE were additionally detected at lower concentrations in four (4) other potable water wells neighboring the site (i.e.: BREMCO, Bolick, Ward, and Simko residences); all three (3) of these compounds were not found in each of all four (4) potable water wells and were mostly found close to the method detection limit for each compound. The presence or absence of these compounds in the additional four (4) potable water wells can not be confirmed at this time.

A summary of the landfill groundwater analysis results for organic compounds listed above can be found on page 1 of Table 4. Page 1 of Table 4 presents all the groundwater analysis results for these six chlorinated volatile organics collected to date for the four well Watauga County Landfill Monitoring Well Network, MW-1, MW-2, MW-3, and MW-4, and additionally the grouted piezometer, PZ-24 (i.e. proposed monitoring MW-6). A summary of residential and business potable well analysis results can be found on Table 5.

The organic compounds detected at significant levels primarily in downgradient groundwater monitoring points located along the Bolick site (i.e.: MW-3 and proposed MW-6), listed by order of decreasing occurrence and concentration are:

Parameters detected at significant levels primarily in downgradient monitoring points located along the Bolick Site	Highest concentrations reported (ppb)	NCS/MCL (ppb; ug/L)	Location of highest concentration
Methylene Chloride, *dichloromethane* (DCM)	23	5/5	MW-3
Dichlorodifluoromethane	21	0.19/---	MW3
Vinyl Chloride	18	0.015/2	MW-6
Benzene	6	1/5	MW-6
Trans-1,3-Dichloropropene	9	70/100	MW-3
Chloroethane	8	---/---	MW-6

Methylene Chloride and Vinyl Chloride were detected above associated MCLs and NCSs in both groundwater wells, MW-3 and PZ-24 (MW-6). Methylene chloride was found just below the MCL at MW-2. It was found recently at the Carroll's residence at 138.2 ppb, well above the MCL of 5 ppb.

Dichlorodifluoromethane was also detected above the NCS in both MW-3 and PZ-24 (MW-6) but does not have an established MCL.

Benzene was also detected above the MCL and NCS in PZ-24 (MW-6) but only above the NCS in MW-3.

Trans-1,3-Dichloropropene was detected twice in MW-3 and PZ-24 (MW-6), although well below the established NCS and MCL.

Chloroethane, although analyzed in four (4) sampling events, was only detected in MW-3 and PZ-24 on one (1) event and additionally detected in MW-2 on a difference sampling event. Chloroethane does not have an established MCL or NCS.

Dichlorodifluoromethane was detected above the established NCS in three of the potable water wells neighboring the site (i.e.: Nissan-Mazda, Carroll, and Perry residences). Again, Dichlorodifluoromethane does not have an associated MCL.

Methylene Chloride was detected in the Carroll residence well water in two out of three sampling events and Vinyl Chloride was detected in the Carroll residence well water in only one out of three sampling events. Although detected on different sampling events the two compounds have also been detected in the accompanying trip blank. The concentrations of Methylene Chloride and Vinyl Chloride detected in the Carroll residence well were above the established NCS and MCL for Methylene Chloride and above and approaching respectively, the established NCS and MCL for Vinyl Chloride. Methylene Chloride was detected at 138.2 ppb in the June 23, 1993 sampling of the Carroll residence well water, well above the MCL of 5 ppb.

Methylene Chloride has also been detected at various levels in three (3) other domestic wells within the Rocky Mountain Heights Subdivision. Methylene Chloride was possibly detected in the Perry residence well water although the analytical result was an estimated result denoted by the analytical lab only as <0.06. Methylene Chloride was detected at significant levels in the initial sampling of two other residential wells (Shared well # 1 and the Ward well). Resampling of the Perry residence well, the Shared Well #1 and the Ward residence well resulted in the absence (non-detection) of Methlene Chloride.

Benzene was detected above the established NCS on all three sampling events of the Carroll residence well but below the established MCL. Benzene was not detected in any other potable water well neighboring the site.

Trans-1,3-Dichloropropene was not detected in any of the sampled potable water wells neighboring the site.

Chloroethane was detected in the Carroll residence well water at concentrations greater than twenty (20) times the concentrations observed in any of the groundwater monitoring wells at the landfill. Chloroethane was also detected in the Nissan-Mazda well water greater than twice the concentrations observed in any of the groundwater monitoring wells at the landfill. Chloroethane does not have an established MCL or NCS.

In summary, parameters detected in the landfill wells and also detected in potable wells above applicable MCLs are Methylene Chloride (Carroll), TCE (Carroll/Nissan) and PCE (Carroll/Nissan).

A summary of analysis results for the organic compounds discussed above can be found in pages 2 and 3 of Table 4. Page 2 of Table 4 lists Chlorinated volatile organics detected primarily in groundwater monitoring points located along the Bolick site and page 3 lists detected Benzene and Propane derivatives.

<u>Questionable Detected Organic Compounds</u>

Other organic compounds identified by landfill groundwater sampling and analysis were:

1) Detected at trace levels approaching or at analytical minimum detection limits,
2) Previously known as common laboratory contaminants,
3) Detected only once and at only one monitoring point, and/or
4) Also detected in the Trip Blank.

These compounds are listed with appropriate detection appendums as referenced above are:

Chloroform	1,3,4
Bromodichloromethane	1,2
Carbon Tetrachloride	1
1,2-Dichloroethane	1
1,4-Dichlorobenzene	1
1,2-Dichloropropane	1
2,2-Dichloropropene	1
1,1-Dichloropropene	2
Bis(2-ethylhexyl)phthalate	2,4
Xylenes, Total	1,2
4,4'-DDD	1,2

2,2-Dichloropropane additionally co-elutes with cis-1,2-Dichloroethene when utilizing EPA Method 502.2. Related data sets utilizing different analytical methods suggests 2,2-Dichloropropane detection was likely the result of the presence of cis-1,2-Dichloroethane.

A summary of analysis results for the organic compounds discussed above can be found on pages 3 and 4 of Table 4. These compounds will continue to be analyzed in Full Appendix II monitoring scheduled for "core" assessment wells.

<u>Organic Compounds Only Detected in Potable Water Wells</u>

Organic compounds detected in the residential and business potable water wells neighboring the site but not detected in the monitoring well network at the landfill, listed by order of decreasing occurrence and concentration are:

Parameters detected only at potable water wells	Highest concentration (ppb)	NCS/MCL (ppb; ug/L)	Location Detected
Chloromethane	1.48/<0.9	---/---	Carroll/Perry
Trichlorofluoromethane	37.1/0.4	2100/---	Carroll/Nissan
Styrene	2.8	0.014/100	Carroll
Xylenes	3.4/0.5	400/10,000	Carroll/Nissan
tert-Butylbenzene	1.1	---/---	Carroll/Bolick
Isopropylbenzene	0.7/0.6	---/---	Bolick
1,3,5-Trimethylbenzene	0.7	---/---	Bolick
Napthalene	0.7	---/---	Perry
Toluene	$0.6^T/0.8^T$	1000/1000	Carroll/Nissan
4-Isopropyltoluene	0.2	---/---	Carroll
alpha-Chlordane	0.4	0.027/2	Shared Well #1
gamma-Chlordane	0.3	0.027/2	Shared Well #1
sec-Butylbenzene	0.2	---/---	Shared Well #1
Tert-Butyl Methyl Ether	2.4	200/---	Carroll

The fourteen (14) organic compounds listed above are generally common contaminants associated with private water wells (Sorg, Thomas, 1986). Seven (7) of the compounds only detected in the residential and business potable water wells are BTEX components and are often found as the result of activities immediately around the private well heads and/or components of the well systems. Eight (8) of the compounds were detected in the Carroll residence well with three (3) of these same compounds also detected in the Nissan-Mazda well.

The two (2) Chlordane compounds are commonly used in Termite extermination. The chlordane compounds were detected in only one (1) well, and their occurrence is likely a result of improper application. A resampling of the chlordane contaminated well resulted in no detection of any organic compounds.

A presentation of analytical results for the fourteen (14) organic compounds discussed above can be found in the summary table for the volatile and semi-volatile constituents detected in the residential and business potable water well testing (Table 5). A summary of the Federal Drinking Water Standards and Health Advisories of detected organic constituents is also included in Table 10.

TABLE 10
Watauga County Landfill
Federal Drinking Water Standards and Health Advisories of Detected Organic Constituents

Chemicals	Standards			Status HA*	Health Advisories								Cancer Group
					10-kg Child			70-kg Adult					
	CStatus Reg.*	MCLG (mg/l)	MCL (mg/l)		One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	RfD (mg/kg/day)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10^{-4} Cancer Risk	
Benzene	F	zero	0.005	F	0.2	0.2	-	-	-	-	-	0.1	A
Bromodichloromethane (THM)	*T*	*zero*	0.1*	D	7	7	4	13	0.02	0.7	-	0.06	B2
n-Butylbenzene	-	-	-	D	-	-	-	-	-	-	-	-	-
Carbon Tetrachloride	F	zero	0.005	F	4	0.2	0.07	0.3	0.0007	0.03	-	0.03	B2
Chloroethane	L	-	-	D	-	-	-	-	-	-	-	-	-
Chloroform (THM)	*T*	*zero*	0.1*	D	4	4	0.1	0.4	0.01	0.4	-	0.6	B2
1,4-Dichlorobenzene	F	0.075	0.075	F	10	10	10	40	0.1	4	0.075	-	C
Dichlorodifluoromethane	L	-	-	F	40	40	9	30	0.2	5	1	-	D
1,1-Dichloroethane	L	--	D	-	-	-	-	-	-	-	-	-	-
1,2-Dichloroethane	F	zero	0.005	F	0.7	0.7	0.7	2.6	-	-	-	0.04	B2
1,1-Dichloroethene	F	0.007	0.007	F	2	1	1	4	0.009	0.4	0.007	-	C
cis-1,2-Dichloroethene	F	0.07	0.07	F	4	3	3	11	0.01	0.4	0.07	-	D
Methylene Chloride	F	zero	0.005	F	10	2	-	-	0.06	2	-	0.5	B2
1,2-Dichloropropane	F	zero	0.005	F	-	0.09	-	-	-	-	-	0.05	B2
2,2-Dichloropropane	L	-	-	D	-	-	-	-	-	-	-	-	-
1,1-Dichloropropene	L	-	-	D	-	-	-	-	-	-	-	-	-
Tetrachloroethene	F	zero	0.005	F	2	2	1	5	0.01	0.5	-	0.07	-
1,1,1-Trichloroethane	F	0.2	0.2	F	100	40	40	100	0.035	1	0.2	-	D
Trichloroethene	F	zero	0.005	F	-	-	-	-	-	0.3	-	0.3	B2
Vinyl Chloride	F	zero	0.002	F	3	3	0.01	0.05	-	-	-	0.0015	A
Xylenes	F	10	10	F	40	40	40	100	2	60	10	-	D

From U.S. EPA, Drinking Water Standards and Health Advisories.

(footnotes located on page 2)

TABLE 10 (cont.)
DRINKING WATER STANDARDS AND HEALTH ADVISORIES

LEGEND

Abbreviations column descriptions are:

MCLG - Maximum Contaminant Level Goal. A non-enforceable concentration of a drinking water contaminant that is protective of adverse human health effects and allows an adequate margin of safety.

MCL - Maximum Contaminant Level. Maximum permissible level of a contaminant in water which is delivered to any user of a public water system.

RfD - Reference Dose. An estimate of a daily exposure to the human population that is likely to be without appreciable risk of deleterious effects over a lifetime.

DWEL - Drinking Water Equivalent Level. A lifetime exposure concentration protective of adverse, non-cancer health effects, that assumes all of the exposure to a contaminant is from a drinking water source.

(*) The codes for the Status Reg and Status HA columns are as follows:

F - final
D - draft
L - listed for regulation
P - proposed
T - tentative

- Large discrepancies between Lifetime and Longer-term HA values may occur because of the Agency's conservative policies, especially with regard to carcinogenicity, relative source contribution, and less than lifetime exposures in chronic toxicity testing. These factors can result in a cumulative UF (uncertainty factor) of 10 to 1000 when calculating a Lifetime HA.

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3.4.2 Contaminant Source

As discussed in Section 2.5, the waste composition at the landfill is an unsegregated mixture of industrial, commercial, municipal, and domestic wastes accumulated from over five decades of disposal. As such, the potential exists for a wide variety of waste components to be contributing sources of the contaminants detected in the groundwater although the levels and extent of groundwater contamination detected suggest the possible presence of significant contributions of industrial waste.

The primary detected organic compounds are all dense chlorinated organics (with the exception of Benzene). These solvent compounds are all interrelated and tend to be found in group associations. For example, 1,1-DCE is used in the production of 1,1,1-TCA and vinyl chloride has been found to be the biodegradation endproduct of PCE and TCE. In addition, change has occurred in industrial solvent uses resulting in changes in associated disposal solvent waste. For example, the use of 1,1,1-TCE has largely replaced the use of TCE as an industrial solvent.

The predominant use of the detected volatile chlorinated organics is as a solvent. Dense chlorinated solvents are widely used in machine and electronics manufacturing, automotive, and engine repair, dry cleaning, dye manufacturing, and many other industrial operations. In addition, these chlorinated solvents have been widely used in many household products such as cleaning agents, aerosols, refrigerants, paint thinners, and septic tank degreasers, Chlorinated solvents are also used by the furniture industry in the furniture staining and paint thinning process. The ubiquitous use of the volatile chlorinated organics, especially 1,1,1-TCA and TCE, result in these compounds being among the volatile organics encountered the most frequently and in the highest concentrations in groundwater. In fact, TCE is the most frequent organic contaminant found in groundwater (EPA/600/8-83/019. May 1983).

3.4.3 Release Mechanism

Potential mechanisms for contaminant release at the site include leaching of contaminants both into groundwater and surface water as well as the release of landfill gas containing volatile organics. An evaluation of existing data reveals that the primary contaminants of concern have only been detected at significant levels within the groundwater. No information presently available suggests that surface water and air emissions have the potential to add the largest concentrations of contaminants to the environment, though significant levels of VOC's have been detected in surface water. Because of the risk potential, leaching of contaminants into the groundwater is the primary release mechanism of concern. The landfill gas investigation and surface water sampling and analysis proposed for the assessment work plan should confirm or reject this initial assessment of contaminant release.

Several springs, documented in previous site studies to occur beneath the water disposal area (discussed in Section 2.2), are likely contributing to mounding of water within the fill. Water residing within the fill is likely providing the dominant release mechanism necessary for leaching of contaminants into the groundwater.

Select physical properties of the primary organic compounds detected at the site are presented in Table 11. In an insoluble form, the primary contaminants detected in the groundwater to date are all Dense Non Aqueous Phase Liquids (DNAPLs). The density of all the listed compounds is greater than that of water (i.e. DNAPL). The associated water solubility of these solvents results in the eventual dissolution and subsequent transport in groundwater. Before dissolving, the tendency of DNAPLs will be to sink. Groundwater analytical data collected to date indicates that the fracture system beneath the waste disposal area is hydraulically connected to water moving through the fill. After sinking to the base of the fill, the potential exists for the DNAPLs to enter the fracture system both in a soluble form along with the water moving through the fill, and an insoluble form as a pure DNAPL.

The chemical and physical structures of the twelve primary detected organic compounds as presented in Figure 10 are all very similar. All twelve compounds are pure chlorinated hydrocarbons with the exception of benzene and dichlorodifluoromethane. Benzene, a pure hydrocarbon, is not a chlorinated compound and dichlorodifluoromethane selectively replaces some chlorine with fluorine.

Groundwater contaminated by dense chlorinated solvent compounds usually contains several predominant compounds and several identifiable ones of lesser concentration. One reason for this compound concentration distribution occurrence (apparent at the Watauga County Landfill site) might be related to solvent purity. In the manufacturing of solvents, the end product depends on temperature, degree of acidification, and chlorination, so a commercial grade solvent might have varying amounts of several related compounds (Figure 11). Other reasons for the presence of a variety of solvents in one location might be the presence of degradation end products of a parent compound or changes in industrial solvent waste disposal practices (EPA/600/8-83/019).

Leachate seeps at the landfill are likely predominantly the product of surface water infiltration into the fill (discussed in Section 3.1.4) and as such are less likely to exhibit the same concentrations of the contaminants detected in the groundwater. Impacts to surface water are influenced by the same contaminant release mechanisms experienced at leachate seeps including runoff from exposed fill as well as leachate. The density and vapor pressure properties of the compounds detected in the groundwater results in these dense and volatile compounds less likely to occur in water residing near the surface. Concentrations of a compound that remain near the surface as a result of the compound's water solubility will tend to volatilize as a result of turbulence and agitation experienced at the surface.

Continued release of contaminants may depend on the form and concentration of contaminant sources remaining within the waste disposal area. Dense chlorinated solvents disposed in containers (i.e.: drums, etc.) may not be as exposed as uncontainerized wastes to the dissolving and washing effects of water moving through the fill. The potential for the presence of significant quantities of hazardous substances still remaining within the fill necessitates the comprehensive leachate, landfill gas, and groundwater plume assessment monitoring activities described in Section IV. Documentation of the concentration levels of continued releases of contaminants will be important in determining feasible, effective, and efficient remediation.

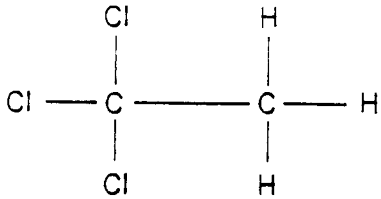
TABLE 11
PHYSICAL PROPERTIES
OF
PRIMARY DETECTED ORGANIC COMPOUNDS
WATAUGA COUNTY LANDFILL

Compound	Density [1]	Dynamic Viscosity [2]	Kinematic Viscosity [3]	Water Solublity [4]	Henry's Law Constant [5]	Vapor Pressure [6]
1,1-Dichloroethane	1.1750	0.3770	0.321	5.5 E+03	5.45 E-04	1.82 E+02
1,1-Dichloroethane	1.2140	0.3300	0.27	4.0 E+02	1.49 E-03	5 E+02
Trans-1,2-Dichloroethane	1.2570	0.4040	0.321	6.3 E+03	5.32 E-03	1.82 E+02
Cis-1,2-Dichloroethene	1.2480	0.4670	0.364	3.5 E+03	7.5 E-03	5 E+02
1,1,1-Trichloroethane	1.3250	0.8580	0.647	9.5 E+02	4.08 E-03	1.82 E+02
Methylene Chloride	1.3250	0.4300	0.324	1.32 E+04	2.57 E-03	5 E+02
Trichloroethene	1.4620	0.5700	0.390	1.0 E+03	8.92 E-03	1.82 E+02
Tetrachloroethene	1.6250	0.8900	0.54	1.5 E+02	2.27 E-02	5 E+02
Vinyl Chloride	0.92	---	---	6.0 E+01	6.4 E+01	2.66 E +02
Benzene	0.89	---	---	1.78 E+03	5.55 E-03	9.5 E+01
Chloroethane	0.90	---	---	8.2 E+03	3.4 E+10	---
Dichlorofluoromethane	1.18	---	---	---	---	---

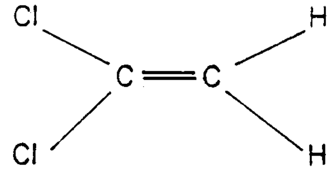
[1] g/cc
[2] centipoise (cp), water has a dynamic viscosity of 1 cp at 20°
[3] centistokes (cs)
[4] mg/L
[5] atm-m^3/mol
[6] mm Hg

From U.S. EPA Documents, EPA/540/4-97/002. March 1991; EPA/600/8-83/019. May 1983; and EPA/600/8-9/901003. March 1990

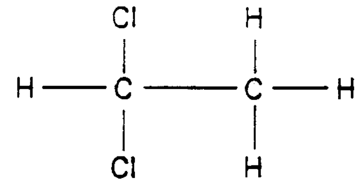
1,1,1-TCA



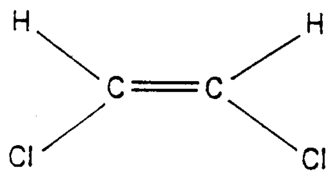
1,1-DCE



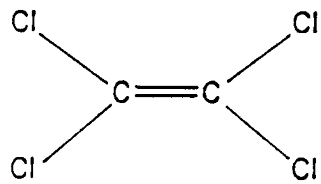
1,1-DCA



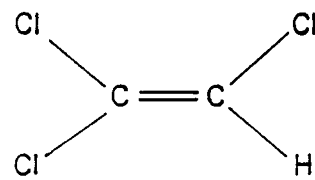
CIS-1,2-DCE



PCE

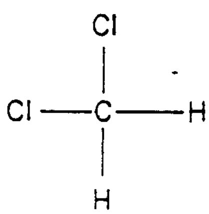


TCE

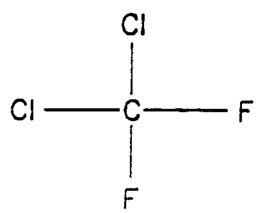


Oraganic compounds detected at significant levels in virtually all downgradient groundwater monitoring wells.

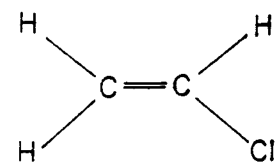
METHYLENE CHLORIDE(DCA)



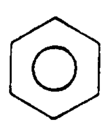
DICHLORODIFLOUROMETHANE



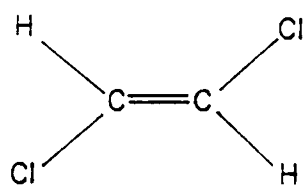
VINYL CHLORIDE



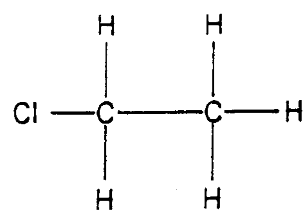
BENZENE



TRANS-1,2-DCE



CHLOROETHANE



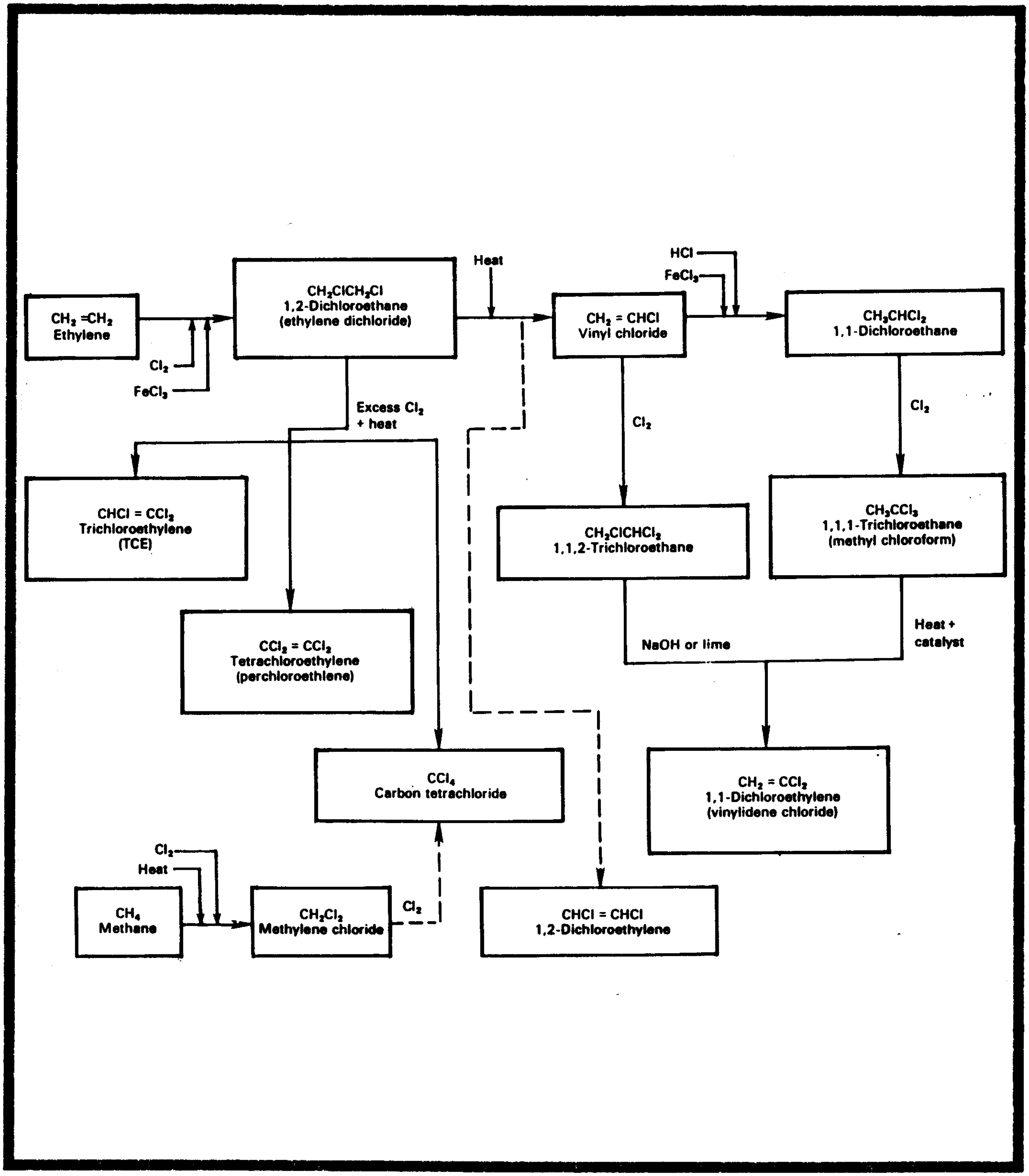
Organic compounds detected at significant levels primarily in downgradient groundwater monitoring wells located along the Bolick site

PHYSICAL STRUCTURES OF DETECTED ORGANIC COMPOUNDS

WATAUGA COUNTY LANDFILL
WATAUGA COUNTY, NORTH CAROLINA

Draper Aden Associates
CONSULTING ENGINEERS
Blacksburg, Virginia – Richmond, Virginia
Nashville, Tennessee

JOB No.	DATE:	SCALE:	FIGURE
6520-13	8/1/93	NONE	10



SOURCE: EPA/600/8-83/019, MAY 1983

SIMPLIFIED MANUFACTURING SCHEME FOR INDUSTRIAL SOLVENTS

WATAUGA COUNTY LANDFILL
WATAUGA COUNTY, NORTH CAROLINA

Draper Aden Associates
CONSULTING ENGINEERS
Blacksburg, Virginia – Richmond, Virginia
Nashville, Tennessee

JOB No.	DATE:	SCALE:	FIGURE
6520-13	8/1/93	NONE	11

3.4.4. Contaminant Transport, Migration, and Fate

Potential contaminant transport mechanisms are similar to potential release mechanisms and include movement within groundwater, leachate seeps, surface water runoff, and landfill gas. Of greatest concern is contaminant transport by movement within groundwater. As discussed in Section 3.4.1, many of the detected contaminants have been detected in the groundwater above the EPA Maximum Contaminant Level (MCL). Contaminant transport and migration with the groundwater takes place within two primary interconnected aquifer systems composed of a fractured bedrock aquifer system and a surficial soil aquifer system (described in Section 2.6).

The initial primary transport medium of contaminants appears to be the fracture aquifer system. Groundwater residing in the fracture system is released above bedrock both below and adjacent to the waste disposal area. Contaminants dissolved in the groundwater released above bedrock are then transported within the surficial soil aquifer. It is not known at this time if movement of contaminants from the surficial soil aquifer back into the fracture system is occurring downgradient.

Several of the primary organic compounds detected in the groundwater at the site have repeatedly been observed to exist at significantly higher concentration levels at certain monitoring wells. The results of contaminant concentrations detected in sampling and analysis performed to date do not exhibit contaminant transport trends that can be attributed to contaminant specific physical properties.

As presented on page 1 of Table 5, 1,1,1,-TCA and 1,1-DCE have repeatedly been detected at significantly higher levels in MW-2 than at any of the other points monitored. MW-2 is screened within the fractured system at 180 feet to 170 feet in depth and is approximately 400 feet from the waste disposal area. Denser compounds may be expected to migrate deep within the fracture system and be detected within MW-2. This migration trend is not apparent in the analytical results collected to date. 1,1,1,-TCA and DCE do not possess greater densities than other organic compounds detected at significantly higher concentrations at any of the other points monitored. The predominant presence of 1,1,1-TCA and 1,1-DCE at MW-2 may be more the result of the disposal of 1,1,1-TCA and 1,1-DCE above recharge zones that migrate to the well head at MW-2, thus effecting these compounds fate.

Several of the primary organic compounds detected in the groundwater have been repeatedly detected at significantly higher levels in MW-3 than at any of the other points monitored including PCE and 1,1-DCA. Again, the physical properties of these compounds do not suggest that these compounds are more likely to migrate to MW-3 rather than other points monitored.

MW-3 is screened from 42 feet to 37 feet in depth in the soil aquifer. PCE possesses the greatest density of any of the primary organic compounds detected at the site, yet instead of migrating in the highest concentrations to the deep fracture system well (MW-2), it is found in the highest concentrations in a surficial soil aquifer well (MW-3). MW-3 is also farther away from the waste disposal unit than any of the other monitoring wells (900 feet), yet PCE possesses higher viscosity properties and the lowest solubility of the primary organic compounds detected and would not be expected from extrapolation of physical properties to preferentially migrate to MW-3.

TCE and cis-1,2-DCE have been reportedly detected at significantly higher concentrations at PZ-24 (i.e. proposed MW-6). PZ-24 is located along the same flow path as MW-3 although immediately adjacent to the waste disposal unit rather than 900 feet away. Comparison of the physical properties of TCE and cis-1,2-DCE to the higher concentrations detected immediately adjacent to the waste disposal area does not reveal any direct correlation between physical properties and migration behavior. Solubility and viscosity properties of TCE and cis-1,2-DCE are average for the primary organic compounds detected in the groundwater. TCE and cis-1,2-DCE do possess the highest Henry's Law constants among the primary organic compounds detected in the groundwater. Generally, the greater the Henry's Law constant, the more volatile the compound and the easier the compound is to remove from solution. It is conceivable that TCE and cis-1,2-DCE are volatilizing from solution as they are migrating away from the source.

3.4.5 Exposure Pathways

The potential for human exposure is generally classified into three routes of exposure: inhalation, dermal contact, and ingestion. The primary exposure pathway of the contaminants detected at the site is through ingestion of impacted groundwater. Use of effected groundwater for other purposes (i.e. bathing, etc.) may also pose dermal contact and inhalation hazards as the detected compounds volatilize easily.

The potential for inhalation of vapors derived from the waste disposal area or contaminated groundwater is present both on and adjacent to the waste disposal area as well as points of groundwater discharge. The potential for inhalation exposure should be limited to authorized workers and technicians involved with assessment field activities in and surrounding the site. As part of the Site Health and Safety Plan (HASP), air monitoring will be conducted to provide a closer indication as to the potential for inhalation exposures further away from the site. All site workers will be informed of contaminants present and provided with appropriate protective equipment.

The potential for inhalation of vapors may also be present at any point of contaminated groundwater discharge (ie: stream, well head taps, etc.). Based on the paucity of human activity at potentially effected streams, the frequency of inhalation exposure next to discharge at streams is relatively low. The potential for inhalation exposure at well head taps of contaminated wells will be greatest during bathing. For wells identified with contamination levels around the EPA MCL, the N.C. Department of Epidemiology recommends limiting showers to five (5) minutes.

The potential for dermal exposure is primarily through contact with contaminated groundwater. Dermal exposure should be limited to authorized workers and technicians involved with the implementation of assessment field activities in and surrounding the site. All site workers will be informed of contaminants present and provided with appropriate protective equipment. The potential for dermal exposure may also be posed by bathing although the risk presented by levels previously identified in the preliminary site characterization is minimal.

The focus of the Assessment Plan Work Tasks will be to identify and protect against potential risks posed by groundwater contamination by defining the horizontal and vertical extent of contamination ("the plumes") and the direction and rate of migration of the plumes in the groundwater. In response to the potential risk associated with groundwater resources, the ongoing potable well risk investigation into potential groundwater contamination migration pathways surrounding the site that has been conducted during the development of the Assessment Plan will continue. Appropriate, timely advisories to the affected community will also continue.

IV. ASSESSMENT PLAN WORK TASKS

The work tasks described in this work plan have been developed to meet the objectives of the Assessment Plan specified in the Consent Agreement between Watauga County and the NCDEHNR Solid Waste Section entered on July 7, 1993. The Assessment Work Plan follows the standard format outlined in Remedial Investigation/Feasibility Study (RI/FS) Guidance Documents (EPA/540/P-91/001. February, 1991 and EPA/540/G-89/004. October, 1988). The field investigation activities are designed to provide data that can be used to document the extent and source(s) of contamination and potential risks to human health and the environment posed by contamination moving off-site. Several of these activities were conducted prior to developing the work plan. These activities include the evaluation of existing data and the performance of limited field investigations; the results of both of these activities are reported in Sections II and III of this Assessment Plan.

4.1 PROJECT PLANNING

4.1.1 Groundwater and Surface Water Sampling and Analysis Plan (SAP)

Groundwater and surface water sampling and analysis activities are covered in a separate attachment (Appendix I) to the Watauga County Landfill Assessment Plan.

The attached Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I) describes the procedures and equipment to be utilized for collecting groundwater and surface water samples, analyzing the samples for specified parameters and evaluating and reporting the resulting groundwater and surface water data. The discussion of laboratory analysis includes reference to appropriate test methods and associated detection limits as well as the laboratory's quality control and quality assurance procedures. Chain of custody requirements are also included.

4.1.2 Quality Assurance Project Plan (QAPP)

4.1.2.1 Quality Assurance Objectives For Measurement

Data quality objectives (DQO) are established to ensure that the data collected throughout the assessment is sufficient and of adequate quality for the intended use. Overall data quality objectives include the following:

- Precision - A measurement of the reproducibility of measurements compared to their average value. Precision is measured by the use of splits, replicate samples, or co-located samples and field audit samples.

- Accuracy - This measures the bias in a measurement system by comparing a measured value to a true or standard value. Accuracy is measured by the use of standards, spiked samples, and field audit samples.

- Representativeness - This is the degree to which a sample represents the characteristic of the population being measured. Representativeness is controlled by defining sample protocols and adhering to them throughout the study.

- Completeness - This is the ratio of validated data points to the total samples collected. Completeness is achieved through duplicate sampling and resampling.

- Comparability - This is the confidence that one data set can be compared to another. Comparability is achieved through the use of standard methods to control the precision and accuracy of the data sets to be compared by use of field audit samples.

The level of detail and data quality needed will vary based upon the intended data use. For this project, data uses include site characterization, risk assessment and corrective action. As the data quality objectives differ among the uses, appropriate analytical levels, contaminants of concern, levels of concern and required detection limits (see Table 4 and 4A of the Watauga County Groundwater and Surface Water Program (Appendix I)) must be taken into account.

To meet the variable needs of data quality, a combination of laboratory services will be utilized in this project as described below:

LEVEL 2 EPA CONTRACT LABORATORIES

To obtain the highest data quality for current target analytes, analytical services will be obtained through EPA Contract Laboratory Program (CLP) participants. Analytical data obtained from CLP services will ensure legally defensible data packages for decision making and cost recovery actions. It should be noted that although the CLP program was established by the EPA, services may be contracted for non-EPA projects as in the case of this project.

- Contract Laboratory Program-Routine Analytical Services (CLP-RAS) - Characterized by uniform methods of analysis, rigorous QA/QC protocols and documentation, and provides qualitative and quantitative analytical data. The workscopes provide achievable Contract Required Quantitation Limits where Detection limits are typically not sufficient for risk assessment/toxicological evaluations.

- Contract Laboratory Program-Special Analytical Services (CLP-SAS) - Designed for non-standard methods which may require method modification, or development. Also provides rigorous QA/QC protocols similar to CLP-RAS.

Detection limits typically not sufficient for risk assessment/toxicological evaluations.

LEVEL 1 NON EPA CONTRACT LABORATORIES

• Non-CLP Laboratories (i.e. commercial laboratories) are designed to provide identification and quantification of compounds using standard EPA approved procedures (i.e. EPA 500 series, SW-846 methods), with less rigorous QA/QC and data quality documentation. In most cases, data obtained may be used in risk assessment, as similar or lower detection limits are achieved compared to available CLP workscopes.

Request for bids from laboratories to provide the analytical services were made in the Request For Proposal (RFP) dated June 28, 1993. The RFP was submitted to the following laboratories:

1. Technical Testing Laboratories, Charleston, WV
2. Central Virginia Laboratories (CVLC), Lynchburg, VA
3. Environmental Laboratories, Richmond, VA
* 4. ETS Laboratories, Roanoke, VA
* 5. Compuchem Laboratories, Research Triangle Park, NC
* 6. Southwest Laboratories, Raleigh, NC
* 7. Chester Labnet, Houston, TX
8. Roche Analytics Laboratory, Richmond, VA
* 9. Pace Laboratories, Asheville, NC
* 10. Oxford Laboratories, Wilmington, NC
11. Aqua Tech Environmental Laboratories, Sanford, NC

Note: * denotes participant in the Contract Laboratory Program (CLP)

Of the eleven RFPs submitted, the following laboratories responded:

1. Technical Testing Laboratories, Charleston, WV
2. Central Virginia Laboratories (CVLC), Lynchburg, VA
* 3. ETS Laboratories, Roanoke, VA
* 4. Southwest Laboratories, Raleigh, NC
* 5. Chester Labnet, Houston, TX
6. Aqua Tech Environmental Laboratories, Sanford, NC

To assist in timely completion of risk assessment evaluation, and initial documentation of the nature and extent of contamination, standard EPA approved procedures under a non-contract laboratory program (non-CLP), LEVEL 1 noted above, will be utilized. This initial data collection is to be considered a preliminary screening event, and the degree of associated data quality documentation obtained will depend on final data usage.

From the preliminary screening activities, a set of target compounds will be compiled. To date, the target compound list compiled from historical sampling is presented in Tables 4 and 4A in the Watauga County Groundwater and Surface Water Monitoring Program (Appendix I). With continued monitoring at the site, targets compounds may be added.

4.1.2.2 Sampling Procedures

Sampling procedures will be conducted as detailed in the Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I).

4.1.2.3 Sample Document Custody Procedures

Sample document custody procedures will be conducted as detailed in the Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I).

4.1.2.4 Analytical Procedures

The following analytical methods will be utilized in this project as deemed appropriate:

- *SW-846 (latest revision) "Test Methods for Evaluating Solid Waste"*
- CLP Organic and Inorganic Statements of Work

Constituents and Analytical Methods are provided in Table 4 and 4A found in the SAP. Other methods may be utilized as needed and approved by the NCDEHNR, to successfully accomplish the work tasks of this Assessment Plan.

4.1.2.5 Internal Quality Control

Field Quality Control

Field Quality Control procedures are as detailed in the Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I).

Analytical Quality Control

Analytical Quality Control procedures are also detailed in the Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I). All quality control data and records generated by the laboratory shall be retained by the laboratory until requested. A laboratory quality control report typically consists of the following components:

- spikes
- blanks
- duplicates
- surrogate compounds
- check samples
- clean-up
- instrument adjustment
- calibration
- additional QC requirements (organic and inorganic)
- tentative compound identification
- quantification

Although all analytical data must be maintained by the laboratory, as previously noted, extensive QA/QC reporting may not be warranted for each sampling event. With increasing necessity for data validation/integrity, as deemed necessary by the owner and/or Draper Aden Associates, two increased QA/QC reporting levels are available.

4.1.2.6 Performance And System Audits

Laboratory QA/QC procedures will be evaluated prior to contract award. Should the laboratory participate in interlaboratory performance tests, data will be evaluated. Evaluation of laboratory performance may include unscheduled testing of performance evaluation samples. Field operations will be periodically reviewed to insure adherence to approved protocols and QA objectives.

4.1.2.7 Preventative Maintenance

All laboratory and field instruments will undergo regularly scheduled maintenance inspections. Inspection reports will remain on file with the contracted laboratory or consultant.

4.1.2.8 Data Assessment Procedures

The precision and accuracy of data will be routinely assessed for all environmental monitoring and measurement data.

4.1.2.9 Corrective Actions

Corrective action procedures are established to implement on activities which do not meet quality assurance objectives, and are typically addressed on a case by case basis.

Upon identification and problem definition the QA officer shall implement the following corrective action procedures as necessary and ensure the corrective action has been resolved.

- Investigate and determine cause of problem, if possible.
- Determine corrective action required to eliminate problem. Specific corrective action is typically handled on a case by case basis, but may include resampling, reanalysis or auditing laboratory procedures.
- Implement corrective action and determine effectiveness.
- Verify corrective action has eliminated the problem.

4.1.2.10 Quality Assurance Reports

Upon completion of each sampling event, Draper Aden Associates shall review the field and laboratory information as per required validation procedures, and provide an overall statement of data quality. The extent of data validation is dependent upon final data usage, and associated data quality documentation. In some cases, recommendations for resampling and/or reanalysis may be necessary.

4.1.3 Field Sampling Plan (FSP)

Field sampling activities are covered in the following section as well as two separate attachments to the Watauga County Landfill Assessment Plan. The Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I) describes the procedures to be implemented for collecting groundwater and surface water samples. The collection of leachate samples are also covered in the discussions concerning the collection of surface water samples. The Watauga County Landfill Health and Safety Plan (Appendix II) describes the procedures to be implemented for monitoring for landfill gas. Landfill gas will be monitored both prior to and during the drilling and installation of the proposed groundwater monitoring wells.

4.1.4 Site Health and Safety Plan (HASP)

Site health and safety activities are covered in a separate attachment (Appendix II) to the Watauga County Landfill Assessment Plan. Although the primary focus of the Watauga County Landfill Health and Safety Plan (HASP) concerns the installation of groundwater monitoring wells surrounding the waste disposal area, consideration is applied to other field activities anticipated to be performed during the initial stages of the Assessment Plan including groundwater and surface water sampling. The Watauga County Landfill Health and Safety Plan will be updated to account for additional Assessment field activities that may contain increased risks (i.e. active exploratory investigations into the waste, etc.).

The enclosed Health and Safety Plan describes the procedures, equipment and decision criteria to be utilized for maintaining a safe environment during well installation operations as well as other field activities anticipated to be performed during the initial stages of the Assessment Plan. The discussion of safety equipment includes reference to personnel safety equipment as well as monitoring equipment and associated proper use and action levels. Hazard and safety zones, task responsibilities, and necessary contacts are also included.

4.2 FIELD INVESTIGATIONS

4.2.1 Cover and Waste Investigations

The initial waste characterization conducted during the evaluation of data (Section 2.3) revealed the potential for a variety of waste sources to be contributing to the contamination observed in the groundwater beneath the site. Ongoing with the Assessment Plan field tasks will be a continuing investigation into potential sources (described in Section III). This investigation will explore the quantities, frequency, duration, and composition of potential waste sources disposed at the site.

The initial cover characterization conducted during the evaluation of existing data (Section 2.4) indicated that non-active portions of the landfill have been preliminarily closed by the application and grading of approximately two to four feet of cover. Active fill areas are currently covered daily by six inches of soil. Prior to the installation of wells adjacent to the waste, several borings will be drilled through the cover utilizing a random grid selection process. The additional cover borings will serve to validate preliminary closed cover characterizations.

The air monitoring program will be conducted as part of health and safety monitoring for all drilling and sampling activities and will note and document the presence of volatile organic constituents detected within the waste.

The leachate monitoring program to be conducted in conjunction with the Watauga County Groundwater and Surface Water Monitoring Program (Appendix I) will consist of the semiannual sampling of any observed zones of leachate production and subsequent analysis for all assessment monitoring parameters (EPA Appendix II List of Hazardous Inorganic and Organic Constituents) previously detected in any plume assessment groundwater monitoring well.

It should be noted that active investigations into landfill contents are rarely implemented at municipal landfills. This is due primarily to frequently encountered problems excavating through refuse and the heterogeneous nature of the refuse, which makes characterization difficult. Exploratory wells may be installed into the waste after additional information has been collected from additional wells installed adjacent to the waste disposal unit. The proposed exploratory wells would be installed primarily for the purpose of characterizing the mounding of groundwater within the fill. The waste characterizations obtained would be secondary objectives.

A gas monitoring program will be conducted concurrent with the cover validation boring program. The gas monitoring program will consist of continuous monitoring of the air emitted at the surface of the cover borings utilizing a gas detector specifically configured to survey landfill generated gases. The gas detector will specifically analyze for the lower explosive limit (L.E.L.) of explosive gases and the percent by volume of oxygen and methane. The primary objective of the gas monitoring program is to identify and protect against hazards posed by potential gases surrounding and occurring within the fill. A detailed description of sampling procedures and action levels for the gas monitoring program are detailed in the enclosed HASP (Appendix II).

The monitoring of components of volatile constituents within the landfill gases and the screening for EPA's Appendix II List of Hazardous Organic and Inorganic constituents in the leachate and groundwater will assist in delineating potential contaminant sources currently remaining within the fill.

4.2.2 Leachate Investigation

The leachate evaluation presented in Section 3.1.4 summarizes current information regarding leachate generation and leachate 'strength'. Concentrations of inorganic and organic constituents in leachate surface seeps sampled at the site are generally at much lower levels than would be expected given the concentrations observed in the groundwater. Dilution, volatization, and sinking of dense nonaqueous phase (DNAPL) compounds experienced in leachate residing in the upper portions of the fill may be contributing to the lower organic concentration levels observed in the sampled leachate. The objective of the leachate investigation will attempt to document relative leachate strengths occurring both vertically and laterally within the fill.

As described above, the leachate monitoring program to be conducted in conjunction with the Watauga County Groundwater and Surface Water Monitoring Program (Appendix I) will consist of the semiannual sampling of any observed zones of leachate production and subsequent analysis for all assessment monitoring parameters (EPA Appendix II List of Hazardous Inorganic and Organic Constituents) previously detected in any plume assessment groundwater monitoring well. Any leachate seeps observed at the site during the semiannual surface water monitoring event will be sampled. Leachate sampling protocol and equipment shall be the same as that required for surface water sampling as defined in the Groundwater and Surface Water Monitoring Program (Appendix I).

Leachate screening samples will be analyzed for the same constituents as that detected in the comprehensive analysis proposed for groundwater, (ie: EPA Appendix II List of Hazardous Inorganic and Organic Constituents) to provide a means for assessing the release mechanisms for contaminant transport and migration as well as eventual contaminant fate. This information will additionally be used to assess the status of the current target analyte list.

In the event that it is determined that exploratory wells should be installed into the waste, leachate will be sampled as it is encountered. Anticipated mounding of groundwater within the fill presents the likelihood that stratification is occurring within the "leachate". If well installation conditions allow (i.e. waste does not encumber or prohibit advancement of the well, hazardous conditions not observed, etc), the exploratory wells installed in the waste may be continued past the static water level to the base of the fill. Well installation to the base of the fill will allow the characterization of potential stratification of contaminants that may be occurring with the "groundwater/leachate" residing within the fill.

Leachate samples would be collected from the exploratory waste wells utilizing a disposable bailer and Teflon coated stainless steel retrieval wire. The leachate sampling equipment utilized for the exploratory waste well sampling would be decontaminated between sampling. The decontamination procedure for non-disposable equipment (i.e. retrieval wire) would entail washing with non-phosphate soapy distilled water and rinsing three times with deionized/distilled water. Leachate seep data would be compared with stratified leachate sampled from various horizons within the waste as well as previous leachate sampling data to assess potential remediation needs.

4.2.3 Landfill Gas Investigation

The goal of the landfill gas characterization is to identify potential areas of the landfill containing high concentrations of explosive or toxic gases. The results of the landfill gas characterization will be utilized to perform an assessment of human health risks due to air toxins and explosive hazards. Landfill gas health risks will be greatest during the drilling conducted adjacent to the waste disposal cell. Surface gas monitoring will be conducted prior to the drilling program to preliminarily identify risks posed by the specific tasks of the drilling program.

The surface gas sampling program will consist of an initial grid field screening at random areas throughout the fill area. A gas detector specifically configured to survey landfill generated gases will be used to screen for landfill gas. Landfill gas samples will be collected from areas of the fill where methane production is observed. Soil gas probes will be used to collect the gas sample into a Tedlar bag. The Tedlar bag samples will be analyzed for all suspected volatile gases identified in previous EPA Appendix II analyses or groundwater beneath the landfill using a laboratory gas chromatograph.

The gas sampling program to be conducted concurrent with the cover boring program and the well installation program will consist of continuous monitoring of the air emitted at the surface of the well head for gas utilizing a gas detector specifically configured to survey landfill generated gases. The gas detector will specifically analyze for the lower explosive limit (L.E.L.) of explosive gases and the percent by volume of oxygen and methane. A detailed description of sampling procedures and action levels are included in the enclosed HASP (Appendix II).

4.2.4 Hydrogeologic Fracture Analysis

The prediction of flow paths (i.e. direction) within fracture systems are generally described in terms of the systems drainage pattern rather than the concept of a water table. These drainage patterns are usually a network of smaller conduits that contribute flow to the larger "trunk" conduits. (RCRA Ground-Water Monitoring: Draft Technical Guidance, Nov. 1992).

Drainage patterns will be interpreted through fracture trace analysis. Fracture traces allow the location of zones of increased weathering, porosity, and permeability that may act as preferential pathways of contaminant migration. Recent studies have indicated that fracture orientations measured on the surface have similar orientations to those in the subsurface (McGlew and Thomas, 1984).

A fracture trace analysis is performed by examining remote sensing imagery such as aerial photography for linear and curvilinear features at various scales. The surface expression of features with a given study area can depend on topography, overlying soils, vegetation, size of study area, and numerous other domain specific expressions. By systematically examining the study area, it is possible to locate fracture traces expressed by continuous or discontinuous variations of surface features.

The cost effectiveness and reliability of geophysical investigations at the site are questionable and require further evaluation of need and usefulness. The vertical and lateral extent of the fracture aquifer system diminishes the feasibility of interpretation by geophysical means. Geophysical methods for interpreting subsurface domains require that properties of the area between the surface and depth of interest be known. The greater the depth of interest, the more investigation and interpretation of the subsurface and associated uncertainties exist.

The variable nature of the gneiss and schist bedrock and the variable nature inherent in the composition of waste results in a media that becomes increasingly difficult to geophysically interpret with depth. The media variations result in white "noise" in the data that must be filtered out before a reliable interpretation can be attained. In extremely complex environments (i.e. greater than fifty (50) feet of waste), often all that is left of the data is white noise.

4.2.5 Plume Assessment Monitoring Well Installation

The objective of the placement of the plume assessment monitoring wells is to delineate the vertical and lateral extent of groundwater contamination and the direction and rate of migration of the plume(s) in the groundwater. The proposed number, location, and depth of the plume assessment wells, including a discussion of the reasons for the location and depth of each plume assessment monitoring well is presented below. A discussion concerning monitoring well construction methods can be found in the enclosed Watauga County Groundwater Monitoring Program.

The three (3) currently impacted downgradient monitoring wells (MW-2, MW-3, and MW-4) within the Watauga County Landfill groundwater monitoring system are located from 400 to 900 feet from the waste disposal unit at the property boundary. Fourteen (14) plume assessment monitoring wells are proposed both adjacent to the waste disposal unit and beyond the compliance property boundary. The intent of wells located beyond the property boundary will be to delineate the horizontal and vertical extent of the contaminant plume(s). The intent of wells located adjacent to the waste disposal unit will be to provide information pertaining to the source, extent, and migration directions and rates of the contaminant plume(s).

Volatile organic data compiled to date (presented in Section II and Section III) indicates that certain compounds are preferentially migrating to individual well locations. For example, 1,1,1-TCA and 1,1-DCE are found at significantly higher concentrations at MW-2, whereas 1,1-DCA and TCE are found at significantly higher concentrations at MW-3. In addition, concentrations for some compounds are currently found at significantly higher concentrations 900 feet away from the waste disposal unit than immediately adjacent to the waste along the same flow path. For example, TCE is found at the highest concentrations in a well located adjacent to the waste (Proposed MW-6), whereas 1,1-DCA is found at the highest concentrations in a well located 900 feet further away from the waste disposal unit (MW-3).

Factors influencing the occurrence of individual compounds at specific well heads may include both vertical as well as horizontal placement of the well screens. In addition, the influence of the surficial soil aquifer and the fracture aquifer system can effect the transport, migration, and fate of contaminants. Within the fracture system, a variety of factors can effect contaminant transport, migration, and fate. Individual discontinuities with the bedrock may be continuous or discontinuous, may have variable effective apertures, may be shear zones or cracks, fissures, fractures and/or joints or may possess other specific attributes that are not universal to the global geometry of the fracture system. An assessment of contaminant behavior within these aquifer system zones can be found in the preliminary exposure assessment contained in Section III.

Six (6) plume assessment monitoring wells are proposed adjacent to the waste boundary. Three (3) of the proposed plume assessment wells were installed during the initial Bolick site investigation and three (3) wells are proposed additional locations. The intent of monitoring well placement adjacent to the waste boundary will be to 1) clarify the influence of well screen depth as well as location, 2) monitor potential contaminant migration pathways not currently monitored by the existing monitoring system, and 3) identify and characterize the concentrations of contaminants adjacent to the waste. Documentation of the nature and relative conductivity of fracture zones accessed will provide additional information with which to interpret factors potentially influencing contaminant transport behaviors.

The intent of monitoring well placement beyond the property boundary is to delineate the horizontal and vertical extent of contamination beyond the existing monitoring well network. Seven (7) monitoring wells are proposed beyond the property boundary. Four (4) of the proposed plume assessment wells are located below the Bolick site and three (3) wells are proposed along the tributary of Rocky Creek below the waste disposal area. One (1) additional monitoring well is proposed along the property boundary below the Bolick site. The intent of the additional proposed monitoring well along the property boundary below the Bolick site is to provide information concerning contaminant concentrations in the fracture system at this location.

Plume Assessment Adjacent to Waste Boundary

Three (3) of the proposed plume assessment monitoring wells (MW-5, MW-6, and MW-7) are the wells previously installed along the topographic divide separating the Bolick site from the waste disposal area during the initial Bolick site investigation as indicated in Figure 2. These wells were previously sampled during the initial Bolick site investigation and provided data useful in delineating contaminant plume concentration isopleths. The intent of the placement of the well screens for these three (3) wells was to tap the uppermost groundwater producing fracture regardless of total water production. None of the three (3) wells located along the topographic divide encountered groundwater above bedrock. Relative flow rates observed in these wells during the initial Bolick site investigation are presented in the aquifer flow characterization contained in Section III.

One (1) additional well (MW-8) is proposed along the topographic divide separating the Bolick site from the waste disposal area as indicated in Figure 2. The purpose of the additional well will be to access a deeper, more productive fracture zone. The potential exists for preferential migration pathways to exist below the fractures accessed by the wells currently installed along the divide. The additional well installed along the divide will attempt to identify deeper fracture zones that may be facilitating contaminant transport. Proposed MW-8 will be drilled no deeper than thirty feet below the base grade of the adjacent fill (i.e. approximate maximum depth of 100 feet).

Another monitoring well (MW-9) is proposed adjacent to the waste disposal area on the opposite side of the landfill drainage (as indicated in Figure 2) for the purpose of monitoring potential groundwater flow entering the Rocky Mountain Heights Subdivision. The proposed well location is immediately adjacent to the Carroll residence well. The (2) previous sampling events identified the Carroll residence well as significantly contaminated (discussed in Section 2.10 and presented in Table 5). Proposed MW-9 will be drilled to attempt to access the same fracture system as the Carroll well at approximately 80 feet in depth.

The residential well sampling program will continue to be conducted within the Rocky Mountain Heights Subdivision to assess the risk to the residents and further investigate the source, nature and extent of groundwater contamination in the subdivision. Currently, the Carroll well is the only well within the Rocky Mountain Heights Subdivision that has shown significant signs of contamination. Several wells have shown trace levels of some of the same contaminants detected in the groundwater beneath the landfill. At this time confirmation of the source of these trace level detections of contaminants is not available. Current and future residential well sampling results will be utilized to further assess potential plume migration within the subdivision. If future residential sampling and analysis results determine that significant contamination has migrated into the Rocky Mtn. Heights area, current methods of plume characterization (i.e. installation of monitoring wells) will be re-evaluated.

The last of the monitoring wells proposed adjacent to the waste disposal area (MW-10) is located immediately downgradient of the fill area (as indicated in Figure 2). The two wells

(MW-2 and MW-4) of the current groundwater monitoring network that monitor the groundwater flow path in this NE drainage are located approximately 400 feet away from the waste disposal area. Proposed MW-10 will provide groundwater quality data that will allow for further evaluation into source, transportation and migration rates, and fates of previously identified contaminants. The proposed monitoring well will be screened at the first hydraulically conductive fracture zone accessed. It is anticipated that a conductive zone will be reached within 100 feet in depth.

Plume Assessment Beyond the Property Boundary - Below the Bolick Site

Four (4) plume assessment wells (MW-11, MW-12, MW-13, and MW-18) are proposed beyond the compliance property boundary below the Bolick site.

Two (2) of the proposed wells (MW-11, MW-13) are to be screened within the soil interval. MW-3 of the current Watauga County Landfill monitoring well network is located at the Bolick site property boundary within the surficial soil aquifer. The intent of the two additional soil aquifer plume assessment wells will be to further delineate the horizontal extent of the contaminant plume within the surficial soil aquifer identified at MW-3.

The screen intervals of the two additional soil aquifer plume assessment wells will be placed directly above bedrock in an attempt to effectively monitor for contamination of dense nonaqueous phase liquid (DNAPL) contaminants. Dense chlorinate solvents (i.e. DNAPL's) rather than typical "floaters" are the principle contaminants of concern and placement of the screen interval directly above bedrock will account for the physical properties of these "sinkers". Well records of MW-3, three (3) other monitoring wells and one (1) production well installed in the general vicinity indicate that approximately 20-55 feet of soils with approximately 15 feet of groundwater exist above bedrock in the area directly below the Bolick site.

Three (3) other existing monitoring wells presently exist below the Bolick site that were installed for the purpose of monitoring the Nissan-Mazda dealership's septic drain fields. The additional two (2) proposed soil aquifer plume assessment wells are located to account for the monitoring ability provided by the Nissan-Mazda monitoring wells (as indicated in Figure 3). Additional monitoring wells located in the vicinity of the drainfield will only have limited interpretive value as the integrity of the well head would be significantly compromised by the influence of potential drainfield contaminants (discussed in Section 2.10.5).

The other two proposed plume assessment wells located beyond the compliance property boundary below the Bolick site (MW-12 and MW-18) are to be screened with the bedrock fracture system. The Nissan-Mazda dealership's production well, located in this area, accesses the bedrock fracture system. Two (2) previous sampling events identified the Boone Nissan-Mazda dealership to be significantly contaminated (discussed in Section 2.10 and presented in Table 5). The Nissan-Mazda dealership's production well encountered significant water production zones at 70 feet (20 gpm) and again at 175 feet (25 gpm) as indicated by Dewey Wright Well and Pump Co. Inc.'s well record.

The two proposed fracture aquifer assessment wells (MW-12 and MW-18) are to be located beyond the Nissan-Mazda dealership's production well as indicated in Figure 3. The location of the proposed wells are designed to access the core fracture zone below the Bolick site as determined by fracture trace analysis (described in Section 4.3.4). MW-12 and MW-18 are to be located a sufficient distance apart (as indicated in Figure 3) as to account for potential fast flow rates that may be transporting contaminants along this fracture zone as identified in the Boone Nissan-Mazda dealership's domestic well. The proposed wells will be screened at a depth that coincides with the first substantial water production zone encountered during drilling within the bedrock. This will allow the proposed plume assessment well to be located closest to the known plume domain. It is anticipated that this interval will coincide with the water production zone encountered at 70 feet in the Nissan-Mazda dealership's production well.

Plume Assessment Beyond the Property Boundary - Along Rocky Creek

Two (2) plume assessment wells are proposed beyond the compliance property boundary along the tributary of Rocky Creek below the waste disposal area. These two (2) wells are to be screened within the fracture aquifer system. MW-2 of the current Watauga County landfill groundwater monitoring well network is located at the property boundary within the fracture aquifer system along the Rocky Creek tributary. The intent of the two additional fracture aquifer plume assessment wells will be to further delineate both the horizontal and vertical extent of the contaminant plume within the fracture aquifer system identified at MW-2.

The screen intervals of one (1) of the two (2) additional fracture aquifer plume assessment wells proposed below MW-2 will be placed at a depth that coincides with the first substantial water production zone encountered during drilling within the bedrock. The other fracture aquifer plume assessment well proposed below MW-2 will be screened within a fracture system occurring at a depth that coincides with the shear zone MW-2 accesses that occurs at approximately 170 feet to 172 feet. In the event that no shallow fractures are encountered, the two fracture aquifer plume assessment wells proposed below MW-2 will both the placed in the deeper fracture zone at appropriate distances apart to further delineate the horizontal extent of the contaminant plume.

Plume Assessment at the Property Boundary

Two (2) final plume assessment wells are proposed to be installed at the facility property boundary. One (1) of these wells (MW-17) is to be located below the Bolick site and one well (MW-16) is to be located along the tributary of Rocky Branch.

The proposed plume assessment well to be installed at the property boundary below the Bolick property (MW-17) will be screened within the fracture zone. The existing well (MW-3) monitoring the preferential flow path at this location is screened within the soil interval. MW-17 is to be screened at a depth coinciding with the first significant water production zone encountered during drilling within the bedrock.

The other proposed plume assessment well located at the compliance property boundary along the tributary of Rocky Branch (MW-16) is to be screened within the surficial soil aquifer. MW-4 of the current Watauga County Landfill Groundwater Monitoring Well Network is located at the compliance property boundary within the soil aquifer along the Rocky Creek tributary. The intent of the additional soil aquifer plume assessment well will be to further delineate the horizontal extent of the contaminant plume within the soil aquifer identified at MW-4.

The third existing monitoring well, MW-2, is also located at the property boundary adjacent to the tributary of Rocky Branch and is screened within a significant fracture groundwater production zone found at a depth of 172 feet.

Plume Assessment Monitoring Well Network Revisions

After each sampling event conducted during assessment monitoring (detailed in the enclosed Watauga County Groundwater and Surface Water Monitoring Program), a re-evaluation of the horizontal and vertical extent of the contaminant plume will be conducted. Appropriate revisions to the network of plume assessment monitoring wells and monitoring program will be initialized after the re-evaluation of the horizontal and vertical extent of the contaminant plume. Proposed revisions to the Watauga County Groundwater Landfill Monitoring Program may include both withdrawal of non-impacted wells and/or installation of additional plume assessment wells, as well as modifications to analytical parameter lists for individual plume assessment monitoring wells. Proposed revisions to the Watauga County Landfill Groundwater and Surface Water Monitoring Program will be submitted to the NCDEHNR for review and approval.

In order to maximize the effectiveness and efficiency of the Watauga County Landfill Plume Assessment Monitoring Program, a core of primary plume assessment wells will be identified after an evaluation of the first sampling event for assessment monitoring has been conducted on the fourteen (14) proposed plume assessment wells and the four (4) existing monitoring wells. The "boundary" plume assessment wells will be selected based on the well's ability to monitor and characterize the limits of the horizontal and vertical extent of the contaminant plume. "Core" plume assessment wells will be selected based on the well's ability to monitor and characterize potential slugs of contaminants migrating within the contaminant plume.

The (4) existing monitoring wells and the "core" plume assessment wells will be monitored according to the schedule for assessment monitoring detailed in the enclosed Watauga County Groundwater and Surface Water Monitoring Program. "Boundary" plume assessment wells will be monitored only on a semi-annual basis and for the previously detected (confirmed) assessment monitoring parameters (40 CFR Part 258 - "Appendix II List of Hazardous Inorganic and Organic Constituents").

4.2.6 Surface Water Sampling and Analysis

Surface Water sampling and analysis field activities are covered in a separated attachment (Appendix I) to the Watauga County Landfill Assessment Plan. The attached Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I) describes the procedures to be utilized for collecting surface water samples, analyzing the samples for specified parameters and evaluating and reporting the resulting surface water data. The discussion of laboratory analysis includes reference to appropriate test methods and associated detection limits as well as the laboratory's quality control and assurance procedures. Chain of custody requirements are also included.

4.2.7 Groundwater Sampling Analysis

Groundwater sampling and analysis field activities are covered in a separated attachment (Appendix I) to the Watauga County Landfill Assessment Plan. The attached Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I) describes the procedures to be utilized for collecting groundwater samples, analyzing the samples for specified parameters and evaluating and reporting the resulting surface water data. The discussion of laboratory analysis includes reference to appropriate test methods and associated detection limits as well as the laboratory's quality control and assurance procedures. Chain of custody requirements are also included.

4.3 DATA ANALYSIS PROCEDURES AND DATA VALIDATION

As previously noted, data uses for this project include site characterization, risk assessment and corrective action. The level of detail and data quality required for each of these activities will vary considerably among these activities. To meet these variable needs, a combination of laboratory services and data quality documentation will be utilized (see Section 4.1.2.1 above). Specific analytical methods are provided in Tables 4 and 4A of the Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I).

All data will undergo data validation, related to the degree of associated data quality documentation. See the Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I) for specific data validation procedures. As target constituents at the landfill will require the highest level of data quality, all CLP data will undergo rigorous data validation utilizing EPA guidance documents where applicable.

4.4 DATA EVALUATION

Assessment sampling and analysis activities will generate analytical data sets for four (4) primary routes of contaminant transport:

- groundwater
- surface water
- leachate and
- gas (air)

Analytical data sets resulting from Assessment activities will be evaluated with respect to Applicable or Relevant and Appropriate Requirements (ARARs). These ARARs will include those established by U.S. EPA and other federal agencies as well as those established by North Carolina that are more stringent than the federal standards.

Groundwater data will be obtained primarily from a network of eighteen (18) 'core' and 'boundary' plume assessment monitoring wells. The decision criteria for inclusion of a plume assessment monitoring well into the "core" network of wells will be the exceedance of an applicable North Carolina Groundwater Quality Standard (NCS) or EPA Maximum Contaminant Level (MCL). The decision criteria for inclusion of a plume assessment monitoring well into the "boundary" network of wells will be the confirmed absence or presence of one or more of the compounds detected in the "core" network of wells utilizing the QA/QC procedures outlined in the attached Groundwater and Surface Water Monitoring Program (Appendix I).

The design criteria of the "core" and "boundary" plume assessment monitoring well networks is intended to establish a valid as well as a technically and economically feasible monitoring program for assessing risks to human health and the environment. The groundwater data obtained from the "boundary" network of monitoring wells will be combined with the groundwater data obtained from the potable well investigation to assess immediate risks to human health and the environment. The initial evaluation objective of groundwater data obtained from the "core" network of monitoring wells will be to provide ongoing evaluation of groundwater quality within and around the landfill area. Finally, analytical data sets from both plume assessment monitoring well networks will be evaluated together to develop a comprehensive revised conceptual site model.

Surface water data will be obtained from a network of four (4) surface water sample collection points. Degradations in surface water quality will be reported to and evaluated by the NCDEHNR Solid Waste Section and reported to the NCDEHNR Division of Environmental Management for review. The primary objective of surface water data evaluation will be to assess the potential impact of landfill runoff and leachate on streams located downgradient of the waste disposal area. Additional actions to protect surface waters not previously required by the Division of Waste Management may be considered by the Environmental Management Commission on a site specific basis.

Leachate data will be obtained according to the occurrence or absence of leachate as determined by the schedule outlined in the attached Groundwater and Surface Water Monitoring Program (Appendix I). Leachate data will be evaluated with respect to potential impacts on surface water quality as well as investigations into source characterization. Attempts will be made to document relative leachate concentrations occurring both vertically and laterally within the fill in order to characterize contaminant transport and migration mechanisms occurring with the waste disposal area.

Air and gas monitoring will be conducted according to the procedures outlined in the Site Health and Safety Plan (HASP). Air and gas monitoring data will be evaluated with respect to health risks posed to workers on site according to the decision criteria outlined in the HASP. Air and gas monitoring data compiled during the implementation of HASP activities will be further evaluated with respect to potential hazards posed to the public in areas surrounding the site. Additional air and gas monitoring activities (ie: confined space monitoring; ambient air monitoring, etc.) will be proposed as suggested by this review of HASP air and gas monitoring data.

A variety of criteria, advisories, guidelines, or proposed standards referred to as "to be considered" (TBC) have been developed by many federal and state programs. This TBC information will be considered in addition to the requirements established as ARARs for data evaluations. Many of these TBCs are also presented in Section 4.8.1 of this report.

4.5 BASELINE RISK ASSESSMENT

A baseline risk assessment will be conducted in conjunction with the acquisition of additional data to assess potential risks posed by the site. The baseline risk assessment includes four major components: contaminant identification, exposure assessment, toxicity assessment and risk characterization. The baseline risk assessment will address all four components noted above to varying degrees based on the site complexity. Further discussion of the baseline risk assessment components are discussed below.

4.5.1 Contaminant Characterization

Contaminants of concern will be identified from data to be collected from the proposed investigative activities and data obtained during preliminary screening activities conducted by Draper Aden Associates and the Appalachian District Health Department - Environmental Health Section.

Upon completion of the site sampling investigation, Draper Aden Associates will rigorously evaluate all data for acceptable quality and for use in the baseline risk assessment. Based on evaluation, a summary of chemicals of potential concern will be compiled. Specific data evaluation procedures are discussed in detail in 4.5. Contaminants of potential concern are selected typically based upon concentration, frequency of detection, toxicological properties, location near critical exposure routes, physical properties, and specific data collection and analysis considerations. Several suspect contaminants identified during the preliminary site screening are presented in Table 10.

4.5.2 Exposure Assessment

To address potential risks associated with the identified site contaminants, data will assess the type and magnitude of exposure from contaminants at or migrating from the waste site. The exposure assessment will include a characterization of the exposure setting, exposure pathways and exposure quantification. Specific components are detailed below. A preliminary exposure assessment has been conducted by Draper Aden Associates and is present in Section 3.4 of this report.

Draper Aden Associates will characterize the site's exposure setting, which includes addressing the site's physical setting characteristics and potentially exposed human populations located on and nearby the site. Physical characteristics to be evaluated include climatic and meteorologic conditions, site geologic setting, and hydrogeologic features. Population characteristics will be evaluated with regard to current populations relative to the site, subpopulations of potential concern, activity patterns, and current and future land use.

Secondly, Draper Aden will further define pathways by which populations may be exposed. Pathways will be assessed based on contaminant sources and receiving media (e.g. ground water, soil, air); and chemical fate and transport in a particular media. Points of potential contact with a chemical, and exposure routes (e.g. inhalation, ingestion, dermal contact) will be assessed based on high potential for contaminant contact.

Lastly, exposure concentrations obtained during the course of the investigation at each exposure will be compiled and evaluated. For each exposure pathway, if required, estimations of chemical intake will be calculated, resulting from the actual or potential contaminant release at the site. Additionally, the exposure assessment will take into account current and projected land usage.

4.5.3 Toxicity Assessment

As part of the baseline risk assessment, the toxicity assessment evaluates a contaminant's potential for causing carcinogenic and noncarcinogenic adverse effects to exposed populations, and assesses the potential degree of adversity associated with length of contaminant exposure. The toxicity values are used in Risk Characterization to estimate the potential of adverse effects occurring in humans at varying exposure levels.

For this project, DAA will review available toxicity information to determine carcinogenic and noncarcinogenic status for the contaminants of concern. Where available, toxicity levels for the contaminants will be compiled and presented. Special consideration will be given to sensitive subpopulations in the selection of toxicity valves. Toxicity information will be obtained from the EPA database IRIS - Integrated Risk Information System. For some contaminants, no toxicity valves may be available and must be evaluated by other means, such as extrapolation according to EPA guidance documents. Uncertainties related to available toxicity information will be discussed as it relates to this project. Upon completion of the toxicity assessment, the information will be summarized.

4.5.4 Risk Characterization

As the final component of the risk assessment process, the risk characterization summarizes information obtained during the above noted activities. Potential risks of adverse health or environmental effects will be presented.

4.6 REMEDIAL INVESTIGATION REPORT

Depending on need and various other appropriate factors, a Remedial Investigation (RI) Report summarizing assessment and remedial investigation activities and findings shall be submitted to the NCDEHNR Solid Waste Section for review and comment. Early chapters of the report will summarize the field investigation activities and analytical data associated with the groundwater and surface water sampling and analysis conducted under the Assessment monitoring program detailed in the attached Watauga County Landfill Groundwater and Surface Water Monitoring Program (Appendix I) and the landfill gas and leachate sampling conducting during the Proposed Well Installation detailed in the attached Watauga County Landfill Health and Safety Plan (Appendix II). The Conceptual Site Model will be revised and refined based upon the results of the first year of the Assessment Plan Work Tasks and presented in the RI Report.

The presentation of the revised Conceptual Site Model will involve discussions concerning the following subjects:

- groundwater contaminant plume migration
- hydrogeologic investigation
- leachate investigation
- landfill gas investigation
- waste investigation

Based on the revised Conceptual Site Model, additional assessment and remedial investigation activities (i.e. installation of additional plume assessment wells) may be proposed. This approach will allow for flexibility to respond to new data and to changes in the project.

V. *ESTIMATED COST AND KEY ASSUMPTIONS*

The following cost estimate presented below is based on the approval and implementation of assessment activities as outlined in the Assessment Plan. Key assumptions include the approval of proposed activities, but do not account for potential need for additional assessment activities, including installation of additional plume assessment monitoring wells or identification of unanticipated target analytes.

Capital costs as outlined below consist of both direct costs and indirect costs. Direct costs include expenditures for equipment, labor, and materials associated with the Assessment Plan work tasks. Indirect costs include expenditures for engineering, and other operational and management services that are not a part of actual infrastructure development or sampling and data analysis, but nonetheless are required to complete, evaluate, or report assessment activities.

5.1 INITIAL FIELD ACTIVITIES

Activity Description

a. Grid Field Gas Screening
b. Gas Probe Sampling and Analysis
c. Develop Access and Easements for Off-Site Well Locations
d. Final Bid Specification and Award for Drilling
e. Final Bid Specification and Award for Analytical Services
f. Well Drilling and Installation (11 Proposed Wells)
g. HASP Implementation During Well Drilling
h. Aquifer Testing
i. New Well Installation Data Analysis and Hydrogeologic Evaluation
j. Dedicated Pump Installation (18 wells)

Total Cost Estimate: $131,860 - $154,160

Key Assumptions for 5.1

- Assumes unit prices for materials, labor, and engineering services.
- Assumes County assistance in obtaining access, easements, and placing culvert.
- Drilling program includes cover validation boring program to be conducted in conjunction with well drilling and installation.
- Well drilling and installation assumes two weeks for completion and HASP implementation during these activities.
- All work for well drilling and installation assumes initial Level C protection for all work crews.

5.2 FIRST YEAR SAMPLING AND ANALYSIS (QUARTERLY)

The following assumes that initially, there will be nine (9) core plume assessment wells and nine (9) boundary plume assessment wells for purposes of monitoring. Also included are four (4) surface water points for risk assessment screening and an assumption of two (2) leachate seeps. Base assumptions include dedicated pumps, no additional equipment blank analysis, and that purge waters can continue to be discharged to the ground surface. Also each sampling event requires an additional Trip Blank, and two duplicate samples and two spike samples for each tenth sample for a specific set of tests.

a. CLP/Risk Assessment Screening Sampling (Two Quarters)
b. CLP Background Sampling at Core and Boundary (Two Quarters)

Total Cost Estimate $87,220 - $101,620

5.3 FIRST YEAR ADDITIONAL ENGINEERING EVALUATIONS/ACTIVITIES

a. Waste and Cover Investigations
b. Leachate Investigation
c. Landfill Gas Investigation
d. Hydrogeologic Fracture Analysis
e. Ongoing Baseline Risk Assessment
f. Project Review
g. End of Year Supplementary Engineering Report

Total Cost Estimate $24,000 - $38,500

Total First Year Cost Estimate: $243,080 - $294,280

5.4 SECOND YEAR SAMPLING AND ANALYSIS: (SEMI-ANNUAL)

Base Assumption for 1st year sampling and analysis are assumed, with additional evaluation of fate and transport.

a. Laboratory Performance Evaluation
b. First Event Full Risk Assessment Screening at Core Wells and Target List Analysis at Boundary Wells
c. Second Event CLP screening at core wells and boundary wells (Same as 5.2.b above, except add Risk Assessment screening at surface locations)

Total Cost Estimate $75,790 - $89,290

5.5 SECOND YEAR ADDITIONAL ENGINEERING EVALUATION/ACTIVITIES

a. Project Reviews
b. Ongoing Baseline Risk Assessment
c. End of Year Supplementary Engineering Report

Total Cost Estimate $21,500 - $32,500

Total 2nd Year Cost Estimate $97,290 - $121,790

VI. SCHEDULE

The following presents a tentative schedule for implementation of the enclosed Assessment Plan Work Tasks. This schedule represents a time line projection moving out from the date at which the Assessment Plan has been approved by the NCDEHNR for implementation.

It is noted that in order to meet the thirty day deadline date for submission of analytical results for groundwater and surface water sampling, analytical results will be submitted to the State within this time period after actual sample collection date, however data validation and quarterly reporting will necessarily require additional time for evaluation prior to submittal to the State. With regard to the described schedule below, it should be realized that certain activities are contingent upon successful completion of previous activities. Delays incurred in completing any activities thus will necessarily extend deadlines for dependent future activities. For purposes of presenting an easily readable schedule as presented below, it is assumed that all time frames begin with State approval of Assessment Plan. As listed below, scheduled activities will attempt to be completed on or before the completion date as noted.

Activity Description	Completion Date
Initial Field Activities	
Grid Field Gas Screening	Week 2
Gas Probe Sampling (as necessary)	Week 2
Gas Probe Analysis	Week 4
Develop Access and Easements for Off-Site Well Locations	Week 4
Award Drilling Services	Week 4
Award Analytical Services	Week 4
Cover Validation Boring Program	Week 10
Well Drilling and Installation	Week 10
Preliminary Activity Report	Week 12
Dedicated Pump Installation	Week 13
First Year Evaluations	
1st Quarter Sampling Event	Week 13
1st Quarter Event Analysis	Week 16
1st Quarter Event Submission of Results to NCDEHNR	Week 17
1st Quarter Event Assessment Report to NCDEHNR	Week 21
1st Quarter Assessment Final Report	Week 22
2nd Quarter Sampling Event	Week 26
2nd Quarter Event Analysis	Week 29
2nd Quarter Event Submission of Results to NCDEHNR	Week 30
2nd Quarter Event Assessment Report to NCDEHNR	Week 34
2nd Quarter Assessment Final Report	Week 35

3rd Quarter Sampling Event	Week 39
3rd Quarter Event Analysis	Week 42
3rd Quarter Event Submission of Results to NCDEHNR	Week 43
3rd Quarter Event Assessment Report to NCDEHNR	Week 47
3rd Quarter Assessment Final Report	Week 48
4th Quarter Sampling Event	Week 52
4th Quarter Event Analysis	Week 55
4th Quarter Event Submission of Results to NCDEHNR	Week 56
4th Quarter Event Assessment Report to NCDEHNR	Week 60
4th Quarter Assessment Final Report	Week 61
End of 1st Year Supplementary Assessment Progress Report to DEHNR:	Week 65

2nd Year Evaluations

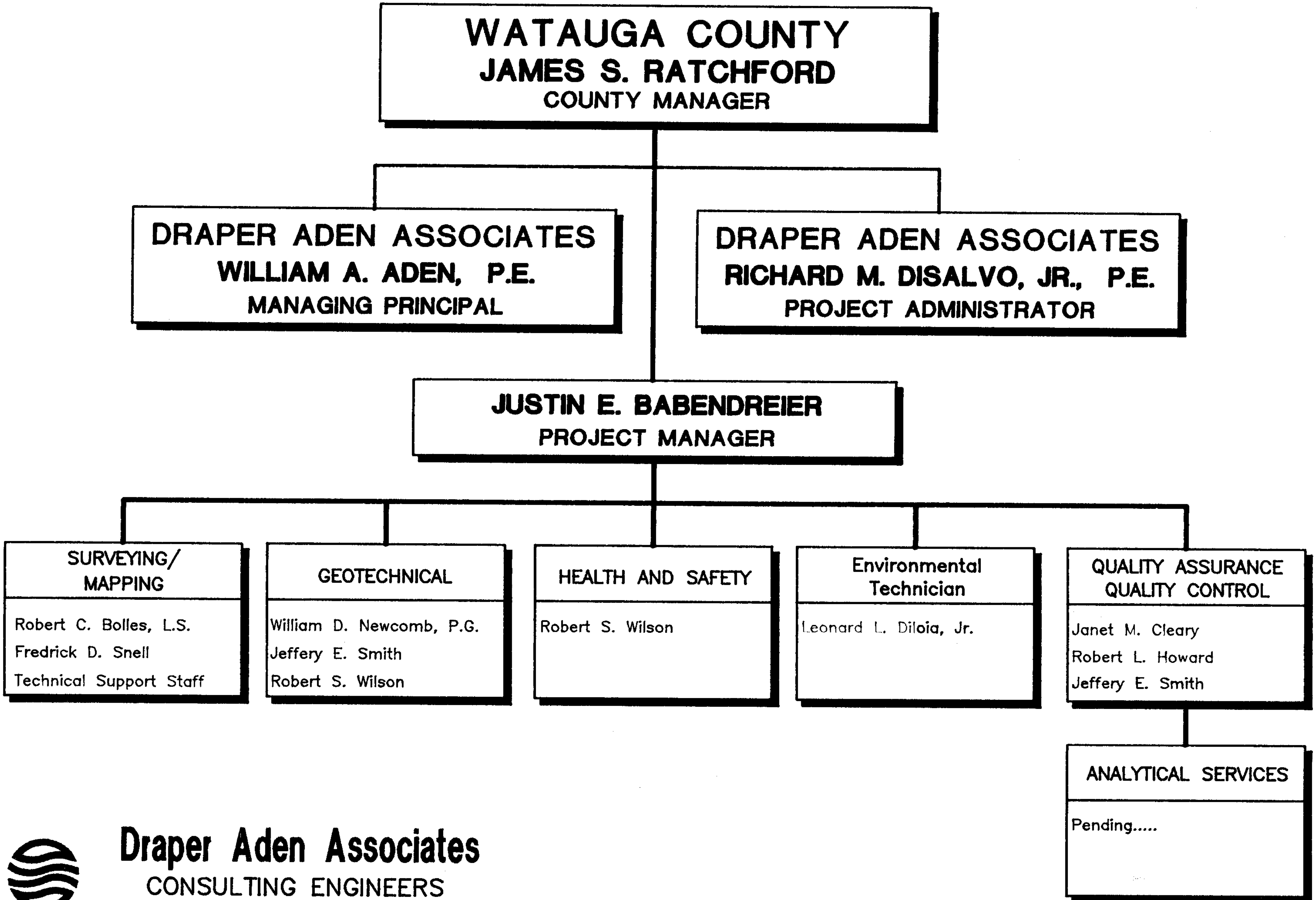
1st Semi-Annual Sampling Event	Week 65
1st Semi-Annual Event Analysis	Week 68
1st Semi-Annual Event Submission of Results to NCDEHNR	Week 69
1st Semi-Annual Event Assessment Report to NCDEHNR	Week 73
1st Semi-Annual Assessment Final Report	Week 74
2nd Semi-Annual Sampling Event	Week 91
2nd Semi-Annual Event Analysis	Week 94
2nd Semi-Annual Event Submission of Results to NCDEHNR	Week 95
2nd Semi-Annual Event Assessment Report to NCDEHNR	Week 99
2nd Semi-Annual Assessment Final Report	Week 100
2nd Year Supplementary Assessment Progress Report to DEHNR:	Week 104

VII. PROJECT MANAGEMENT

The following Project Organization Chart outlines project management responsibilities, such as staffing and coordination for implementation of the Assessment Plan. The Watauga County Landfill is presently owned and operated by Watauga County under the direct supervision of Mr. Mark Combs, Watauga County Sanitation Supervisor. Watauga County's governing body is composed of a Board of Commissioners and the Watauga County Manager, Mr. James S. Ratchford. All offsite potable well testing will be under the supervision of the Appalachian District Health Department, Mr. John Alley, Chief Sanitarian. Watauga County has secured the services of Draper Aden Associates to prepare and implement the Assessment Plan.

Project management will be under the responsible charge of North Carolina registered Professional Engineers at Draper Aden Associates as outlined in the following Project Organization Chart. Staffing and coordination of various Assessment work tasks such as sampling and analysis, health and safety, etc. are additionally noted.

DAA PROJECT ORGANIZATION CHART



Draper Aden Associates
CONSULTING ENGINEERS
Blacksburg, Va. – Richmond, Va. – Nashville, Tenn.

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APPENDIX III

Watauga County Landfill Assessment Plan
Public Comment and Response

PUBLIC COMMENT AND RESPONSE

In an effort to further inform the community of the activities associated with the enclosed Assessment Plan, Watauga County advertised in various public formats the availability of the August 21, 1993 draft Assessment Plan for public review between August 23, 1993 and August 30, 1993. As well, Watauga County's Board of Commissioners called a public meeting which took place on August 26, 1993 in the Town of Boone, North Carolina.

The following discussion presents an overview of the public meeting proceedings, as well as a specific response to all written comments received during open public comment. In reference to written public comment, only one (1) response was received from the Blue Ridge Environmental Defense League (BREDL), written by Ms. Susan Sharpe, Co-President. Her written response is enclosed at the end of this discussion.

Overview of Public Meeting Proceedings

On August 26, 1993 Watauga County hosted a public meeting. The purpose of the meeting was to present the draft Assessment Plan and to discuss the specific issues and answer questions regarding the ongoing activities associated with groundwater contamination in and around the Watauga County Landfill. In brief, the meeting appeared to be very helpful and the Assessment Plan was generally well received by the community.

Written Public Comment and Response

As indicated in the discussion and associated recommendations of Sections 1 & 2 of the response from BREDL, BREDL requested sediment sampling at the surface water sampling locations. The apparent basis for this request is the potential impact of accumulated contaminants in stream sediments which are released during storm events. In response, while Draper Aden Associates understands the concern and appreciates the discussion regarding the potential effects of accumulated heavy metals in the stream bottom sediments, it is noted that heavy metal deposition is not presently a conclusive issue of concern based on available evidence at the site. As indicated in revised discussion in Section 2.1.4, heavy metals occur naturally in rock and soil types found in the local geology. Actual non-point source discharges from the fill area, as well as other areas around the landfill off-site, would be impossible to differentiate from natural composition.

It is very important in accomplishing the goals of the Assessment Plan, to monitor for potential discharges of contaminants from the landfill to surface drainage. However, the sediment stream sampling does not avail itself to measurable assessment of a release from the landfill, in the context of a usable comparison for risk assessment. One point not necessarily agreed on is that the levels of heavy metals which have tended to fluctuate at the site are due to storm events and stream sediment bottoms. There is associated relatively low level quality assurance and quality control for this data, and also the data does not present overriding concerns for the potential of hazardous waste classification of sediment bottoms. The effect is also likely due to erosional effects from naturally occurring soils washed into the drainages. In any case, such leaching characteristics of the sediment bottoms will be adequately monitored by surface water testing and leachate testing. In summary, sediment sampling data collection does not appear to be feasible in its ability to associate the data with risks to surface water receptors as caused by impact from the landfill. Investigation which could adequately describe the actual sources of sediment contaminants, would be prohibitably expensive, with a low likelihood of success.

With regard to Section 3 of BREDL's response to the Assessment Plan, Draper Aden Associates notes that indefinite testing of surface water as an obligation by the Watauga County Landfill could best be evaluated within the existing regulatory mechanisms established for sanitary landfill operations. In evaluating the needs of the Assessment Plan and the evaluation of potential contamination to surface water, it is appropriate to reevaluate the need for surface water testing based upon the conclusion of releases of contaminants by the landfill from groundwater and surface water test results. In summary, it is more appropriate to utilize the existing guidance provided EPA Subtitle D in evaluating criteria for Assessment monitoring requirements at sanitary landfills. Therefore, Draper Aden Associates does not recommend indefinite surface water testing, however we recommend reevaluating the needs of surface water testing after the two year minimum investigation.

Blue Ridge Environmental Defense League

Janet Hoyle, Director

Proposed Changes to the Draft Assessment Plan for Monitoring the Watauga County Landfill
August 26, 1993
submitted by: Susan Sharpe, BREDL Co-President

Topic: Surface Water Testing

The levels of heavy metals in surface water tests of 7/92 and 11/92 fluctuate greatly, and indicates storm flows that resuspend the metals. It is important to recognize that metals do not go away as volatiles do.

1) section 3, paragraph 3.1.4--site description, p.49
--says dilution effects in stream are not as apparent as expected. This is due to cumulative effects from non-point-source discharges from the fill area.

2) appendix 1, section 3, paragraph 3.4
--states that only water samples from well-mixed flows will be taken.
It is important to recognize that stream sediments are a significant sink for metals, and can accumulate contaminants. These contaminants can be released during storm flows and may not be apparent during lower water conditions.
Recommendation: sediment sampling at the surface water sites.

3) appendix 1, section 4, paragraph 4.2 p.40-41
says that monitoring will cease when 2 consecutive annual monitoring events show no contaminants. Doesn't state whether it applies to surface water sampling, but if so, this is not recommended, because it has already been stated (see section 3, par. 3.1.4) that non-point-source discharges into the stream are not all known nor can their potential for contamination be assessed.
Recommendation: that surface water tests be continued beyond two years regardless of clean samples.

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APPENDIX IV

Administrative Agreement on Consent

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT,
HEALTH AND NATURAL RESOURCES
DIVISION OF SOLID WASTE MANAGEMENT
SOLID WASTE SECTION

COUNTY OF WATAUGA) IN RE: WATAUGA COUNTY) SANITARY LANDFILL)	ADMINISTRATIVE AGREEMENT ON CONSENT DOCKET NUMBER 93-SW-03

I. Jurisdiction

This Administrative Agreement on Consent is entered pursuant to the North Carolina Solid Waste Management Act, N.C.G.S. 130A, Article 9, and Rules, codified at 15A NCAC 13B. William L. Meyer, Director of the Division of Solid Waste Management ("The Division"), has been delegated the authority to imple[illegible] Waste Management Program under the Act and Rules.

II. Statement of Purpose

This Consent Agreement is entered for the limited purpose of investigating contamination of the groundwater and possible contamination of surface water in the vicinity of the sanitary landfill owned and operated by the County of Watauga, North Carolina. This Agreement is entered without prejudice to any further study or remedial activity which may be necessary at this site.

III. Stipulation of Facts

Based upon information available at the effective date of this Consent Agreement, the following facts are stipulated for the purposes of this Consent Agreement:

A. The County of Watauga owns a sanitary land[illegible] off State Road 1655 and U.S. Hwy. 421 approximately [illegible] of Boone.

B. Watauga County has operated a sanitary landfill permitted to receive solid, non-hazardous waste for disposal under Solid Waste Permit No. 95-02 since April 19, 1984. Prior to this date the Town of Boone held Permit No. 95-01 for a sanitary landfill located in this same area. A dump was operated at this general location for many years. This dump was converted to a sanitary landfill authorized by the State Solid Waste and Vector Control Section in a letter dated November 21, 1972. Watauga County's Solid Waste Permit No. 95-02 was amended in November, 1986, and amended again to allow a vertical expansion in January, 199[illegible]

C. Groundwater monitoring analytical results first indicated the possibility of some volatile organic contamination in on-site monitoring wells in a sampling event conducted in December, 1990, in which the State Solid Waste Section split samples with the County's sampling contractor in order to run additional analyses, including analyses for volatile organic compounds.

D. In January, 1992, the County Engineers, Draper Aden Associates, and Watauga County met with State Solid Waste Management officials to discuss the County landfill plans, including plans for expansion to an adjacent tract. State officials advised the County to conduct additional subsurface investigation to determine groundwater flow directions and rates and groundwater quality in the proposed expansion area. Subsequent sampling and analyses by the County's consulting engineers, Draper Aden Associates, conducted during the course of a subsurface investigation of the site indicated the presence [illegible] organic contamination in groundwater beneath the Watauga County landfill site. Screening data from a September, [illegible] event conducted by Draper Aden Associates indicated the potential presence of halogenated organic compounds in groundwater monitoring wells at the Watauga County landfill site. Contamination of on-site groundwater was confirmed upon completion of and evaluation of laboratory analyses of the November, 1992 groundwater samples, as compiled in a report dated March 1, 1993 prepared by Draper Aden Associates.

E. Upon receipt of the Draper Aden report, the County brought the results of the September and November sampling events to the attention of the Solid Waste Section. County and State officials and representatives of Draper Aden met on March 4, 1993. The Draper Aden report also provided data on groundwater flow directions and rates which indicated the possibility of related groundwater contamination outside the compliance boundary of the Watauga County landfill site.

F. On the basis of this new information provided by Watauga County, the Solid Waste Section on March 4, 1993, issued Watauga County a Notice of Violation of Groundwater Quality Standards, which standards were exceeded for certain constituents in monitoring wells located at the compliance boundary for the landfill.

G. On March 5, 1993, Draper Aden Associates, on behalf of Watauga County, sampled twelve drinking water wells in [illegible] of the Watauga County landfill. Upon receipt of [illegible] analyses from these wells on March 17, 1993, the [illegible] Section forwarded copies of the analyses to the [illegible] Epidemiology for a Health Risk Evaluation. Of five wells reported to have some volatile organic compounds present, two wells were determined by Dr. Ken Rudo of the State Environmental Epidemiology Section to be "significantly contaminated" and Dr. Rudo recommended that these wells "not be used for drinking or cooking". Watauga County immediately made potable water available to the parties involved. No semi-volatile organic chemicals were detected in the March 5th water samples from the twelve wells. On March 18, 1993, an additional seven off-site wells were sampled by Draper Aden on behalf of the County. Results of that sampling event indicated that of the seven wells sampled, two wells were reported to have trace levels of some volatile/semi-volatile organic compounds present, and five wells had no such compounds reported. On March 18 and 24, respectively, each of the two off-site wells in which "significant contamination" had been detected on March 5 was re-sampled. Significant contamination was again detected in each well.

H. As of the effective date of this Consent Agreement, the nature and extent of contamination in the groundwater beneath the Watauga County sanitary landfill have not been clearly determined, and the source, nature and extent of off-site contamination in the vicinity of the landfill have not been determined.

IV. Applicable Law

A. 15A NCAC 13B .0503(2)(d)(i) adopts by referenc[illegible] 2L, Classifications and Water Quality Standards App[illegible] Groundwaters of North Carolina.

B. 15A NCAC 13B .0503(2)(c)(i) states that "A (landfill) site shall not cause a discharge of pollutants into waters of the state that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES), under Section 402 of the Clean Water Act, as amended". Rule 15A NCAC 13B(2)(c)(iii) states that "a site shall not cause non-point source pollution of waters of the state that violates assigned water quality standards".

C. 15A NCAC 13B .0601(a) states that "The Division shall require a solid waste management facility to provide such groundwater monitoring capability as the Division determines to be necessary to detect the effects of the facility on groundwater in the area".

D. 15A NCAC 13B .0602(a) states that "The Division shall require a solid waste management facility to provide such surface water monitoring capability as the Division determines to be necessary to detect the effects of the facility on surface water in the area".

E. 15A NCAC 13B .0201(d) states that "All solid waste management facilities shall be operated in conformity with these

Rules and in such a manner as to prevent the creation of a nuisance, insanitary conditions, or potential public health hazard".

V. <u>Determination By The Division</u>

Based upon the facts and applicable law, the [illegible] determined, for purposes of this Consent Agreement, [illegible] following:

A. Analyses of samples of groundwater taken at the Watauga County sanitary landfill in November, 1992 indicate that various volatile organic constituents are present in certain locations at levels that exceed groundwater standards.

B. An investigation of groundwater conditions in the vicinity of the landfill is necessary to identify any plumes of contamination, the direction and rate of movement of the plumes and to determine the type, concentration, source and extent of contamination.

C. An investigation is necessary to determine the horizontal and vertical extent of groundwater contamination and if any contamination has moved across the property boundary.

D. An investigation of surface water conditions at the site is necessary to determine the type, concentration, source and movement of surface water contamination.

E. An investigation of the ground and surface water receptors in the general area of the landfill is necessary to determine the potential impact on public health of contamination that the investigation of ground and surface water reveals.

VI. Scope of Work

A. The Division has determined that this Ag[illegible] promote the protection of public health and the envi[illegible] in the public interest. The provisions of this Administra[illegible] Agreement shall henceforth govern the actions of Watauga Co[illegible] Therefore, in an effort to determine the status of ground and surface water quality at its landfill property, Watauga County agrees to perform the following actions:

1. Within sixty (60) calendar days of execution of this Agreement, Watauga County shall develop and submit a plan for a ground and surface water quality investigation which, upon approval by the Division, will constitute the approved assessment plan. The plan shall be prepared under the responsible charge of a Professional Engineer [illegible] Professional Geologist with experience in assessment and remediation of groundwater contamination. Watauga County's professional engineering/geological consultant shall meet with the Solid Waste Section's Hydrogeologist to discuss the landfill site prior to developing the assessment plan. The objectives of the assessment plan shall be to determine the following:

(a) The nature and concentration of the contamination in the ground and surface waters.

(b) The horizontal and vertical extent of contamination ("the plumes") and the direction and rate of migration of the plumes in the groundwater[illegible]

(c) The source(s) of contamination detected in ground and surface water.

(d) Potential ground and surface water receptors that could be affected by migration of the contamination.

(e) The possible effects of the contaminated groundwater moving off-site.

2. The assessment plan to be submitted sh[illegible] detailed plan for the initial phase of the investigatio[illegible] a strategy and timetable for accomplishing the overall goals of the water quality assessment. The assessment plan must specify:

(a) The procedures and methods necessary to determine fully flow direction and rate of movement of the groundwater and surface waters.

(b) The methods and techniques to be used in defining the horizontal and vertical extent of the groundwater contaminant plumes[illegible]

(c) The proposed number, location and depth [illegible] plume assessment wells. The proposal shall include a discussion of the reasons for the location and depth of each plume assessment monitoring well.

(d) A ground and surface water sampling plan prepared in accordance with the <u>N.C. Water</u>

Quality Monitoring Guidance Document for Solid Waste Facilities.

(e) A ground and surface water analy[illegible] specifies parameters to be tested [illegible] plume assessment wells and [illegible] samples, including detectable levels and appropriate test methods. Additionally, a description of chain-of-custody and the laboratory's quality control and quality assurance procedures shall be included. In implementing the plan, analytical results must be submitted to the Division within 30 calendar days of sample collection and must specify collection date and well numbers [illegible] a corresponding map of the wells[illegible]

(f) Evaluation procedures, including any use [illegible] previously gathered groundwater quality data.

(g) The location of the nearest downstream surface water intake in the watershed, and the location of all groundwater wells within at least one half mile of the landfill site (which could be potentially impacted by the contaminant plumes).

(h) A schedule for implementation of the work described in the assessment plan.

3. Before the end of the sixty-day perio[illegible] for the County to consider carefully any comments, the County will make the draft assessment plan available for public review and comment.

B. The Division shall review the submitted plan, approve it, or request more information or amendment, as it deems necessary. The approved plan constitutes the assessment plan which Watauga County shall implement.

C. Any request for modification of the assessme[illegible] be submitted in writing to the Division and app[illegible] Division.

D. If the Division determines that any submission [illegible] evaluation or report made pursuant to the approved assessment plan is inadequate, it will notify Watauga County and submit suggested corrections. If the parties cannot agree, they will proceed in accordance with the provisions of the "Dispute Resolution" Section of this Consent Agreement.

E. All work performed pursuant to the assessment plan shall be performed under the supervision of a Professional Engineer or Licensed Professional Geologist.

F. Watauga County shall submit to the Divisio[illegible] report summarizing work completed in the approved asse[illegible]

G. Within sixty (60) days of satisfactory comp[illegible] elements of the assessment plan, Watauga County shall submit a final report including any proposals for further actions as may be recommended by the County and its consultants. The Division shall review the report and may request more information or [illegible] it deems necessary.

VII. <u>Sampling, Access, and Data/Document Availability</u>

At the request of the Division, the County shall allow split or duplicate samples to be taken by the Division, of any samples collected by the County pursuant to the implementation of this Consent Agreement. The County shall notify the Division not less than ten (10) days in advance of any sample collection activity.

The Division shall also allow split or duplicate samples to be taken by the County of any samples collected by the Division during the period of performance of work associated with this Consent Agreement. The Division shall notify the County not less than ten (10) days in advance of any sample collection activity.

The Division shall have the authority to enter and freely [illegible] about all property at the Site at all reasonable times for the purposes of, inter alia: inspecting non-privileged records, operating logs, and contracts related to work under this Consent Agreement; reviewing the progress of the County in carrying out the terms of this Consent Agreement; conducting such tests as the Division deems necessary; and verifying the data submitted to the Division by the County. The County shall permit such persons to inspect and copy all non-privileged records, files, photographs, documents, and other writings including all sampling and monitoring data, in any way pertaining to work undertaken pursuant to this Consent Agreement. Documents subject to the attorney-client privilege or attorney work product doctrine are not subject to inspection and copying.

VIII. <u>Delay in Performance</u>

If any event occurs which causes delay in the achievement of the requirements of this Consent Agreement, Watauga County shall have the burden of showing that the delay was caused by circumstances beyond the reasonable control of the county, which could not have been overcome by due diligence. Watauga County shall promptly notify the Division's Primary Contact orally and shall, within seven (7) calendar days of oral notification to the Division, notify the Division in writing of the anticipated length and cause of the delay, and the timetable by which the county intends to implement these measures. If the parties can agree that the delay has been or will be caused by circumstances beyond the reasonable control of the county, the time for performance hereunder shall be extended for a period equal to the delay resulting from such circumstances. Watauga County shall adopt all reasonable measures to avoid or minimize delay. Failure of the County to comply with the notice requirements of this paragraph shall render this paragraph void and constitute a waiver of the County's rights to request a waiver of the requirements of this Consent Agreement. Increased costs of performance of the terms of this Consent Agreement or changed economic circumstances shall not be considered circumstances beyond the control of Watauga County.

In the event that the Division and Watauga County cannot agree that any delay in the achievement of the requirements of this

Consent Agreement, including the failure to submit [illegible] document, has been or will be caused by circumstances [illegible] reasonable control of the County, the dispute shall be resolved in accordance with the provision of the "Dispute Resolution" Section of this Consent Agreement.

IX. <u>Dispute Resolution</u>

If Watauga County objects to any notice of disapproval or decision made pursuant to this Consent Agreement by the Division, Watauga County shall notify the Division in writing of its objections within fourteen (14) calendar days of receipt of the decision. The Division and Watauga County then have [illegible] fourteen (14) calendar days from receipt by the [illegible] notification of objection to reach agreement. If agreement cannot be reached on any issue within this fourteen (14) calendar day period, the Division shall immediately provide a written statement of its decision to Watauga County.

Thereafter, if the Division and Watauga County cannot agree, the Division shall retain all applicable enforcement rights, and Watauga County shall retain all applicable defenses.

X. <u>Notice</u>

Any and all written notices to be made pursuant to Sections VII, VIII, and IX of this Consent Agreement shall [illegible] certified mail, return receipt requested, or by hand delivery addressed to the respective primary contact as designated in [illegible] Consent Agreement.

The names, addresses, and telephone numbers of the designated primary contacts for the Division and the County are stated below. Should there be any change in the primary contact person during the course of the investigation covered under this Consent Agreement, this must be communicated in writing to the other party immediately.

The primary contact for the Division:

Bobby Lutfy, Hydrogeologist
Division of Solid Waste Management
Department of Environment, Health,
and Natural Resources
P. O. Box 27687
Raleigh, North Carolina 27611-7687
Telephone: (919) 733-0692

For Watauga [illegible]

James S. Ratch[illegible]
County Manage[illegible]
Box 1, Courthous[illegible]
403 W. King [illegible]
Boone, North Carolina [illegible]

Telephone: (704) 265-8000

This Agreement on Consent is entered into on the 7th day of July, 1993.

The Division of Solid Waste Management
North Carolina Department of Environment, Health & Natural Resources

By: [signature] 7/7/93
William L. Meyer, Director — Date

Watauga County

By: [signature] 6-11-93
Chairman, Watauga County Board of Commissioners — Date

Attest: Roberta M. Watson 6-11-93
Clerk to the Board — Date