*580SERBSF10,634*

*580SERBSF10,634*

| | |
|---|---|
| Site Name (Subject): | TRI-COUNTY COMMUNITY COLLEGE |
| Site ID (Document ID): | NCD038551263 |
| Document Name (DocType): | Preliminary Assessment/Site Inspection (PA/SI) |
| Report Segment: | |
| **Description:** | Site Inspection Report |
| Date of Document: | 3/31/1987 |
| Date Received: | |
| Box: *Enter SF and # with no spaces* | SF10,634 |
| Access Level: | PUBLIC |
| Division: | WASTE MANAGEMENT |
| Section: | SUPERFUND |
| Program (Document Group): | SERB (SERB) |
| Document Category: | FACILITY |

**Print Report for Record** | **Go to New Blank Record** | **Go to New Record - (default to last record values)** | **Delete Record**

# SITE INSPECTION REPORT

Tri-County Community College
NC D038551263
Route 1, P.O. Box 40
Murphy, NC 28906

31 March 1987



Stan T. Atwood, Toxicologist
NC Division of Health Services
Solid and Hazardous Waste Management Branch
CERCLA Unit

## EXECUTIVE SUMMARY

Tri-County Community College opened in 1967. There are four main classroom and administrative buildings with a fifth under construction on the 77 acre campus. The site was originally occupied by the NC Department of Corrections (DOC) who operated a prison there from the late 1930s until 1965. Clifton Precision, a manufacturer of electric motors, occupied the site from March 1966 until January 1967, and the NC Department of Transportation (DOT) operated a maintenance shop at the site until August 1976.

The DOC originally installed a septic system with a sand filter bed for domestic sewage. The leachate is discharged to McComb Branch. Tri-County Community College still uses this system and maintains an NPDES permit for the discharge.

In January 1987 trichloroethene (300 ppb) was detected in the drinking water well at this site. Other wells in the community (including two industrial sites) were also found to contain low levels of chlorinated solvents. Tri-County Community College now uses bottled water for drinking.

It was reported that small amounts of trichloroethene have been used in the chemistry labs and machine shop. A 55-gallon drum labeled trichloroethene was found in the machine shop, but it contains used motor oil. The origin of the drums is unknown.

A CERCLA site inspection was conducted on 10-11 February 1987. Ground water, surface water, and sediment samples were collected. The well contained 542 ppb trichloroethene and McComb Branch contained 68 ppb trichloroethene. No metals were detected in the well sample.

The site is located in an alluvial valley. Geology is complex with much local folding. Fractured bedrock is the aquifer of concern.

## BACKGROUND

### Location

Tri-County Community College is located in Cherokee County about 4.5 miles east of Murphy on US 64. The address is Route 1, P.O. Box 40, Murphy, NC 28906. The coordinates are: latitude 35° 03' 58", longitude 83° 57' 59".

### Site Layout

There are four main classroom buildings with one other building under construction. The college is located between SR 1548 (just off US 64) and the forks of McComb Branch. There are two wells on site and a septic tank with a sand filter bed (Figure 1). There is an abandoned Department of Transportation maintenance shop adjacent to the site on the south.

### Ownership History

Tri-County Community College has occupied the site since 1967. Former occupants of the site are as follows: Clifton Precision, 1966-1967; Department of Corrections (DOC), late 1930's-1965; Department of Transportation (DOT) Maintenance Facility, prior to 1976 (1).

### Site Use History

There are no documented spills or disposals of chlorinated solvents at the site. Clifton Precision has used trichloroethene at its present location (about 2.5 miles north on NC 141) and has ground water contamination there; however, Clifton only operated at the site for nine months, and reportedly did not use trichloroethene at the time (1,2). The DOT reportedly used some kerosene and gasoline to clean parts. Trichloroethene has been used by the community college in chemistry labs and the machine shop. A 55-gallon drum labeled trichloroethene was discovered in the machine shop, but site representatives reported that they were unable to determine when the drum was purchased (3).

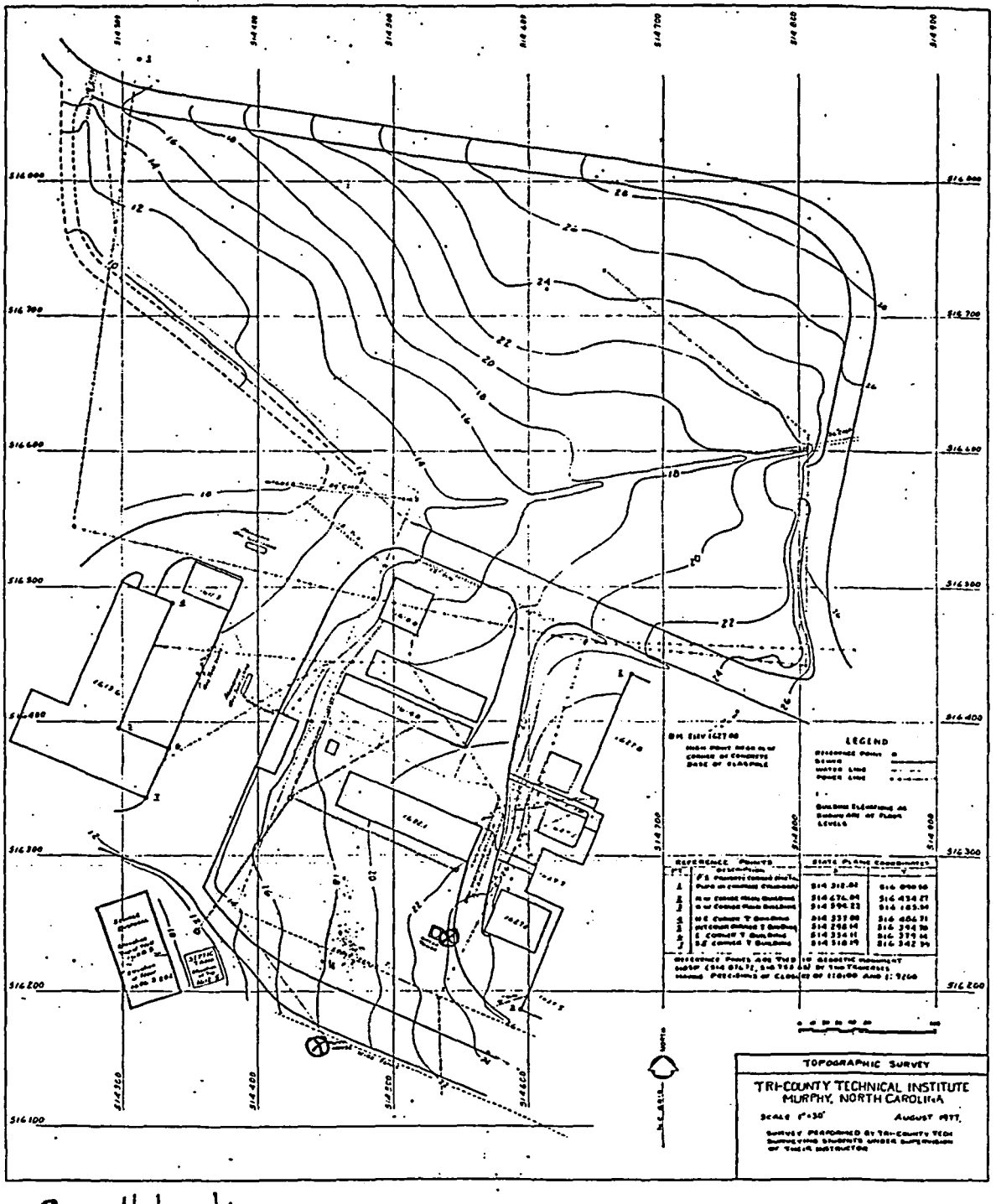
### Permit and Regulatory History

Tri-County Community College maintains an NPDES permit # NC 0035394 to discharge domestic waste water into McComb Branch. This permit is presently up for renewal and will be reissued on 1 April 1987 (4).

### Remedial Actions to Date

After finding well contamination at the site in January 1987, bottled water was supplied for drinking purposes.

Figure 1. Tri-County Community College site layout.




⊗-well location

Summary Trip Report

Joint site investigations were conducted at Tri-County Community College and Emerson Electric Company on 10-11 February 1987 by Jack Butler and Stan Atwood, NC DHR/DHS CERCLA Unit. Bob Wood, Cherokee County Health Director; Layton Schuh, Emerson Electric Co.; and Don Link and Roy Davis, NC NRCD/DEM, were notified prior to the investigation.

We stopped in Asheville on the way up and talked with Don Link and Ted Minnick (DEM). Mr. Link gave us a summary sheet of 66 wells that have been sampled to date in the Peachtree Community. He was also preparing a map of the sampling locations which we picked up on the return trip. Mr. Link also explained that they were working with Emerson Electric under the state ground-water regulations to effect a clean-up.

We arrived in Murphy at 2:30 p.m. and met Bob Wood at his office. We briefly discussed our plans and arranged to meet with him the next morning at 8:00 a.m. Mr. Wood gave us a copy of a general services map of the Peachtree Community, which locates all buildings and houses, to assist us with estimating populations within three miles of the site (554 houses counted). We later drove along all the roads not included on the above map and counted 334 additional houses (all but six were on the south side of the Hiwassee River).

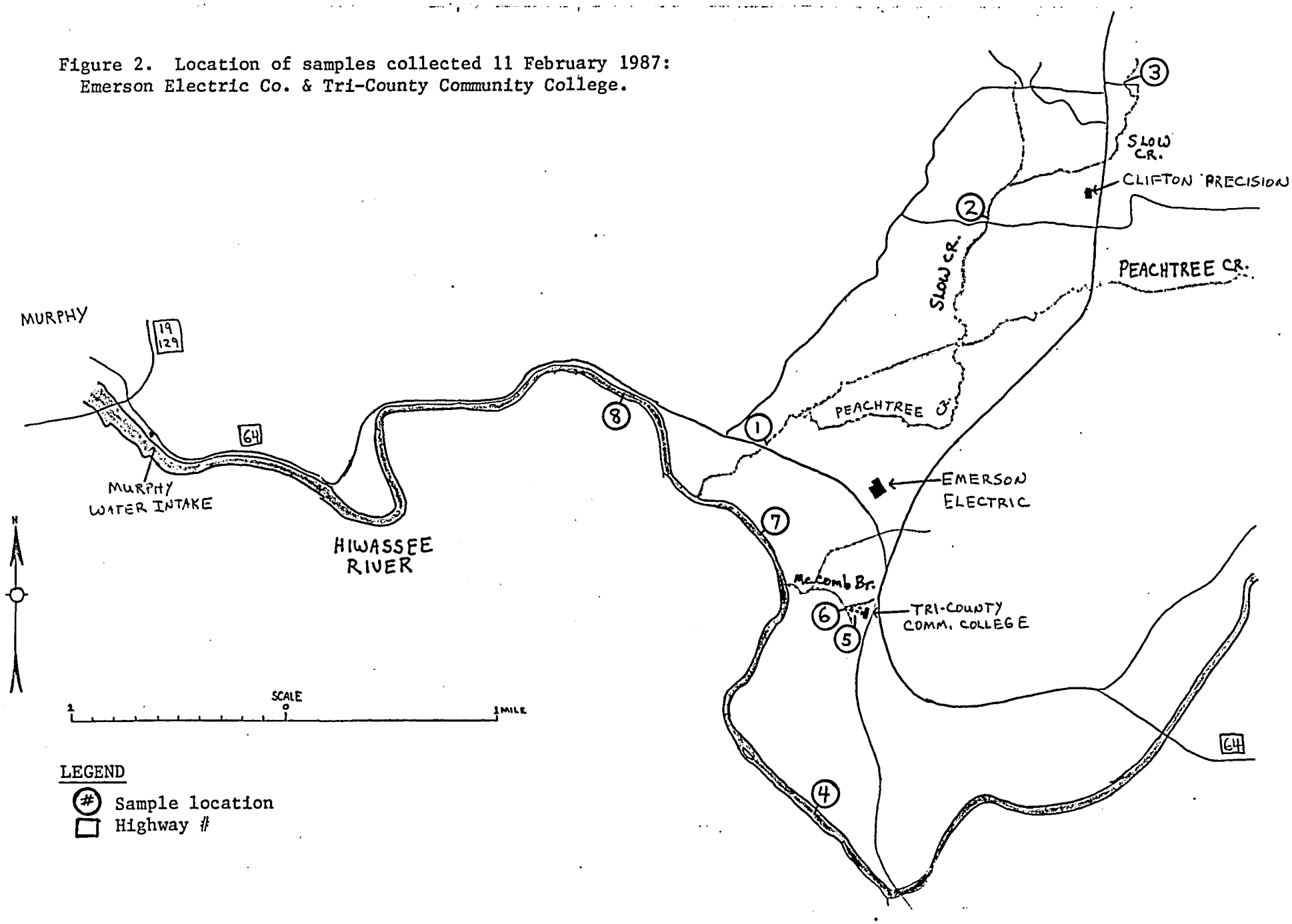
As arranged, we met Mr. Wood at his office at 8:00 a.m. on 11 February 1987. We had selected eight sampling points as follows (Figure 2):

1. Peachtree Creek below Emerson.
2. Slow Creek above Emerson and below Clifton Precision.
3. Slow Creek above Clifton Precision.
4. Hiwassee River above Tri-County Community College.
5. Drinking water well - Tri-County Community College.
6. McComb Branch below Tri-County Community College.
7. Emerson industrial waste discharge.
8. Hiwassee River 3 miles above Murphy intake.

The Hiwassee River ranged in depth between a few feet to less than 10 feet in site vicinity. Mr. Wood also confirmed that the surface waters downstream from the sites were not used for irrigation, but the Hiwassee River is stocked with trout and fished. No alternative water sources (other than bottled water) are presently available to the community.

While at the Tri-County Community College site we met with Mr. Leon Tatham, Dean of Instruction, and Mr. Lyle Carringer, Business Manager. Mr. Tatham provided a map of the campus and told us that a 55-gallon drum of trichloroethene was found in the campus body shop. There were no records indicating that the college had ever purchased the drum. About two pints of trichloroethene were found in the chemistry lab and a small amount is used in the office on packing labels.

Figure 2. Location of samples collected 11 February 1987:
Emerson Electric Co. & Tri-County Community College.



## ENVIRONMENTAL SETTING

### Topography

The site is in the Blue Ridge physiographic province of North Carolina. Elevations near the site range between 1550 ft. along the Hiwassee River to over 2000 ft. The site is located about 1625 ft. on a valley slope about 0.3 miles from the Hiwassee River. The site slopes toward the river at three to five percent, but grades to less than three percent about 1000 ft. from the river (Topo maps - Appendix A).

### Surface Waters

Drainage from the site enters McComb Branch which flows about 0.3 mile to the Hiwassee River. The Hiwassee River flows about 10 miles to Lake Hiwassee. The mean discharge of the river is about 921 $ft^3/s$. the flow is regulated by Chatuge Lake, located 22 miles upstream. Flow is greatest in the winter and lowest in the fall (5). The gradient of the Hiwassee River is about 12 ft. per mile (6). It is a WS III class stream and McComb Branch is a class C stream (7).

### Geology and Soils

The geology in the site vicinity is complex: quartzite, phyllite, schist, gneiss, and marble bedrock occur (Figure 3). Except where changed by local folding, layers of rock in the Murphy area strike northeast and dip steeply southeast (6). The site is located in an area of complex folding (Figure 3).

Fracturing is abundant in rocks in the Murphy area. Jointing and cleavage are the most abundant types of fractures, but minor faulting is common (6). The Mary King Mountain Fault underlies the Peachtree Community (8).

Depth to the bedrock at the site is unknown; however, available data for wells in the area indicate depths to bedrock between 80 and 100 feet (6).

Remnants of old valley bottoms form benches along the sides of valleys, and are commonly veneered by a thin deposit of sand and gravel. Tri-County Community College is situated on such a bench slightly above the Hiwassee River. Available data from drillers' logs indicate a deep sandy clay soil layer (9). Hydraulic conductivities are likely in the $10^{-3}$ to $10^{-5}$ cm/sec range (10).

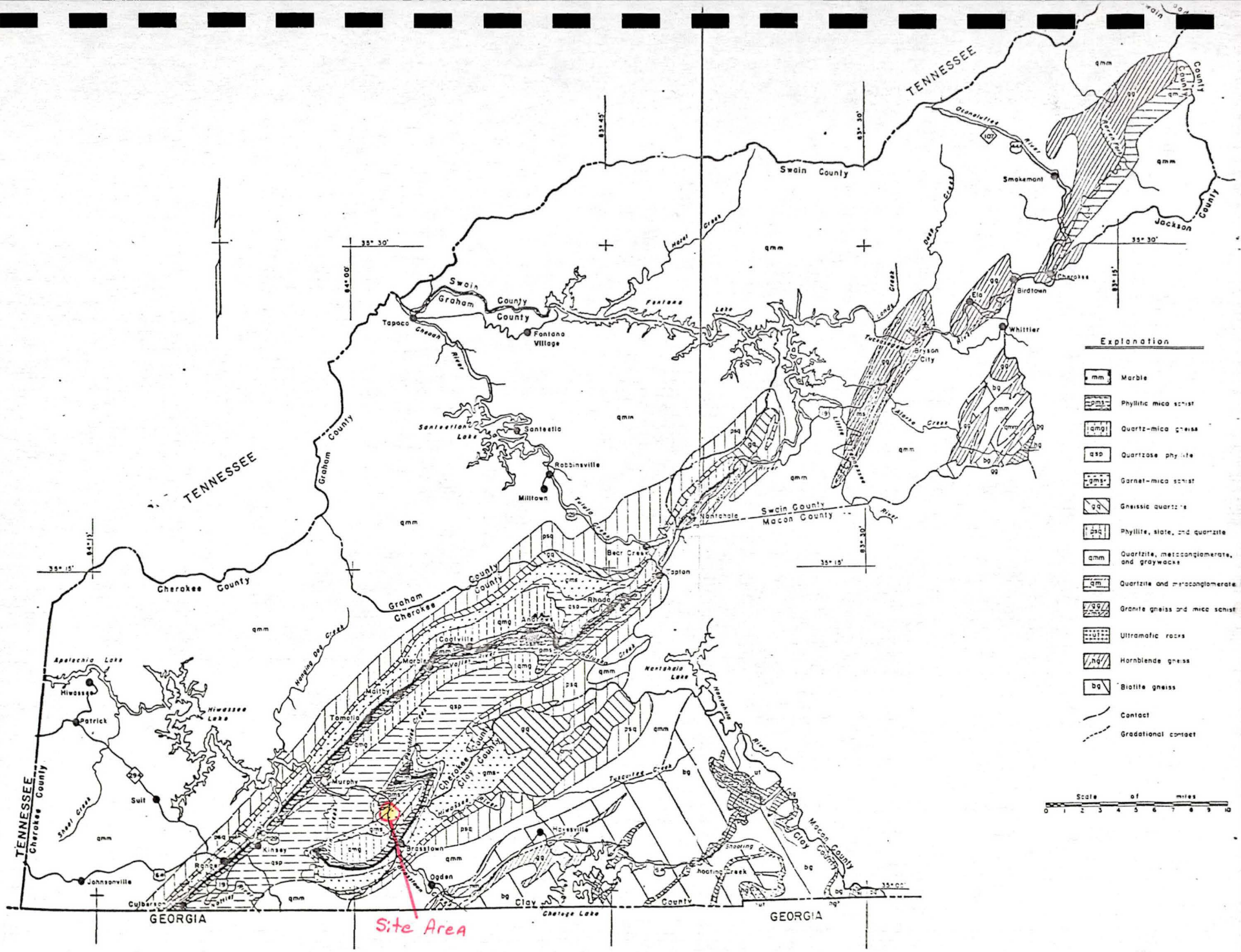



Figure 3.- Geologic map of the Murphy area, North Carolina

## Groundwater

The chief aquifers in Cherokee County are fractured zones in bedrock; although the unconsolidated deposits overlying the bedrock may be aquifers (6). Depth to the water table at the site is less than 20 feet (11). Water levels in the Murphy area are usually highest in March and lowest in November or December. Water levels may fluctuate 10 feet or more in a year (6).

The amount of rainfall primarily controls the quantity of ground water available. About 9 percent of the rainfall becomes ground water in the Murphy area. This is more than 144,000 gallons per acre per year. Reported yields exceed 30 gpm in less than 5 percent of the wells. Most drilled wells are between 100 and 200 feet deep; dug wells may be as much as 90 feet deep, but most are between 25 and 40 feet deep (6). An on-site well was reported to be 270 feet deep. Springs are also very common in the area.

Chemical quality of ground water in the area is good. Chemical analyses of ground water can be subdivided into five basic types based on mineral constituents. Ground water in the site vicinity is usually a calcium, magnesium, sodium bicarbonate type (Type 1) or calcium, sodium, magnesium bicarbonate type (Type 2) (6).

## Climate and Meteorology (12,13)

| | (°F) | January | July |
|---|---|---|---|
| Seasonal Temperatures: | Mean Max. | 50 - 54 | 86 - 88 |
| | Mean Min. | 28 - 32 | 60 - 64 |
| | Mean | 36 - 40 | 72 - 76 |

| | (inches) | |
|---|---|---|
| Precipitation: | Mean annual precipitation: | 56 |
| | Mean annual evaporation: | 35 |
| | Net annual precipitation: | 21 |
| | Mean annual snowfall: | 10 |
| | 1 year 24-hour rainfall: | 3 - 3.5 |
| Storm Events: | Mean days/year with thunderstorms: | 50 - 60 |
| | Prevailing winds and wind speeds: | NW at 8 mph |

Emissions Inventory Summary for Cherokee County (Tons/yr) (14)

| Type | Area Sources | Point Sources |
|---|---|---|
| Particulates | 3,332 | 50 |
| Sulfur Dioxide | 104 | 1 |
| Nitrogen Oxides | 1,050 | 6 |
| Volatile Organics & Hydrocarbons | 1,750 | 1 |
| Carbon Monoxide | 7,010 | 1 |

## Land Use

The Peachtree area is a rural community situated in a mountain valley. The bottomlands are used for cropland and pasture while the mountains remain largely undeveloped woodland.

## Population Distribution

A population estimate within a three mile radius of the site was derived from house counts taken from a Peachtree Community General Services Map and a "windshield" survey. A total of 554 houses were counted from the map north of the Hiwassee River and 334 houses were counted from the windshield survey south of the Hiwassee River (3). Using a factor of 3.8 people per house, the following estimates are made: North of the river, 2105; south of the river, 1269; total, 3374. In addition, the following facilities and institutions add an additional 2450 people (15,16):

| | | |
|---|---|---|
| 1. | Tri-County Community College | 1316 |
| 2. | Emerson Electric Company | 300 + |
| 3. | Clifton Precision | 476 |
| 4. | Murphy Medical Center and Nursing Home | 110 + |
| 5. | Peachtree Elementary School | 250 |
| | Total | 2452 + |

## Water Supply

The Peachtree Community is presently dependent on ground water resources for its water supply. Both springs and wells are used by residents in the area. The nearest community water system is for the town of Murphy with an intake in the Hiwassee River about four miles downstream. Surface waters downstream from the site are not used for irrigation (3).

## Critical Environments

There are no known critical environments in the site vicinity.

## WASTE TYPES AND QUANTITIES

There have been no reported spills or disposals of hazardous wastes at the site. Trichloroethene has been detected in the ground water and has been used in small quantities in the chemistry lab and machine shop. A 55-gallon drums marked "trichloroethylene" was found in the machine shop but contained used motor oil. The origin of this drum is unknown but it is believed to have been there for 10 to 15 years (3,11).

A septic system with a sand filter bed drainage system (originally installed by the Department of Corrections) has been used for more than 40 years (1).

## LABORATORY DATA

Summary (Appendix B)

| Sample | Date | Results (ppb) |
|---|---|---|
| TCCC Well | 1/19/87 | Trichloroethene (300)<br>Tetrachloroethene (0.06) |
| TCCC Well | 2/11/87 | Trichloroethene (542) |
| McComb Branch | 2/11/87 | Trichloroethene (68)<br>1,2-trans-dichloroethene ( 5)<br>Chloroform ( 5)<br>Phenanthrene ( 330) |
| Zimmerman Well (46) | 2/2/87 | Trichloroethene (0.23) |

Inorganic analyses were requested for the TCCC well on 11 February 1987. The results were negative.

## TOXICOLOGICAL/CHEMICAL CHARACTERISTICS

The acute toxicity of trichloroethene is slight; however, numerous deaths resulting from its use as an anesthetic or from industrial exposures have been recorded. Death results from cardiac arrest of respiratory failure. Trichloroethene can affect the CNS, liver, kidney, GI tract, lung, heart, skin, or bone marrow. The chief symptoms include: fatigue, headache, irritability, gastric disturbances, and intolerance to alcohol (17,18). EPA classifies trichloroethene in Group B2 (sufficient animal evidence of carcinogenicity and inadequate human evidence), and has proposed a maximum contaminant level (MCL) of 0.005 mg/l in drinking water (19).

Volunteers exposed to 200 ppm (1070 $mg/m^3$) for seven hours each day for five days only suffered mild symptoms (fatigue and sleepiness). Two-hour exposures to 1000 ppm resulted in effects on vision and motor skills; however, two-hour exposures at 300 ppm and 100 ppm produced no significant effects. In the later report, it was noted that previous exposure to alcohol augmented the effects of trichloroethene (18).

About 60% of inspired trichloroethene is absorbed by the body (17). It is excreted unchanged in the expired air or metabolized to trichloroacetic acid (TCAA) and trichloroethanol (TCOH), which are excreted in the urine. Both metabolites accumulate in the body and may be used as indicators of total exposures. TCAA concentration in the urine peaks on the third to fifth day after exposure and declines slowly with a half-life of 50-100 hours. TCOH concentration peaks during the first three hours after exposure and then declines with a half-life of 12-26 hours (18). Table 1 summarizes some toxicological/chemical properties of trichloroethene.

Table 1. Toxicological/chemical properties of trichloroethene (17,18,20)

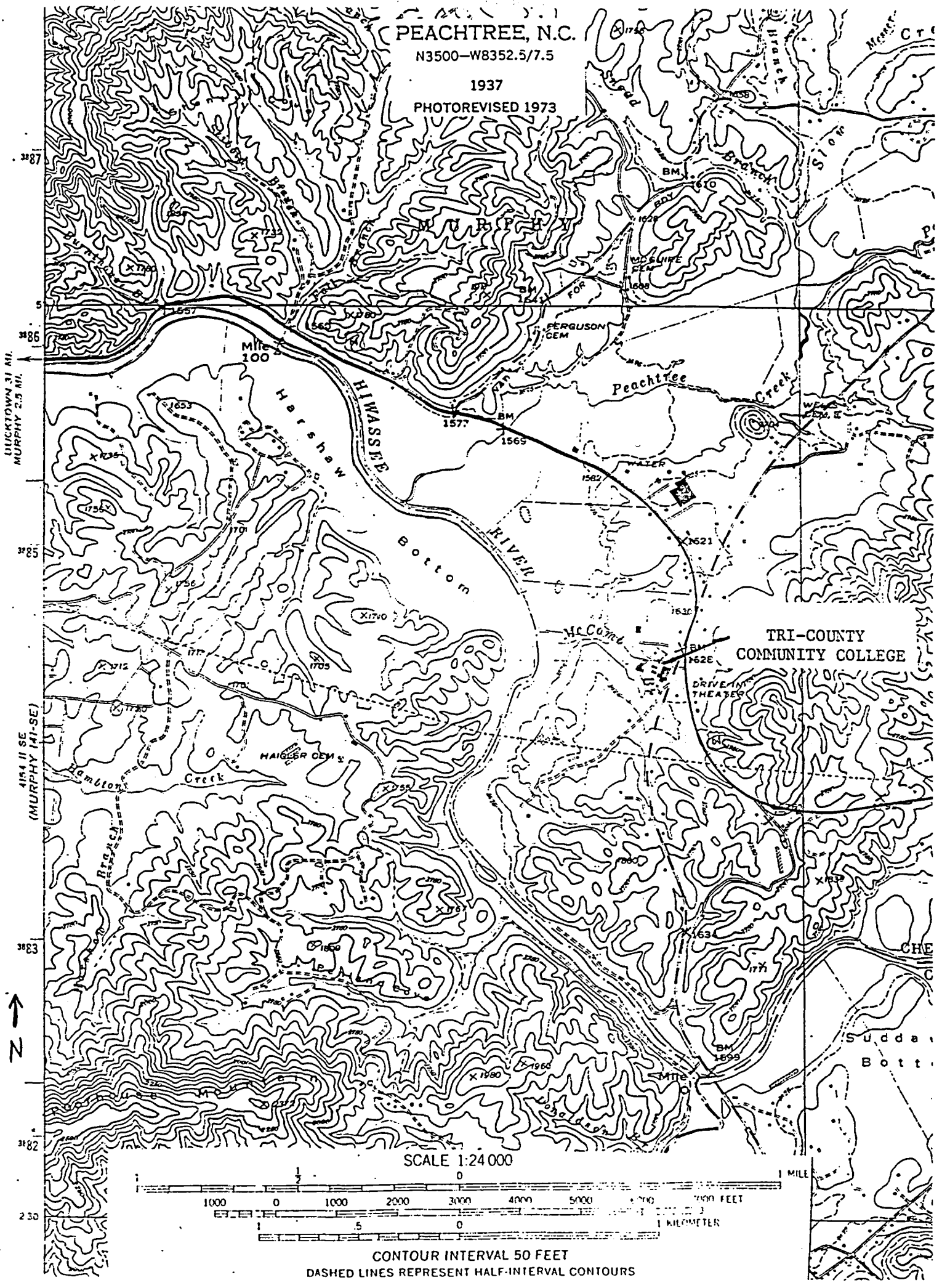
| | |
|---|---|
| Toxicity/Persistence | 12 |
| Density | 1.46 |
| Solubility (20°C) | 0.1% |
| Vapor Pressure (25°C) | 77 mm |
| TLV-TWA ($mg/m^3$) | 270 |
| TLV-STEL ($mg/m^3$) | 805 |
| $LD_{50}$ (rat) | 4.92 g/kg |
| $LD_{LO}$ (man) | 7 g/kg |

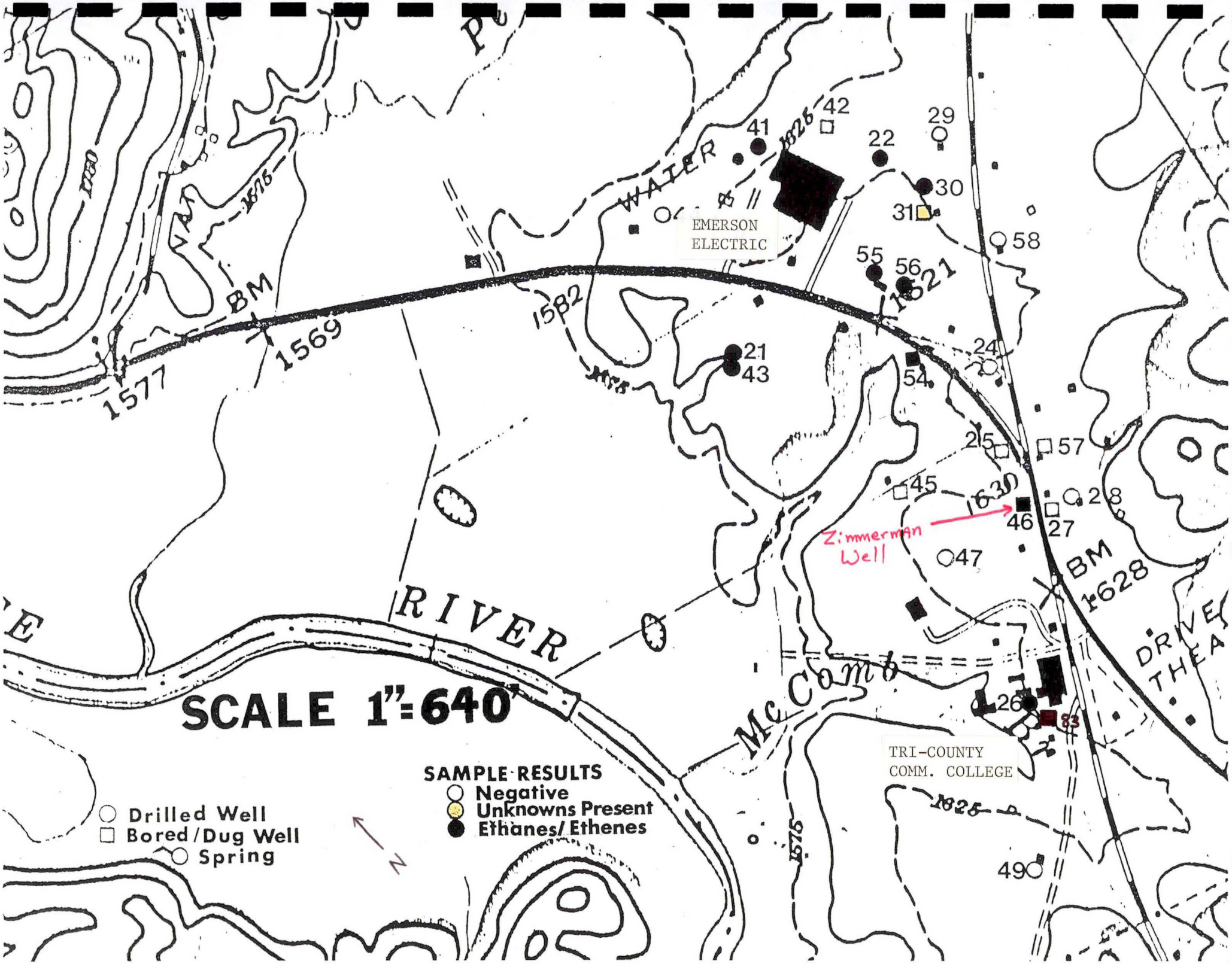
Stability: Non flammable, decomposes with heat, UV-light and alkali.

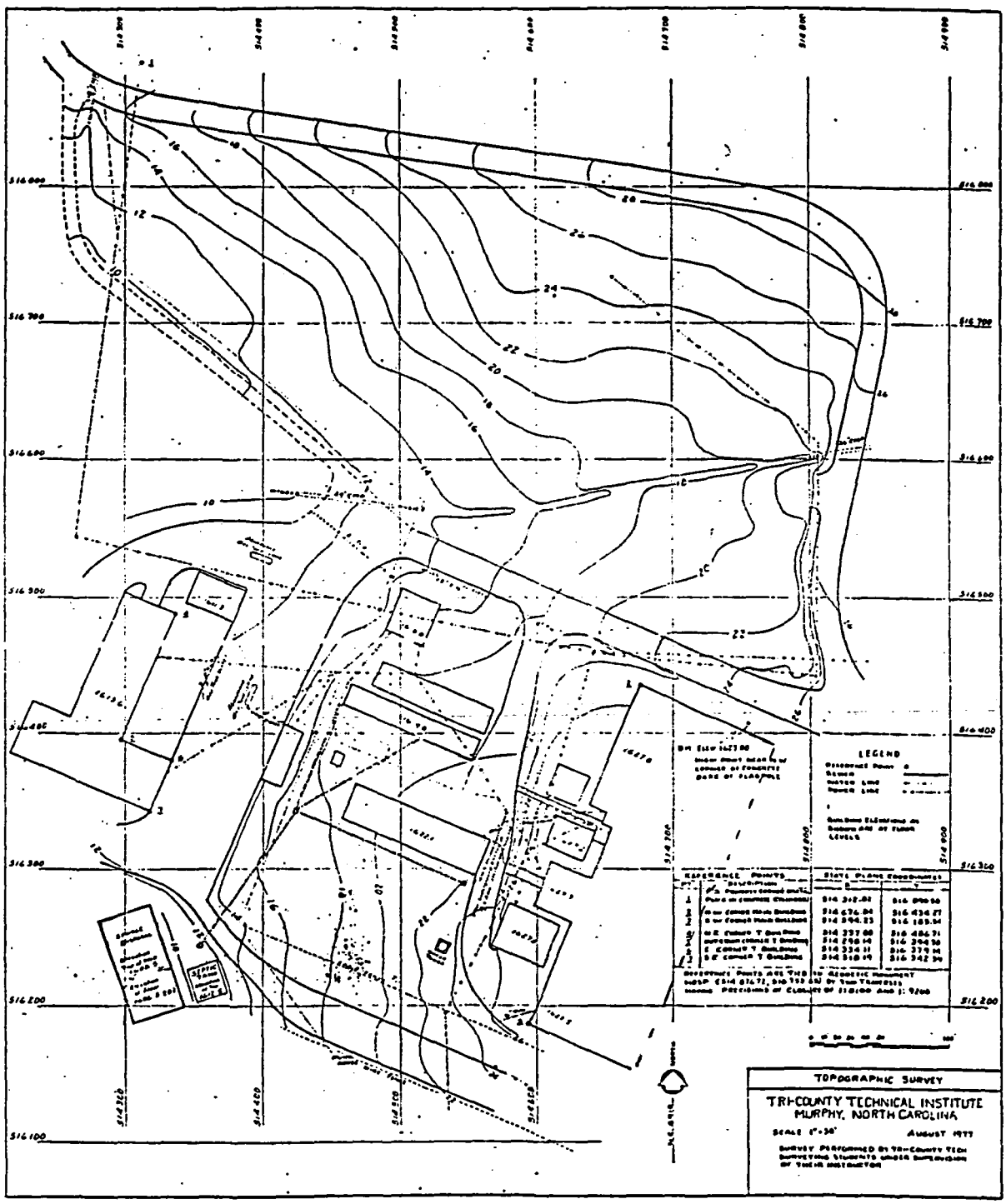
# Appendix A

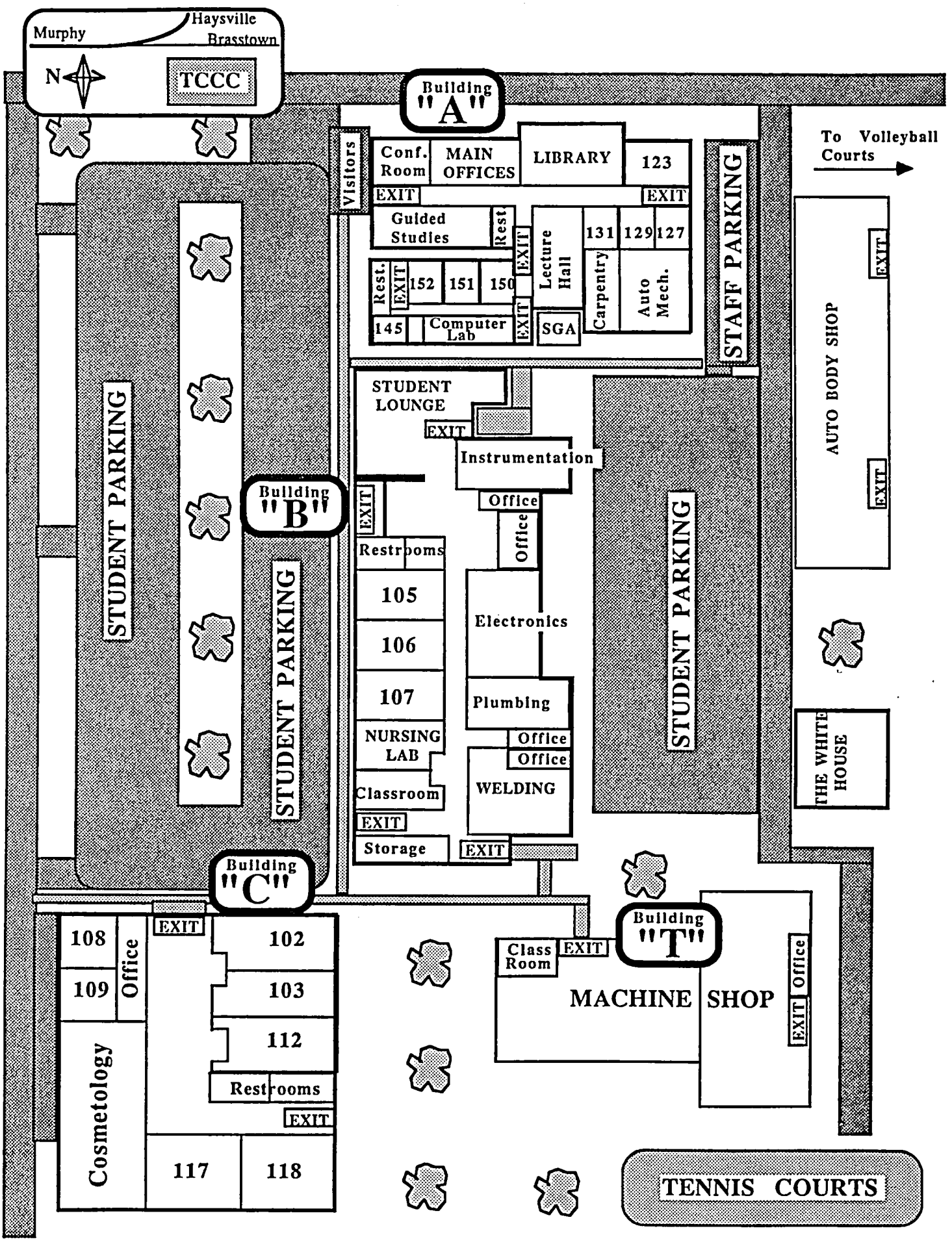
## Maps and Photographs

USGS Topographic Map and
Photographs inside back cover


PEACHTREE, N.C.
N3500—W8352.5/7.5
1937
PHOTOREVISED 1973
MURPHY
HIWASSEE RIVER
Harshaw Bottom
Peachtree Creek
McComb
Hambton Creek
Branch
HAIGLER CEM
FERGUSON CEM
MCGUIRE CEM
WATER
DRIVE-IN THEATER
TRI-COUNTY COMMUNITY COLLEGE
Mile 100
Sudda Bott
DUCKTOWN 31 MI.
MURPHY 2.5 MI.
4154 II SE
(MURPHY 141-SE)
N
SCALE 1:24 000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
CONTOUR INTERVAL 50 FEET
DASHED LINES REPRESENT HALF-INTERVAL CONTOURS


SCALE 1"=640'
SAMPLE RESULTS
Negative
Unknowns Present
Ethanes/ Ethenes
Drilled Well
Bored/Dug Well
Spring
N
EMERSON ELECTRIC
TRI-COUNTY COMM. COLLEGE
Zimmerman Well
WATER
RIVER
McComb
BM 1569
BM 1628
1577
1582
1621
1630
1625
1626
1616
1628
42
41
22
29
30
31
58
55
56
21
43
54
24
25
57
45
28
46
27
47
26
83
49


LEGEND
TOPOGRAPHIC SURVEY
TRI-COUNTY TECHNICAL INSTITUTE
MURPHY, NORTH CAROLINA
SCALE 1"=50'
AUGUST 1977


Murphy
Haysville
Brasstown
N
TCCC
Building "A"
Visitors
Conf. Room
MAIN OFFICES
LIBRARY
123
EXIT
EXIT
Guided Studies
Rest
EXIT
Lecture Hall
131
129
127
Rest.
EXIT
152
151
150
Carpentry
Auto Mech.
145
Computer Lab
EXIT
SGA
STAFF PARKING
To Volleyball Courts
AUTO BODY SHOP
EXIT
EXIT
STUDENT LOUNGE
EXIT
Instrumentation
Office
Office
Building "B"
EXIT
Restrooms
105
106
107
Electronics
Plumbing
NURSING LAB
Office
Office
Classroom
WELDING
EXIT
Storage
EXIT
STUDENT PARKING
STUDENT PARKING
STUDENT PARKING
THE WHITE HOUSE
Building "C"
EXIT
108
Office
109
102
103
112
Cosmetology
Restrooms
EXIT
117
118
Building "T"
Class Room
EXIT
MACHINE SHOP
Office
EXIT
TENNIS COURTS

# Appendix B

## Laboratory Data

[redacted] LAB NUMBER [redacted]

QUAD NO. 7103 SERIAL NO. _____ & COMMUNITY DEVELOPMENT

LAT. 350000 LONG. 835500 DEM

GROUNDWATER FIELD/LAB FORM

(26)

DATE RECEIVED 1-20-87 Time 9:30

Rec'd by: DMT From: Bus Courier, Other _____

Report to: ARO, FRO, MRO, RRO, WaRO, WIRO, WSRO, Kinston FO Other _____

SAMPLE PRIORITY

☐ ROUTINE ☒ EMERGENCY

DATA ENTRY BY: LBM CK: [illegible]

DATE REPORTED: 1-22-87

Shipped by: Bus Courier, Other _____

COLLECTOR(S): MINNICK DATE 1/19/87 TIME _____ PURPOSE: BASELINE, COMPLAINT, COMPLIANCE, LUST, OTHER _____ (circle one)

## FIELD ANALYSES

pH 400 _____ Spec. Cond. 94 _____ at 25°C

Temp. 10 _____ °C Odor _____

Appearance _____ Taste _____

Field Analysis By: _____

Owner TRI-CO COMM. COLLEGE

Location or site PEACHTREE

Description of sampling point INSIDE TAP

Sampling Method PUMP (pump, bailer, etc.) Sample Interval _____

Remarks _____ (pumping time, air temp, etc.)

## LABORATORY ANALYSES

| | | |
|---|---|---|
| | $BOD_5$ 310 | mg/l |
| | COD High 340 | mg/l |
| | COD Low 335 | mg/l |
| | Coliform:MF Fecal 31616 | /100ml |
| | Coliform:MF Total 31504 | /100ml |
| | TOC 680 | mg/l |
| | Turbidity 76 | NTU |
| | | |
| | | |
| | pH 403 | units |
| | Alkalinity to pH 4.5 410 | mg/l |
| | Alkalinity to pH 8.3 415 | mg/l |
| | Carbonate 445 | mg/l |
| | Bicarbonate 440 | mg/l |
| | Arsenic:Total 1002 | ug/l |
| | Carbon dioxide 405 | mg/l |
| | Chloride 940 | mg/l |
| | Chromium:Hex 1032 | ug/l |
| | Color:True 80 | Pt-Co |
| | Cyanide 720 | mg/l |

| | | |
|---|---|---|
| | Diss. Solids 70300 | mg/l |
| | Fluoride 951 | mg/l |
| | Hardness:Total 900 | mg/l |
| | Hardness (non-carb) 902 | mg/l |
| | Phenols 32730 | ug/l |
| | Specific Cond. 95 | uMhos/cm |
| | Sulfate 945 | mg/l |
| | Sulfide 745 | mg/l |
| | | |
| | | |
| | | |
| | | |
| | | |
| | $NH_3$ as N 610 | mg/l |
| | TKN as N 625 | mg/l |
| | $NO_2 + NO_3$ as N 630 | mg/l |
| | P:Total as P 665 | mg/l |
| | | |
| | | |
| | | |

| | | |
|---|---|---|
| | Ag - Silver 1077 | ug/l |
| | Al - Aluminum 1105 | ug/l |
| | Ba - Barium 1007 | ug/l |
| | Ca - Calcium 916 | mg/l |
| | Cd - Cadmium 1027 | ug/l |
| | Chromium:Total 1034 | ug/l |
| | Cu - Copper 1042 | ug/l |
| | Fe - Iron 1045 | ug/l |
| | Hg - Mercury 71900 | ug/l |
| | K - Potassium 937 | mg/l |
| | Mg - Magnesium 927 | mg/l |
| | Mn - Manganese 1055 | ug/l |
| | Na - Sodium 929 | mg/l |
| | Ni - Nickel 1067 | ug/l |
| | Pb - Lead 1051 | ug/l |
| | Se - Selenium 1147 | ug/l |
| | Zn - Zinc 1092 | ug/l |
| | | |
| | | |
| | | |

| | |
|---|---|
| | Organochlorine Pesticides |
| | Organophosphorus Pesticides |
| | |
| | Acid Herbicides |
| | |
| | Base / Neutral Extractable Organics |
| | Acid Extractable Organics |
| | |
| X | Purgeable Organics (VOA bottle) |
| | |
| | 1,2 - Dibromoethane (EDB) |
| | |
| | |
| | SEE ATTACHED ORGANICS ANALYSIS REPORT |
| | |
| | |
| | |
| | |

RECEIVED JAN 23 1987 Groundwater Section Asheville Regional Office

Lab Comments: _____

GW-54 Revised 7/85

For Dissolved Analysis - submit filtered sample and write "DIS" in block

White copy - Headquarters Pink copy - Region Yellow copy - Lab

Reported by CA

Checked by ALC

Supervisor RPK

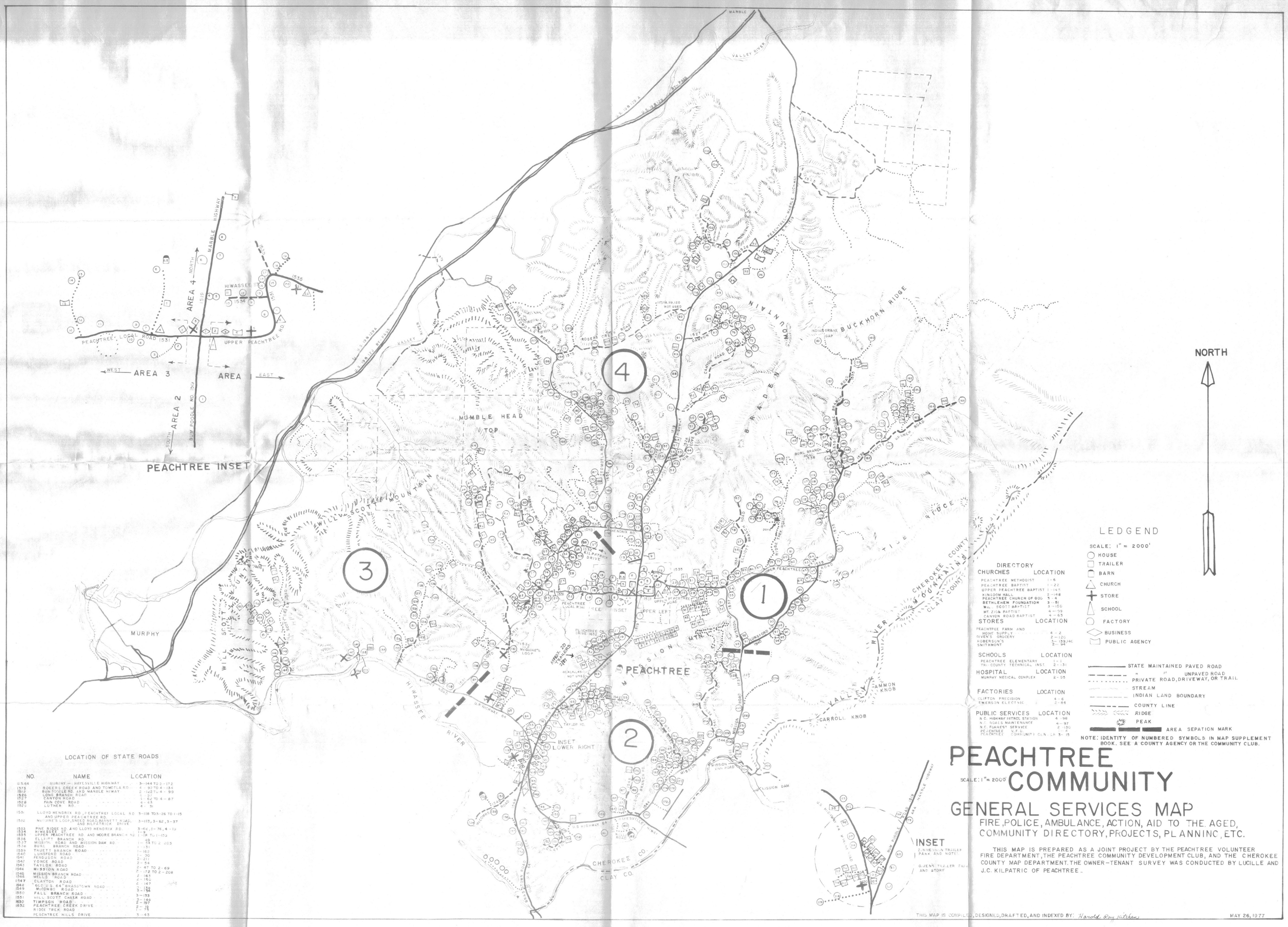
Date 1/21/87

ORGANIC ANALYSIS

Entered by LM

Checked by [illegible]

| Lab No. | (3 waters) Analytical Results |
|---|---|
| 7G73 | No organics volatiles detected by GC/Halide |
| 7G74 | No organics volatiles detected by GC/Halide |
| 7G75 | No organics volatiles detected by GC/PID |
| | Tetrachloroethene 0.06 ug/l } detected |
| | Trichloroethene 300 ug/l } by GC/Halide |
| | 2 unid peaks |


PEACHTREE INSET
AREA 1
AREA 2
AREA 3
AREA 4
NORTH
SOUTH
WEST
EAST
MARBLE HIGHWAY
PEACHTREE LOCAL ROAD 1531
UPPER PEACHTREE RD.
BUM POODLE RD. 1519
HIWASSEE ST.
1516
1534
1535
1536
MARBLE
VALLEY RIVER
MUMBLE HEAD TOP
BRADEN MOUNTAIN
BUCKHORN RIDGE
INDIAN GRAVE GAP
BURL BRANCH ROAD
ROGERS CREEK ROAD
CANYON ROAD
PEACHTREE - MARBLE HIGHWAY
SCOTT MOUNTAIN
WILL SCOTT MOUNTAIN
MURPHY
HIWASSEE RIVER
PEACHTREE
MISSION MTN.
LUNSFORD ROAD
MISSION ROAD
MISSION DAM
VALLEY RIVER
AMMON KNOB
CARROLL KNOB
CHEROKEE COUNTY
CLAY COUNTY
CHEROKEE CO.
CLAY CO.
U.S. HIGHWAY 64
INSET LOWER RIGHT
INSET UPPER LEFT
1
2
3
4
INSET
ZIMMERMAN TRAILER PARK AND HOTEL
GIVENS TRAILER PARK AND STORE
BUM POODLE RD.
MARBLE HIGHWAY
NORTH
LEDGEND
SCALE: 1" = 2000'
HOUSE
TRAILER
BARN
CHURCH
STORE
SCHOOL
FACTORY
BUSINESS
PUBLIC AGENCY
STATE MAINTAINED PAVED ROAD
" " UNPAVED ROAD
PRIVATE ROAD, DRIVEWAY, OR TRAIL
STREAM
INDIAN LAND BOUNDARY
COUNTY LINE
RIDGE
PEAK
AREA SEPATION MARK
NOTE: IDENTITY OF NUMBERED SYMBOLS IN MAP SUPPLEMENT BOOK. SEE A COUNTY AGENCY OR THE COMMUNITY CLUB.
DIRECTORY
CHURCHES LOCATION
PEACHTREE METHODIST 1-6
PEACHTREE BAPTIST 1-22
UPPER PEACHTREE BAPTIST 1-145
KINGDOM HALL 2-148
PEACHTREE CHURCH OF GOD 3-4
BETHLEHEM FOUNDATION 3-51
WM. SCOTT BAPTIST 3-150
MT. ZION BAPTIST 4-59
CANYON ROAD BAPTIST 4-63
STORES LOCATION
PEACHTREE FARM AND HOME SUPPLY 4-2
GIVENS GROCERY 2-120
ROBERSON'S 3-139,140
SMITHMONT 2-94
SCHOOLS LOCATION
PEACHTREE ELEMENTARY 1-1
TRI COUNTY TECHNICAL INST. 2-131
HOSPITAL LOCATION
MURPHY MEDICAL COMPLEX 2-95
FACTORIES LOCATION
CLIFTON PRECISION 4-6
EMERSON ELECTRIC 2-84
PUBLIC SERVICES LOCATION
N.C. HIGHWAY PATROL STATION 4-98
N.C. ROADS MAINTENANCE 4-97
N.C. FORREST SERVICE 2-130
PEACHTREE V.F.D. 4-4
PEACHTREE COMMUNITY CLUB 3-15
LOCATION OF STATE ROADS
NO. NAME LOCATION
U.S.64 MURPHY — HAYESVILLE HIGHWAY 3-144 TO 2-172
1373 ROGERS CREEK ROAD AND TOMOTLA RD. 4-90 TO 4-134
1519 BUM POODLE RD. AND MARBLE HIWAY 2-162 TO 4-99
1526 LONG BRANCH ROAD 1-27
1527 CANYON ROAD 1-62 TO 4-87
1528 PAIN COVE ROAD 4-45
1529 LUTHER RD. 4-31
1531 LLOYD HENDRIX RD., PEACHTREE LOCAL RD AND UPPER PEACHTREE RD. 3-118 TO 3-26 TO 1-15
1532 McGUIRE'S LOOP, SNEED ROAD, BARNETT ROAD, AND KILPATRICK DRIVE 3-113, 3-62, 3-37
1533 PINE RIDGE RD. AND LLOYD HENDRIX RD. 3-66, 3-76, 4-19
1534 HIWASSEE ST. 1-9
1535 UPPER PEACHTREE RD. AND MOORE BRANCH RD. 1-18 TO 1-159
1536 ELLIOTT BRANCH RD. 1-48
1537 MISSION ROAD AND MISSION DAM RD. 1-54 TO 2-203
1538 BURL BRANCH ROAD 1-131
1539 TRUETT BRANCH ROAD 1-162
1540 LUNSFORD ROAD 1-30
1541 FERGUSON ROAD 2-211
1542 YONCE ROAD 2-54
1543 TAYLOR ROAD 2-47 TO 2-69
1544 MISSION ROAD 2-172 TO 2-208
1545 MISSION BRANCH ROAD 2-163
1546 WELLS ROAD 2-160
1547 CLAYTON ROAD 2-147
1548 OLD U.S. 64 "BRASSTOWN ROAD 3-124
1549 McCOMBS ROAD 3-132
1550 FALL BRANCH ROAD 3-133
1551 HILL SCOTT CREEK ROAD 2-144
1630 TIMPSON ROAD 2-197
1632 PEACHTREE CREEK DRIVE 2-18
RIDGE TREK ROAD 1-75
PEACHTREE HILLS DRIVE 3-43
PEACHTREE COMMUNITY
GENERAL SERVICES MAP
FIRE, POLICE, AMBULANCE, ACTION, AID TO THE AGED, COMMUNITY DIRECTORY, PROJECTS, PLANNING, ETC.
THIS MAP IS PREPARED AS A JOINT PROJECT BY THE PEACHTREE VOLUNTEER FIRE DEPARTMENT, THE PEACHTREE COMMUNITY DEVELOPMENT CLUB, AND THE CHEROKEE COUNTY MAP DEPARTMENT. THE OWNER-TENANT SURVEY WAS CONDUCTED BY LUCILLE AND J.C. KILPATRIC OF PEACHTREE.
THIS MAP IS COMPILED, DESIGNED, DRAFTED, AND INDEXED BY: Harold Ray Kitchen
MAY 26, 1977

[redacted]

COUNTY Cherokee

QUAD NO. I103 SERIAL NO. _____

LAT. _____ LONG. _____

N.C. DEPARTMENT OF NATURAL RESOURCES & COMMUNITY DEVELOPMENT

DEM

# CHAIN OF CUSTODY

GROUNDWATER BUDGET FORM

LAB NUMBER 8 76-309

DATE RECEIVED 870305 Time 0845

Rec'd by: HMW From: Bus Courier

Other _____

DATA ENTRY BY: SM CK: LM

DATE REPORTED: 3-6-87

Report to: ARO FRO, MRO, RRO, WaRO, WiRO, WSRO, Kinston FO Other _____

Shipped by: Bus, Courier, Other _____

SAMPLE PRIORITY

☐ ROUTINE ☒ EMERGENCY

COLLECTOR(S): Barber DATE _____ TIME _____ PURPOSE: BASELINE, COMPLAINT, COMPLIANCE, LUST, OTHER _____ (circle one)

## FIELD ANALYSES

pH 400 _____ Spec. Cond. 94 _____ at 25°C

Temp. 10 _____ °C Odor _____

Appearance _____ Taste _____

Field Analysis By: _____

Owner Tri County Community College Well #2

Location or site Hwy 64 Peachtree

Description of sampling point [redacted] Inside spigot in house

Sampling Method _____ (pump, bailer, etc.) Sample Interval _____

Remarks Well #2 (pumping time, air temp, etc.)

## LABORATORY ANALYSES

| | | |
|---|---|---|
| | $BOD_5$ 310 | mg/l |
| | COD High 340 | mg/l |
| | COD Low 335 | mg/l |
| | Coliform:MF Fecal 31616 | /100ml |
| | Coliform:MF Total 31504 | /100ml |
| | TOC 680 | mg/l |
| | Turbidity 76 | NTU |
| | | |
| | | |
| | pH 403 | units |
| | Alkalinity to pH 4.5 410 | mg/l |
| | Alkalinity to pH 8.3 415 | mg/l |
| | Carbonate 445 | mg/l |
| | Bicarbonate 440 | mg/l |
| | Arsenic:Total 1002 | ug/l |
| | Carbon dioxide 405 | mg/l |
| | Chloride 940 | mg/l |
| | Chromium:Hex 1032 | ug/l |
| | Color:True 80 | Pt-Co |
| | Cyanide 720 | mg/l |

| | | |
|---|---|---|
| | Diss. Solids 70300 | mg/l |
| | Fluoride 951 | mg/l |
| | Hardness:Total 900 | mg/l |
| | Hardness (non-carb) 902 | mg/l |
| | Phenols 32730 | ug/l |
| | Specific Cond. 95 | uMhos/cm² |
| | Sulfate 945 | mg/l |
| | Sulfide 745 | mg/l |
| | | |
| | | |
| | | |
| | | |
| | | |
| | $NH_3$ as N 610 | mg/l |
| | TKN as N 625 | mg/l |
| | $NO_2 + NO_3$ as N 630 | mg/l |
| | P:Total as P 665 | mg/l |
| | | |
| | | |
| | | |

| | | |
|---|---|---|
| | Ag - Silver 1077 | ug/l |
| | Al - Aluminum 1105 | ug/l |
| | Ba - Barium 1007 | ug/l |
| | Ca - Calcium 916 | mg/l |
| | Cd - Cadmium 1027 | ug/l |
| | Chromium:Total 1034 | ug/l |
| | Cu - Copper 1042 | ug/l |
| | Fe - Iron 1045 | ug/l |
| | Hg - Mercury 71900 | ug/l |
| | K - Potassium 937 | mg/l |
| | Mg - Magnesium 927 | mg/l |
| | Mn - Manganese 1055 | ug/l |
| | Na - Sodium 929 | mg/l |
| | Ni - Nickel 1067 | ug/l |
| | Pb - Lead 1051 | ug/l |
| | Se - Selenium 1147 | ug/l |
| | Zn - Zinc 1092 | ug/l |
| | | |
| | | |
| | | |

| | |
|---|---|
| | Organochlorine Pesticides |
| | Organophosphorus Pesticides |
| | |
| | Acid Herdicides |
| | |
| | Base / Neutral Extractable Organics |
| | Acid Extractable Organics |
| | |
| X | Purgeable Organics (VOA bottle) |
| | |
| | 1,2 - Dibromoethane (EDB) |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

SEE ATTACHED ORGANICS ANALYSIS REPORT

MAR 9 1987

GROUND WATER SECTION

RALEIGH, N. C.

Lab Comments: _____

GW-54 Revised 7/85

For Dissolved Analysis - submit filtered sample and write "DIS" in block

White copy - Headquarters Pink copy - Region Yellow copy - Lab

Reported by WM

Checked by ALC

Supervisor REK

Date 5/6/81

ORGANIC ANALYSIS

Entered by BM

Checked by LM

| Lab No. | Sample Type : Water Analytical Results | Concentration |
|---|---|---|
| | | |
| 7G309 | no organic volatiles detected by GC/PID | |
| | | |
| | 1 unidentified peak | |
| | Tetrachloroethene | 0.09 µg/l |
| | Trichloroethene | 14 µg/l |
| | detected by GC/Hall | |

_____ GC/MS/DS used

N. C. DEPARTMENT OF HUMAN RESOURCES
DIVISION OF HEALTH SERVICES
SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH

## Chain of Custody Record

Hazardous Waste Materials

Location of Sampling: ___ Generator ___ Transporter ___ Treatment Facility
___ Storage Facility ___ Disposal Facility ___ Landfill
✓ Other: CERCLA

Company's Name Tri County Comm. Coll. Telephone (704) 837-7486

Address U.S. 64 E, Murphy, N.C.

Collector's Name Stanley G. Atwood (signature) Telephone (919) 733-2801

Date Sampled Feb. 11, 1987 Time Sampled A.M.

Type of Process Generating Waste College

Field Information

Field Sample No. 3851

Chain of Possession:

| | signature | title | inclusive dates |
|---|---|---|---|
| 1. | Jack Butler | Env. Eng. | Feb. 11 & 12, 1987 |
| 2. | Paul J. Childers | Chemist | 2/12/87 |
| 3. | | | |

Results reported

signature ___ title ___ date ___

Instructions: Complete all applicable information including signatures, and submit with analysis request forms.

URCE

DIVISION OF HEALTH SERVICES
SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH

## Receipt for Samples

The samples described below were collected in connection with the administration, enforcement, and documentation of the:

( ) North Carolina Hazardous Waste Management Rules, 10 NCAC 10F

( ) North Carolina Solid Waste Management Rules, 10 NCAC 10G

( ) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

( ) Toxic Substances Control Act (TSCA). 15 U.S.C. §2601, et seq., specifically Section 11 of TSCA, 15 U.S.C. § 2610.

Inspector's Name _____ Inspector's Address _____

Name of Firm _____ Firm Address _____

Firm Owner, Operator, or Agent _____ Title _____

| SAMPLE NUMBER | COLLECTED | | SAMPLE TYPE | | | DUPLICATE SAMPLES | | | SAMPLE LOCATION | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DATE | TIME | WATER | SOIL | OTHER | OFFERED | ACCEPTED | REJECTED | ON-SITE | OFF-SITE |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

Receipt for the sample(s) described above is hereby acknowledged:

Signature of Inspector _____

Title _____

Receipt/rejection of duplicate or split samples is hereby acknowledged:

Signature of Firm Owner, Operator, or Agent _____

Title _____

COMMENTS _____

Department of Human Resources
Division of Health Services

# SAMPLE ANALYSES REQUEST

Received 3-30-87

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

CERCLA

Number 20D (TBA) Field Sample Number 3851

Site Tri-County Community College Site Location Murphy, N.C.

Collected By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 1000

Type of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ✓ Groundwater (1) | ___ Solid (5) | #6 TCCC Well |
| ___ Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ___ Other (4) | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | ✓ Arsenic | <0.01 | ✓ Silver | <0.05 |
| Barium | | ✓ Barium | <0.1 | Sulfates | |
| Cadmium | | ✓ Cadmium | <0.005 | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | ✓ Chromium | <0.01 | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | ✓ Lead | <0.03 | | |
| | | Manganese | | | |
| | | ✓ Mercury | <0.0002 | | |
| | | Nitrate | | | |
| | | ✓ Selenium | <0.005 | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| P&T:GC/MS | | EDB | | Methoxychlor | |
| Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| (MF) Coliform Colonies/100mls |
| (MPN) Coliform Colonies/100mls |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| Gross Alpha | |
| Gross Beta | |

Received ___ Date Reported 3/3/87

Extracted ___ Date Analyzed ___

Collected By ___ Lab Number 003108 FEB 1987

Revised 7/85

RESOURCES
DIVISION OF HEALTH SERVICES
SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH

## Chain of Custody Record

### Hazardous Waste Materials

Location of Sampling: ___ Generator ___ Transporter ___ Treatment Facility
___ Storage Facility ___ Disposal Facility ___ Landfill
✓ Other: CERCLA

Company's Name Tri County Comm. Coll. Telephone (704) 837-7486

Address U.S. 64 E, Murphy, N.C.

Collector's Name Stanley G Tilwood Telephone (919) 733-2801
signature

Date Sampled Feb. 11, 1987 Time Sampled A.M.

Type of Process Generating Waste College

Field Information

Field Sample No. 3554 3555 3556 3557 3558 3559 3560
3561

Chain of Possession:

| | signature | title | inclusive dates |
|---|---|---|---|
| 1. | Mark Butler | Env. Eng. | Feb. 11 & 12, 1987 |
| 2. | William DeMent | Analytical Chem. | 2-12-87 |
| 3. | | | |

Results reported

| signature | title | date |
|---|---|---|
| | | |

Instructions: Complete all applicable information including signatures, and submit with analysis request forms.

Department of Human Resources
of Health Services

# SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 200 (TBA) Field Sample Number 3554

Name of Site Tri County Community College Site Location Murphy, N.C.

Collected By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 0930

Type of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ___ Groundwater (1) | ___ Solid (5) | #4 Upstream Hiwasee River |
| X Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ___ Other (4) | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | Arsenic | | Silver | |
| Barium | | Barium | | Sulfates | |
| Cadmium | | Cadmium | | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | Chromium | | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | Lead | | | |
| | | Manganese | | | |
| | | Mercury | | | |
| | | Nitrate | | | |
| | | Selenium | | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| P&T:GC/MS | | EDB | | Methoxychlor | |
| Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| ___ (MF) Coliform Colonies/100mls |
| ___ (MPN) Coliform Colonies/100mls |
| |
| |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| ___ Gross Alpha | |
| ___ Gross Beta | |
| | |
| | |

Date Received ___ Date Reported ___

Date Extracted ___ Date Analyzed ___

Entered By ___ Lab Number 700354

Department of Human Resources
Division of Health Services

# SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 20D (TBA) Field Sample Number 3555

Name of Site Tri-County Community College Site Location Murphy, N.C.

Collected By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 0930

Type of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ___ Groundwater (1) | ___ Solid (5) | #4 Upstream Hiwasee River |
| X Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ___ Other (4) | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | Arsenic | | Silver | |
| Barium | | Barium | | Sulfates | |
| Cadmium | | Cadmium | | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | Chromium | | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | Lead | | | |
| | | Manganese | | | |
| | | Mercury | | | |
| | | Nitrate | | | |
| | | Selenium | | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| P&T:GC/MS | | EDB | | Methoxychlor | |
| Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| (MF) Coliform Colonies/100mls |
| (MPN) Coliform Colonies/100mls |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| Gross Alpha | |
| Gross Beta | |

Date Received ___ Date Reported ___

Date Extracted 2-13-87 AH LO EB Date Analyzed ___

Reported By ___ Lab Number 700355

Department of Human Resources
Division of Health Services

# SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 20D (TBA) Field Sample Number 3556

Name of Site Tri-County Community College Site Location Murphy, N.C.

Collected By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 0930

Type of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ___ Groundwater (1) | ___ Solid (5) | #4 Upstream Hiwassee River |
| ___ Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ___ Other (4) Sed. | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | Arsenic | | Silver | |
| Barium | | Barium | | Sulfates | |
| Cadmium | | Cadmium | | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | Chromium | | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | Lead | | | |
| | | Manganese | | | |
| | | Mercury | | | |
| | | Nitrate | | | |
| | | Selenium | | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| P&T:GC/MS | | EDB | | Methoxychlor | |
| Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| (MF) Coliform Colonies/100mls |
| (MPN) Coliform Colonies/100mls |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| Gross Alpha | |
| Gross Beta | |

Date Received ___ Date Reported ___

Date Extracted ___ Date Analyzed ___

Reported By ___ Lab Number 760356

Department of Human Resources
Division of Health Services

# SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 200 (TBA) Field Sample Number 3557

Name of Site Tri-County Community College Site Location Murphy, N.C.

Collected By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 1030

Type of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ___ Groundwater (1) | ___ Solid (5) | #5 McCamb Creek |
| ✓ Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ___ Other (4) | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | Arsenic | | Silver | |
| Barium | | Barium | | Sulfates | |
| Cadmium | | Cadmium | | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | Chromium | | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | Lead | | | |
| | | Manganese | | | |
| | | Mercury | | | |
| | | Nitrate | | | |
| | | Selenium | | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| ✓ P&T:GC/MS | | EDB | | Methoxychlor | |
| Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| (MF) Coliform Colonies/100mls |
| (MPN) Coliform Colonies/100mls |
| |
| |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| Gross Alpha | |
| Gross Beta | |
| | |
| | |

Date Received ___ Date Reported ___

Date Extracted ___ Date Analyzed ___

Reported By ___ Lab Number 700357

Department of Human Resources
of Health Services

# SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 20D (TBA) Field Sample Number 3558

of Site Tri County Community College Site Location Murphy, N.C.

ed By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 1030

of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ___ Groundwater (1) | ___ Solid (5) | #5 McComb Creek |
| ✓ Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ___ Other (4) | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | Arsenic | | Silver | |
| Barium | | Barium | | Sulfates | |
| Cadmium | | Cadmium | | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | Chromium | | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | Lead | | | |
| | | Manganese | | | |
| | | Mercury | | | |
| | | Nitrate | | | |
| | | Selenium | | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| P&T:GC/MS | | EDB | | Methoxychlor | |
| ✓ Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| (MF) Coliform Colonies/100mls |
| (MPN) Coliform Colonies/100mls |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| Gross Alpha | |
| Gross Beta | |

Received ___ Date Reported ___

Extracted 2-13-87 HA LD FB Date Analyzed ___

ported By ___ Lab Number 700358

Department of Human Resources
Division of Health Services

# SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 20D (TBA) Field Sample Number 3559

Name of Site Tri-County Community College Site Location Murphy, N.C.

Collected By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 1030

Type of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ___ Groundwater (1) | ___ Solid (5) | #5 McComb Creek |
| ___ Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ✓ Other (4) Sed. | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | Arsenic | | Silver | |
| Barium | | Barium | | Sulfates | |
| Cadmium | | Cadmium | | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | Chromium | | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | Lead | | | |
| | | Manganese | | | |
| | | Mercury | | | |
| | | Nitrate | | | |
| | | Selenium | | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| P&T:GC/MS | | EDB | | Methoxychlor | |
| Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| (MF) Coliform Colonies/100mls |
| (MPN) Coliform Colonies/100mls |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| Gross Alpha | |
| Gross Beta | |

Date Received ___ Date Reported ___

Date Extracted ___ Date Analyzed ___

Reported By ___ Lab Number ___ 760359

Department of Human Resources
Division of Health Services

# SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 20D (TBA) Field Sample Number 3560

Name of Site Tri County Community College Site Location Murphy, N.C.

Collected By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 1000

Type of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ✓ Groundwater (1) | ___ Solid (5) | #6 TCCC Well |
| ___ Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ___ Other (4) | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | Arsenic | | Silver | |
| Barium | | Barium | | Sulfates | |
| Cadmium | | Cadmium | | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | Chromium | | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | Lead | | | |
| | | Manganese | | | |
| | | Mercury | | | |
| | | Nitrate | | | |
| | | Selenium | | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| P&T:GC/MS | | EDB | | Methoxychlor | |
| Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| (MF) Coliform Colonies/100mls |
| (MPN) Coliform Colonies/100mls |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| Gross Alpha | |
| Gross Beta | |

Date Received ___ Date Reported ___

Date Extracted ___ Date Analyzed ___

Reported By ___ Lab Number 760360

Department of Human Resources
Division of Health Services

# SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 20D (TBA) Field Sample Number 3561

Name of Site Tri-County Community College Site Location Murphy, N.C.

Collected By Stan Atwood ID# 45 Date Collected Feb. 11, 1987 Time 1000

Type of Sample:

| Environmental | Concentrate | Comments |
|---|---|---|
| ✓ Groundwater (1) | ___ Solid (5) | #6 TCCC Well |
| ___ Surface Water (2) | ___ Liquid (6) | |
| ___ Soil (3) | ___ Sludge (7) | |
| ___ Other (4) | ___ Other (8) | |

## INORGANIC CHEMISTRY

| Extractables | | Total | | | |
|---|---|---|---|---|---|
| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
| Arsenic | | Arsenic | | Silver | |
| Barium | | Barium | | Sulfates | |
| Cadmium | | Cadmium | | Zinc | |
| Chromium | | Chloride | | Ph | |
| Lead | | Chromium | | Conductivity | |
| Mercury | | Copper | | TDS | |
| Selenium | | Fluoride | | TOC | |
| Silver | | Iron | | | |
| | | Lead | | | |
| | | Manganese | | | |
| | | Mercury | | | |
| | | Nitrate | | | |
| | | Selenium | | | |

## ORGANIC CHEMISTRY

| Parameter | Results mg/1 | Parameter | Results mg/1 | Parameter | Results mg/1 |
|---|---|---|---|---|---|
| P&T:GC/MS | | EDB | | Methoxychlor | |
| Acid:B/N Ext. | | PCB's | | Toxaphene | |
| TOX | | Petroleum | | 2,4-D | |
| | | Endrin | | 2,4,5-TP (silvex) | |
| | | Lindane | | | |

## MICROBIOLOGY

| Parameter |
|---|
| (MF) Coliform Colonies/100mls |
| (MPN) Coliform Colonies/100mls |

## RADIOCHEMISTRY

| Parameter | Results PCi/1 |
|---|---|
| Gross Alpha | |
| Gross Beta | |

Date Received ___ Date Reported ___

Date Extracted 2-16-87 Date Analyzed ___

Reported By ___ Lab Number 750361

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES, N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON, ST., RALEIGH, N.C. 27611

ORGANIC CHEMICAL ANALYSIS

| BASE/NEUTRAL AND ACID EXTRACTABLES | LAB NO | 700355 | 700356 | 700358 | 700359 | 700361 | 700363 |
|---|---|---|---|---|---|---|---|
| | FIELD # | 3555 | 3556 | 3558 | 3559 | 3561 | 3563 |
| COMPOUND | TYPE | (2) | (4) | (2) | (4) | (1) | (4) |
| | UNITS | µg/l µg/kg | µg/l µg/kg | µg/l µg/kg | µg/l µg/kg | µg/l µg/kg | µg/l µg/kg |
| N-nitrosodimethylamine | | u | u | u | u | u | u |
| bis(2-chloroethyl)ether | | | | | | | |
| 2-chlorophenol | | | | | | | ↓ |
| phenol | | | | | | | 107 |
| 1,3-dichlorobenzene | | | | | | | u |
| 1,4-dichlorobenzene | | | | | | | |
| 1,2-dichlorobenzene | | | | | | | |
| bis(2-chloroisopropyl)ether | | | | | | | |
| hexachloroethane | | | | | | | |
| N-nitroso-di-n-propylamine | | | | | | | |
| nitrobenzene | | | | | | | ↓ |
| isophorone | | | | | | | 34 |
| 2-nitrophenol | | | | | | | u |
| 2,4-dimethylphenol | | | | | | | |
| bis(2-chloroethoxy)methane | | | | | | | |
| 2,4-dichlorophenol | See page 2 | | | | | | |
| 1,2,4-trichlorobenzene | | | | | | | |
| naphthalene | | | | | | | |
| hexachlorobutadiene | | | | | | | |
| 4-chloro-m-cresol | | | | | | | |
| hexachlorocyclopentadiene | | | | | | | |
| 2,4,6-trichlorophenol | | | | | | | |
| 2-chloronaphthalene | | | | | | | |
| acenaphthylene | | | | | | | |
| dimethyl phthalate | | | | | | | |
| 2,6-dinitrotoluene | | | | | | | |
| acenaphthene | | | | | | | |
| 2,4-dinitrophenol | | | | | | | |
| 2,4-dinitrotoluene | | | | | | | |
| 4-nitrophenol | | | | | | | |
| fluorene | | | | | | | |
| 4-chlorophenylphenylether | | | | ↓ | | | ↓ |
| diethyl phthalate | | | | 10K | | | 10K |
| 4,6-dinitro-o-cresol | | | | u | | | u |
| diphenylamine | | | | | | | |
| azobenzene | | | | | | | |
| 4-bromophenylphenylether | | | | | | | |
| hexachlorobenzene | | | | | | | |
| pentachlorophenol | | | | | | ↓ | ↓ |
| phenanthrene | | | | | 330K | | 10. |
| anthracene | | | | | u | | u |
| dibutyl phthalate | B | | | | u | | u |
| fluoranthene | | ↓ | ↓ | ↓ | u | ↓ | u |

B - Found in Blank
J - Estimated value.
K - Actual value is known to be less than value given.
L - Actual value is known to be greater than value given.
U - Material was analyzed for but not detected. The number is the Minimum Detection Limit.
NA - Not analyzed.
1/ - Tentative identification.
2/ - On NRDC List of Priority Pollutants.

N.C. Division of Health Services

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES, N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON, ST., RALEIGH, N.C. 27611

ORGANIC CHEMICAL ANALYSIS

| BASE/NEUTRAL AND ACID EXTRACTABLES COMPOUND | LAB NO | 700355 | 700356 | 700358 | 700359 | 700361 | 700363 |
|---|---|---|---|---|---|---|---|
| | FIELD # | 3555 | 3556 | 3558 | 3559 | 3561 | 3563 |
| | TYPE | (2) | (4) | (2) | (4) | (1) | (4) |
| | UNITS | µg/l µg/kg | µg/l µg/kg | µg/l µg/kg | µg/l µg/kg | µg/l µg/kg | µg/l µg/kg |
| pyrene | | 4 | 4 | 4 | 4 | 4 | 4 |
| benzidine | | | | | | | |
| butyl benzyl phthalate | | | | | | | |
| benz(a)anthracene | | | | | | | |
| chrysene | | | | | | | |
| 3,3-dichlorobenzidine | | | | | | | |
| bis(2-ethylhexyl)phthalate | B | | | | | | |
| di-n-octyl phthalate | | | | | | | |
| benzo(b)fluoranthene | | | | | | | |
| benzo(k)fluoranthene | | | | | | | |
| benzo(a)pyrene | | | | | | | |
| indeno(1,2,3-cd)pyrene | | | | | | | |
| dibenzo(a,h)anthracene | | | | | | | |
| benzo(g,h,i)perylene | | | | | | | |
| | | | | | | | |
| aniline | | 4 | 4 | 4 | 4 | 4 | 4 |
| benzoic acid | | | | | | | |
| benzyl alcohol | | | | | | | |
| 4-chloroaniline | | | | | | | |
| dibenzofuran | | | | | | | |
| 2-methylnaphthalene | | | | | | | |
| 2-methylphenol | | | | | | | |
| 4-methylphenol | | | | | | | |
| 2-nitroaniline | | | | | | | |
| 3-nitroaniline | | | | | | | |
| 4-nitroaniline | | | | | | | |
| 2,4,5-trichlorophenol | | | | | | | |
| | | | | | | | |
| Hydrocarbons | +/- | - | - | - | - | - | + |

MDL for Base Neu (2)

B - Found in Blank
J - Estimated value.
K - Actual value is known to be less than value given.
L - Actual value is known to be greater than value given.
U - Material was analyzed for but not detected. The number is the Minimum Detection Limit.
NA - Not analyzed.
1/ - Tentative identification.
2/ - On NRDC List of Priority Pollutants.

N.C. Division of Health Services

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES, N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON, ST., RALEIGH, N.C. 27611

ORGANIC CHEMICAL ANALYSIS

| PURGEABLE COMPOUNDS | LAB NO | 700354 | 700356 | 700357 | 700359 | 700360 | 700362 |
|---|---|---|---|---|---|---|---|
| | FIELD # | 3554 | 3556 | 3557 | 3559 | 3560 | 3562 |
| COMPOUND | TYPE | (2) | (4) | (2) | (4) | (1) | (8) |
| | UNITS | (µg/l) µg/kg | µg/l (µg/kg) | (µg/l) µg/kg | µg/l (µg/kg) | (µg/l) µg/kg | (µg/l) µg/kg |
| chloromethane | 10 | u | u | u | u | u | u |
| bromomethane | 10 | | | | | | |
| dichlorodifluoromethane | 20 | | | | | | |
| vinyl chloride | 10 | | | | | | |
| chloroethane | 10 | | | | | | ↓ |
| methylene chloride | 5 | | | | | | 8J |
| trichlorofluoromethane | 20 | | | | | | u |
| ethene, 1,1-dichloro | 5 | | | | | | |
| ethane, 1,1-dichloro- | | | | ↓ | | | |
| 1,2-trans-dichloroethene | | | | 5K II | | | |
| chloroform | | | | 5K II | | | |
| ethane, 1,2-dichloro- | | | | | | | |
| ethane, 1,1,1-trichloro- | | | | | | | |
| carbontetrachloride | | | | | | | |
| bromodichloromethane | | | | | | | |
| propane, 1,2-dichloro- | | | | | | | |
| 1,3-trans-dichloropropene | | | | ↓ | | ↓ | |
| trichloroethylene | | | | 68 | | 542 | |
| chlorodibromomethane | | | | u | | u | |
| benzene | | | | | | | |
| ethane, 1,1,2-trichloro- | | | | | | | |
| 1,3-cis-dichloropropene | ↓ | | | | | | |
| 2-chloroethyl vinyl ether | 10 | | | | | | |
| bromoform | 5 | | | | | | |
| ethane, 1,1,2,2-tetrachloro- | | | | | | | |
| ethene, tetrachloro- | | | | | | | |
| toluene | | | | | | | |
| chlorobenzene | | | | | | | |
| ethylbenzene | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| | | | | | | | |
| acetone | +/- | u | u | u | u | u | ⊕ |
| 2-butanone | 10 | | | | | | 80 ✓ |
| carbondisulfide | 5 | | | | | | u |
| 2-hexanone | 10 | | | | | | |
| 4-methyl-2-pentanone | 10 | | | | | | |
| styrene | 5 | | | | | | |
| vinyl acetate | 10 | | | | | | |
| o-xylene | 5 | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 1,1,2-trichloro-1,2,2-trifluoro-ethane | +/- | ⊖ | ⊖ | ⊕ | ⊖ | ⊖ | ⊖ |
| | | | | | | | |
| | | | | | | | |
| | MDL | | | | | | |
| | µg/l (water) | | | | | | |

J - Estimated value.
K - Actual value is known to be less than value given.
L - Actual value is known to be greater than value given.
U - Material was analyzed for but not detected. The number is the Minimum Detection Limit. = MDL
NA - Not analyzed.
1/ - Tentative identification.
2/ - On NRDC List of Priority Pollutants.

#700362 → 1-butanol and 1-hexan[illegible] present in high concentr[illegible]

N.C. Division of Health Services
DHS 3068-0 (4/86 Laborator[illegible]

Draft -

# VOLATILE ORGANIC ANALYSES IN PEACHTREE AREA-CHEROKEE COUNTY

| Sample Number | Quadrangle Number | Owner | Source | Results | Date |
|---|---|---|---|---|---|
| 1 | S103v4 | Jimmy Morrow | Drilled Well | Negative | 1/12/87 |
| 2 | S103v5 | Peachtree Supply | Drilled Well | Negative | 1/12/87 |
| 3 | S103w7 | Herman Robinson | Drilled Well | Negative | 1/12/87 |
| 4 | S103w8 | Herman Robinson | Bored Well/36' | Negative | 1/12/87 |
| 5 | S103w9 | Marvin Stiles | Bored Well/30' | Negative | 1/12/87 |
| 6 | S103w10 | Sams | Dug Well | Negative | 1/12/87 |
| 7 | S103v6 | Kermit Stiles | Bored Well/58' | Negative | 1/12/87 |
| 8 | S103w11 | John Worley | Drilled Well/200' | Negative | 1/12/87 |
| 9 | S103v7 | Kenny Green | Bored Well/35'-40' | Negative | 1/12/87 |
| 10 | S103v8 | Kenny Green | Bored Well/30'-35' | 1,1-Dichloroethane 2.3 ug/l | 1/12/87 |
| | | | | 1,1,1-Trichloro-ethane 0.99 ug/l | 1/12/87 |
| | | | | Tetrachloroethene 0.85 ug/l | 1/12/87 |
| | | | | Chloroform 13 ug/l | 1/12/87 |
| | | | | Trichloroethene 11 ug/l | 1/12/87 |
| | | | | 2 unidentified compounds | 1/12/87 |
| 11 | S103v9 | Randy Gaddis | Same as well No. 10 | Trichloroethene 1.49 ug/l | 1/12/87 |
| | | | | Tetrachloroethene .072 ug/l | 1/12/87 |

| | | | | | |
|---|---|---|---|---|---|
| 22 | T103c7 | Emerson Electric (Well No. 2) | Drilled Well/532' | 1,1-Dichloroethane 64 ug/l | 1/12/87 |
| | | | | 1,1,1-Trichloro-ethane 290 ug/l | 1/12/87 |
| | | | | 1,2-Dichloroethane 0.39 ug/l | 1/12/87 |
| | | | | Trichloroethene 0.51 ug/l | 1/12/87 |
| | | | | 7 unidentified compounds | 1/12/87 |
| 23 | T10464 | Murphy Water Treatment Plant | Murphy Raw Water (Not shown on map) | Chloroform 29 ug/l | 1/12/87 |
| | | | | Chlorodibromo-methane 0.27 ug/l | 1/12/87 |
| | | | | 4 unidentified compounds | 1/12/87 |
| 24 | T103c8 | Tommy Conley | Drilled Well/100+' | Negative | 1/19/87 |
| 25 | T103c9 | "Big D" Conven-ience Store | | Negative | 1/19/87 |
| 26 | T103h2 | Tri-County Community College | Drilled Well/400+' | Trichloroethene 300 ug/l | 1/19/87 |
| | | | | Tetrachloroethene 0.06 ug/l | 1/19/87 |
| | | | | 2 unidentified compounds | 1/19/87 |
| 27 | T103c10 | Bob Byers Amoco | Bored Well/30' | Negative | 1/19/87 |
| 28 | T103c11 | Joe Ferguson | Drilled Well/150' | Negative | 1/19/87 |
| 29 | T103c12 | Lucy McKeon | Drilled Well/100' | Negative | 1/19/87 |

| | | | | | |
|---|---|---|---|---|---|
| 41 | T103c23 | Emerson Electric | Drilled Well/550' | 1,1-Dichloroethane 1.2 ug/l | 1/19/87 |
| | | (Well No. 3) | | 1,1,1-Trichloro-ethane 1.7 ug/l | 1/19/87 |
| 42 | T103c5 | Emerson Electric (Monitor Well) | Monitor Well/40' (Water-table well) | Negative | 1/19/87 |
| 43 | T103d5 | Murphy Medical Center | Drilled Well/450' | 1,1-Dichloroethane 2.7 ug/l | 1/19/87 |
| | | (Well No. 2) | | 1,1,1-Trichloro-ethane 1.9 ug/l | 1/19/87 |
| | | | | Trichloroethene 0.06 ug/l | 1/19/87 |
| 44 | T103d6 | Marcella Smith Mobile Home Park | Drilled Well | Negative | 1/19/87 |
| 45 | T103c15 | Ruth Shields | Bored Well/78' | Negative | 2/2/87 |
| 46 | T103c16 | Willie Zimmerman | Bored Well/22-1/2' | Trichloroethene 0.23 ug/l | 2/2/87 |
| 47 | T103d7 | N.C. Forest Service | Drilled Well/310' | Negative | 2/2/87 |
| 48 | T103g1 | Mike Mauney | Driled Well/125' | Negative | 2/2/87 |
| 49 | T103g2 | Dillard McCombs | Drilled Well/208' | Negative | 2/2/87 |
| 50 | T103g3 | Harry Bishop | Bored Well/70' | Negative | 2/2/87 |
| 51 | T103i5 | Allen Dehart | Drilled Well/300' | Negative | 2/2/87 |
| 52 | T103h3 | Roy Wells | Drilled Well/145' | Negative | 2/2/87 |
| 53 | T103h4 | Gene Clayton | Spring | 1,1,1-Trichloro-ethene .19 ug/l | 2/2/87 |
| | | | | Tetrachloroethene .079 ug/l | 2/2/87 |

# Appendix C

## References

## REFERENCES


1. Bob Wood, Cherokee County Health Department, telephone conversation with Stan Atwood, NC DHR/DHS, 4 February 1987.

2. Patty Little, Cherokee Scout Newspaper, Chemical Leak Contaminates Clifton's Water Supply, 6 January 1987.

3. Stan Atwood, NC DHR/DHS, Summary Trip Report, Emerson Electric Company and Tri-County Community College, 12 February 1987.

4. Sam Bridges, NC NRCD/DEM, telephone conversation with Stan Atwood, NC DHR/DHS, 2 March 1987.

5. Gunter, H.C., C.L. Hill, and T.E. Dillard. Water Resources Data; North Carolina Water Year 1983. U.S. Geological Survey, Water-Data Report NC-83-1.

6. Dodson, C.L. and R.L. Laney. Geology and Ground-Water Resources of the Murphy Area North Carolina. North Carolina Department of Water and Air Resources, Division of Ground Water, Bulletin #13, August 1968.

7. Department of Natural Resources and Community Development, Division of Environmental Management. Classification and Water Quality Standards Assigned to the Waters of the Hiwassee River Basin, 15 NCAC 2B .0302, Raleigh, NC, 1981, amended 2-1-86.

8. North Carolina Geological Survey Map of North Carolina, 1985.

9. John Whitehead, Soil and Materials Engineers, Inc., letter to Mike Hogshead, Clifton Precision, Monitoring Well Installation, 12 November 1986.

10. U.S.G.S. Water Resources Investigations, Open File Report 80-44. Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina. U.S. Department of the Interior and NC NRCD, 1980.

11. Leon Tatham, Tri-County Community College, telephone conversation with Stan Atwood, NC DHR/DHS, 4 March 1986.

12. Clay, J.W., D.M. Orr, Jr., and A.W. Stuart. North Carolina Atlas: Portrait of a Changing Southern State. University of North Carolina Press, Chapel Hill, 1975.

13. Uncontrolled Hazardous Waste Site Ranking System; A User's Manual. National Oil and Hazardous Substances Contingency Plan , Appendix A (40 CFR 300), or (47 FR 31219), 16 July 1982.

14. North Carolina State Government Statistical Abstract, Fifth Edition, 1984. North Carolina State Data Center. Research and Planning Services, Office of State Budget and Management.

15. Leon Tatham, Tri-County Community College, telephone conversation with Stan Atwood, NC DHR/DHS, 25 February 1987.

16. Bob Wood, Cherokee County Health Department, telephone conversation with Stan Atwood, NC DHR/DHS, 25 February 1987.

17. IARC. IARC Monographs of the Evaluation of the Carcinogenic Risk of Chemicals to Humans, 20, Some Halogenated Hydrocarbons, Lyon, 1979, pp. 545-572.

18. Documentation of Threshold Limit Values, Fourth Edition. American Conference of Governmental Industrial Hygienists, Inc., Cincinnati, Ohio, 1980, pp. 406-407, BEI-25 - BEI-28.

19. Federal Register. United States Government Printing Office, 50:219, pp. 46886-46887, 46904.

20. Sax, N.I. Dangerous Properties of Industrial Materials, 6th Edition. Van Nostrand Reinhold, New York, 1984, pp. 2621-2622.

Ref 1

4 February 1987

TO: File

FROM: Stan Atwood SA

RE: Ground water contamination: Emerson Electric and Tri-County Community College.

I spoke by telephone with Bob Wood, Health Director, about his knowledge of the waste management histories of the subject sites. He gave the following information:

1. Tri-County Community College has occupied the present site since 1967. They have used some chlorinated solvents, including trichloroethene, in the body shop and chemistry labs.

2. Clifton Precision occupied the site between March 1966 and January 1967.

3. The Department of Transportation had a maintenance shed at the site prior to 1976: Used kerosene and gasoline to clean parts.

4. The Department of Corrections also operated a prison at the site from the late 1930's until February 1965.

5. No records of solvent spills or disposal on site.

6. Clifton Precision claims to have used freon at this site.

7. The prison constructed a sand filter bed for domestic sewage.

8. Emerson used trichloroethane until December 1985. Spent solvents reportedly drummed and shipped off site.

9. Contacts at Tri-County Community College - Vincent Crisp, President; Lyle Carringer, 837-6810 or 5651.

/tb/0193b

CHEROKEE SCOUT
MURPHY, N.C.

JAN-06-87

# Chemical Leak Contaminates Clifton's Water Supply

Traces of the chemical trichloroethlyene, a common cleaning solvent and known cancer-causing agent, have been found in the water supply and on the grounds of Clifton Precision, according to the company's vice president and general manager Spencer Latham.

In an interview Tuesday, Latham explained that soil and water samples taken in November from the grounds and the shallow ground water surrounding the factory contained chemical wastes called volatile organics which are carbon-and chloride-based chemicals used in numerous cleaning compounds and solvents. These solvents, he added, are used at Clifton to clean grease and oil from machinery parts.

"Following the results from the November testing," Latham explained, "a duplicate set of tests were run to double check the first results. At that time, samples of the factory's drinking water were drawn from the deep wells."

This second testing was conducted on Dec. 2, with the results returning on both Dec. 29 and 31.

According to Latham, it was at this date that "we were advised that the factory's drinking water also contained these volatile organics and in particular 1.2 to 1.3 parts per million of trichloroethlyene, which appears to be the only chemical found in any great amounts."

Clifton employees were advised Monday to avoid drinking the tap water at the factory until further notice. Meanwhile, state and area health officials have been notified of the chemical contamination and began taking soil and water samples of the immediate vicinity, to determine the extent of the contamination.

Cherokee County Health Department Director Bob Wood said Tuesday that water and soil samples had been taken from Peachtree Elementary school, the Small World Day Care Center, the Peachtree Church of God, the Peachtree Community Center and from various residences located near Clifton.

"These samples will be sent to the Division of Health in Raleigh for testing," Wood added, "with the results tentatively scheduled to be completed Fri-

See CHEMICALS, page 10

Pg 2

Ref 2

# Chemicals — Continued from front page

day.

"Since it is unknown if the contamination has spread to other areas other than the factory grounds," Wood added, "it would be premature to speculate what danger, if any, this current situation holds to area residents."

According to Latham, the initial sample tests were taken as a part of Clifton's state-approved plan to close the factory's old waste treatment system, located on the company grounds.

The closing of the old waste treatment system is part of the company's process to upgrade and change the classification of its waste treatment facility in accordance with the Federal Resource Conservation and Recovery Act (RCRA) of 1980.

Prior to the RCRA, according to Latham, Clifton disposed of its wastes as most other facilities throughout the nation did — "through the sewer system."

"This was done before the hazards of some waste within the environment was known," Latham said. "However, with the passage of the RCRA, Clifton began shipping it's chemical waste to federally appointed hazardous waste disposal areas."

Latham explained that Clifton last used the chemical trichloroethylene in its full-strength form in 1973. "However, since that time we have used other cleaning solvents which could possibly have a trichloroethylene compound in it," he added. "We are checking on that now."

Latham added that it is possible that the contamination could date back to as far as 1973. "We are just not sure at this time."

Toxicologist Dr. Ted Taylor, with the Division of Health explained Tuesday that it was "very possible that the contamination could indeed date back that far."

"Similar chemicals have been known to stay in the ground for extremely long periods of time," he added.

Taylor added that the traces of trichloroethylene reportedly found in Clifton's water supply could "possibly pose an unreasonable threat of cancer for those who drink the water over a period of time."

"It would be best not to drink any of the water until the extent and amount of contamination can be determined," he added.

Currently, local and state health agencies, along with Clifton Precision officials are working together to assess the damage, if any, the contamination has caused or could possibly cause Latham said.

"We hate that this has happened," he added, "and will do everything we can to rectify the situation as soon as possible."

—Patty Little

Ref 3

North Carolina Department of Human Resources
Division of Health Services
P.O. Box 2091 • Raleigh, North Carolina 27602-2091

James G. Martin, Governor
Phillip J. Kirk, Jr., Secretary

Ronald H. Levine, M.D., M.P.H.
State Health Director

12 February 1987

Ms. Denise Smith
EPA NC CERCLA Project Officer
EPA Region IV Waste Division
345 Courtland Street, N.E.
Atlanta, GA 30365

Dear Ms. Smith:

SUBJECT: Summary Trip Report
Emerson Electric Co. NC D089989917
Tri-County Community College NC D038551263

Emerson Electric Co. and Tri-County Community College are located along US 64 east of Murphy, NC in the Peachtree community. In January 1987 drinking water wells were sampled at both these sites as part of a community wide investigation of ground-water quality. This investigation was initiated when wells at an industrial site in the community were found to contain chlorinated solvents. One of Emerson's wells contained 64 ppb 1,1-dichloroethane; 290 ppb 1,1,1-trichloroethane; and trace amounts of 1,2-dichloroethane and trichloroethene. The community college well contained 300 ppb trichloroethene and trace amounts of tetrachloroethene. Although no disposals or spills of these chemicals have been documented for either site; chlorinated solvents have been used at the sites.

A CERCLA site investigation was conducted at these sites on 10-11 February 1987 by Stan Atwood and Jack Butler. Prior to the trip I notified Bob Wood, Cherokee County Health Director; Layton Schuh, Emerson Electric; and Don Link and Roy Davis, Division of Environmental Management (DEM), of the investigation. We stopped in Asheville on the way up and talked with Don Link and Ted Minnick (DEM). Mr. Link gave us a summary sheet of 66 wells that have been sampled to date in the Peachtree Community. He was also preparing a map of the sampling locations which we picked up on the return trip. Mr. Link also explained that they were working with Emerson Electric under the state ground-water regulations to effect a clean-up.

Ref 3



We arrived in Murphy at 2:30 p.m. and met Bob Wood at his office. We briefly discussed our plans and arranged to meet with him the next morning at 8:00 a.m. Mr. Wood gave us a copy of a general services map of the Peachtree Community, which locates all buildings and houses, to assist us with estimating populations within three miles of the site (554 houses counted). We later drove along all the roads not included on the above map and counted 334 additional houses (all but six were on the south side of the Hiwassee River).

As arranged, we met Mr. Wood at his office at 8:00 a.m. on 11 February 1987. We had selected eight sampling points as follows (Figure 1):

1. Peachtree Creek below Emerson.
2. Slow Creek above Emerson and below Clifton Precision.
3. Slow Creek above Clifton Precision.
4. Hiwassee River above Tri-County Community College.
5. Drinking water well - Tri-County Community College.
6. McComb Branch below Tri-County Community College.
7. Emerson industrial waste discharge.
8. Hiwassee River 3 miles above Murphy Intake.

The Hiwassee River ranged in depth between a few feet to less than 10 feet in the site vicinity. Mr. Wood also confirmed that the surface waters downstream from the sites were not used for irrigation, but the Hiwassee River is stocked with trout and fished. No alternative water sources (other than bottled water) are presently available to the community.

While at the Tri-County Community College site we met with Mr. Leon Tatham, Dean of Instruction, and Mr. Lyle Carringer, Business Manager. Mr. Tatham provided a map of the campus and told us that a 55-gallon drum of trichloroethene was found in the campus body shop. There were no records indicating that the college had ever purchased the drum. About two pints of trichloroethene were found in the chemistry lab and a small amount is used in the office on packing labels.

Photographs were taken at each sampling point. All samples were placed in a cooler and iced. The investigation was concluded at 1:00 p.m. If you have any questions, please contact me at (919) 733-2801.

Sincerely,

Stan Atwood, Toxicologist
CERCLA Unit
Solid and Hazardous Waste Management Branch
Environmental Health Section

SA/tb/0193b

Ref 4

2 March 1987

TO: File

FROM: Stan Atwood SA

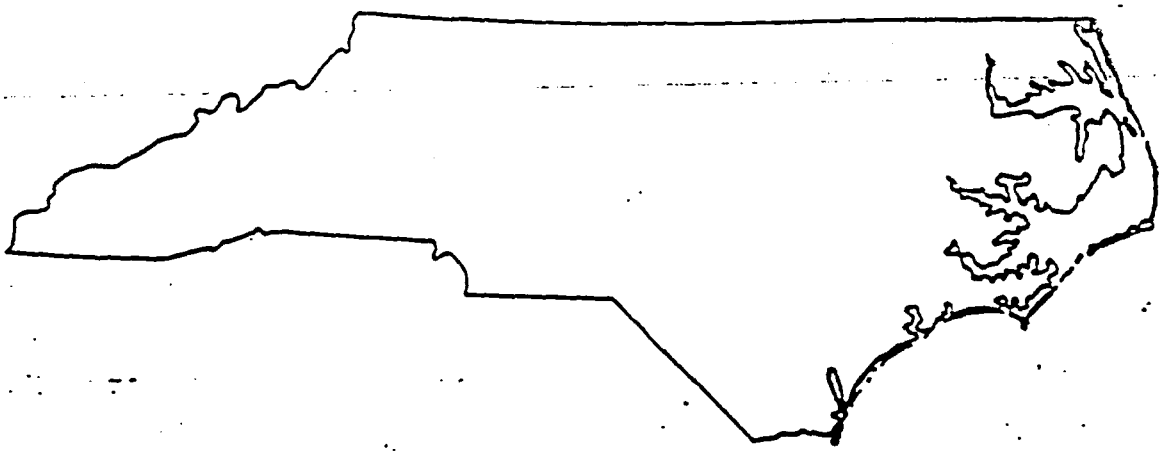
RE: Tri-County Community College NPDES permit

I spoke by telephone with Sam Bridges, DEM - Water Quality, (919) 733-5083. Tri-County Community College has an NPDES permit (#NC 0035394) which is presently up for renewal on 1 April 1987.

SA/tb/0187b

# Water Resources Data North Carolina Water Year 1983

by H.C. Gunter, C.L. Hill, and T.E. Dillard



U.S. GEOLOGICAL SURVEY WATER-DATA REPORT NC-83-1
Prepared in cooperation with the North Carolina Department of Natural Resources and Community Development, and with other State, municipal, and Federal agencies

Ref 5

## 03548500 HIWASSEE RIVER ABOVE MURPHY, NC

LOCATION.--Lat 35°04'49", long 84°00'10", Cherokee County, Hydrologic Unit 06020002, on right bank on U.S. Highway 64, 600 ft upstream from Will Scott Creek, 2.0 mi southeast of Murphy, and at mile 99.1.

DRAINAGE AREA.--406 mi².

### WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--June 1896 to August 1897, gage heights only, October 1897 to current year. Published as "at Murphy" 1897-1940. Records published for both sites August 1939 to April 1940. Monthly discharge only for some periods, published in WSP 1306.

REVISED RECORD.--WSP 583: 1899(M). WSP 973: Drainage area. WSP 1003: 1943. WSP 1306: 1901-2, 1904-17, 1919(M), 1922(M), 1924-26(M). WSP 1706: 1899, 1907.

GAGE.--Water-stage recorder. Datum of gage is 1,538.23 ft National Geodetic Vertical Datum of 1929 (levels by Tennessee Valley Authority). Prior to Jan. 30, 1921, nonrecording gage at bridge 2.8 mi downstream at datum 30.40 ft lower. Jan. 30, 1921 to Nov. 8, 1926, nonrecording gage 2.8 mi downstream at datum 28.40 ft lower. Nov. 9, 1926 to Apr. 30, 1940, water-stage recorder 2.8 mi downstream at datum 28.20 ft lower.

REMARKS.--Water-discharge records good. Considerable diurnal fluctuation since 1924 caused by Mission powerplant at Andrews Dam 7 mi upstream, normal regulated storage, about 75 ft³/s-day. Flow regulated since 1942 by Chatuge Lake 22 mi upstream (see p. 493).

COOPERATION.--Chemical and biological data shown in last table were furnished by the North Carolina Department of Natural Resources and Community Development.

AVERAGE DISCHARGE.--86 years (1897-1983), 921 ft³/s, 30.81 in/yr, adjusted for storage.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 23,100 ft³/s Mar. 19, 1899, gage height, 18.4 ft, from graph based on gage readings, site and datum then in use, from rating curve extended above 5,000 ft³/s; minimum daily, 10 ft³/s Dec. 3, 1924, result of freezeup and filling of Andrews Lake; minimum daily during normal regulation, 62 ft³/s Oct. 19, 1952.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum stage observed is that of Mar. 19, 1899.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 4,220 ft³/s Feb. 2, gage height, 6.60 ft; minimum, 109 ft³/s Aug. 29, gage height, 2.19 ft; minimum daily, 125 ft³/s Sept. 25.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1982 TO SEPTEMBER 1983
MEAN VALUES

| DAY | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 540 | 320 | 2160 | 1600 | 1310 | 668 | 453 | 472 | 1240 | 916 | 342 | 722 |
| 2 | 535 | 768 | 1710 | 1540 | 3130 | 746 | 487 | 455 | 992 | 642 | 731 | 635 |
| 3 | 187 | 686 | 1240 | 1620 | 2100 | 739 | 471 | 592 | 1060 | 289 | 662 | 893 |
| 4 | 315 | 701 | 829 | 1550 | 1900 | 702 | 514 | 1200 | 966 | 254 | 644 | 230 |
| 5 | 181 | 751 | 2010 | 1610 | 1390 | 357 | 1010 | 1030 | 732 | 681 | 623 | 160 |
| 6 | 315 | 359 | 2320 | 1490 | 1140 | 902 | 2470 | 999 | 1130 | 1020 | 463 | 414 |
| 7 | 329 | 317 | 1630 | 1570 | 1640 | 953 | 1380 | 635 | 1030 | 959 | 385 | 1030 |
| 8 | 791 | 665 | 1450 | 1490 | 1950 | 667 | 1280 | 798 | 1130 | 929 | 532 | 742 |
| 9 | 499 | 724 | 1440 | 1090 | 1530 | 875 | 1780 | 965 | 1230 | 603 | 913 | 909 |
| 10 | 235 | 587 | 1610 | 1140 | 1790 | 1200 | 1800 | 884 | 1070 | 474 | 894 | 406 |
| 11 | 470 | 512 | 1640 | 1150 | 1870 | 789 | 1330 | 882 | 734 | 532 | 980 | 305 |
| 12 | 568 | 421 | 2320 | 1370 | 1630 | 417 | 1840 | 767 | 694 | 921 | 1190 | 378 |
| 13 | 1390 | 922 | 1850 | 1480 | 1440 | 386 | 1660 | 1270 | 885 | 869 | 571 | 676 |
| 14 | 871 | 672 | 1710 | 1150 | 1560 | 693 | 1580 | 565 | 978 | 868 | 143 | 623 |
| 15 | 1070 | 770 | 1660 | 1220 | 1690 | 733 | 1870 | 709 | 967 | 871 | 579 | 603 |
| 16 | 497 | 355 | 2390 | 1430 | 1640 | 718 | 1610 | 1180 | 954 | 573 | 1100 | 588 |
| 17 | 321 | 953 | 2080 | 1410 | 1410 | 530 | 1450 | 1750 | 1020 | 192 | 984 | 386 |
| 18 | 562 | 797 | 2060 | 1460 | 1460 | 700 | 1460 | 991 | 779 | 707 | 1110 | 346 |
| 19 | 608 | 772 | 1260 | 1450 | 1020 | 573 | 1370 | 1500 | 719 | 1040 | 1120 | 478 |
| 20 | 427 | 548 | 1690 | 1450 | 874 | 364 | 1310 | 3080 | 543 | 949 | 807 | 816 |
| 21 | 975 | 304 | 1740 | 1070 | 984 | 766 | 1180 | 3080 | 800 | 1090 | 571 | 825 |
| 22 | 658 | 668 | 1640 | 542 | 1150 | 933 | 1100 | 3020 | 842 | 1000 | 493 | 678 |
| 23 | 575 | 1030 | 1670 | 379 | 702 | 869 | 800 | 2730 | 769 | 866 | 707 | 679 |
| 24 | 270 | 1210 | 1670 | 797 | 1460 | 902 | 748 | 2030 | 898 | 509 | 943 | 395 |
| 25 | 652 | 1110 | 1570 | 1180 | 1360 | 803 | 1080 | 1710 | 691 | 853 | 1070 | 125 |
| 26 | 549 | 1070 | 1600 | 1170 | 1130 | 412 | 1040 | 1550 | 520 | 802 | 1120 | 377 |
| 27 | 548 | 726 | 1880 | 1310 | 674 | 593 | 1080 | 1400 | 439 | 783 | 642 | 649 |
| 28 | 510 | 366 | 1980 | 1250 | 890 | 990 | 1020 | 948 | 1070 | 790 | 438 | 702 |
| 29 | 509 | 1410 | 2040 | 1040 | --- | 1100 | 1010 | 846 | 954 | 758 | 375 | 751 |
| 30 | 240 | 1540 | 1640 | 336 | --- | 733 | 670 | 1240 | 927 | 581 | 669 | 758 |
| 31 | 218 | --- | 1390 | 1130 | --- | 514 | --- | 1190 | --- | 363 | 746 | --- |
| TOTAL | 16227 | 22034 | 53879 | 38374 | 40824 | 22517 | 36853 | 40568 | 26763 | 22684 | 22547 | 17321 |
| MEAN | 523 | 734 | 1738 | 1238 | 1458 | 726 | 1228 | 1309 | 892 | 732 | 727 | 577 |
| MAX | 1390 | 1540 | 2390 | 1620 | 3130 | 1200 | 2470 | 3080 | 1240 | 1090 | 1190 | 1030 |
| MIN | 167 | 304 | 829 | 336 | 674 | 357 | 453 | 455 | 439 | 192 | 143 | 125 |

CAL YR 1982 TOTAL 328514 MEAN 900 MAX 5860 MIN 167 MEAN* 916 CFSM* 2.26 IN.* 30.61
WTR YR 1983 TOTAL 360591 MEAN 988 MAX 3130 MIN 125 MEAN* 982 CFSM* 2.42 IN.* 32.82

* Adjusted for change in contents in Chatuge Lake.

Ref 6

# GEOLOGY AND GROUND-WATER RESOURCES of the MURPHY AREA NORTH CAROLINA

By

Chester L. Dodson

*Geologist*, U. S. Geological Survey

and

R. L. Laney

*Chemist*, U. S. Geological Survey

GROUND WATER BULLETIN NO. 13

NORTH CAROLINA
DEPARTMENT OF WATER AND AIR RESOURCES

George E. Pickett, *Director*

DIVISION OF GROUND WATER

Harry M. Peek, *Chief*

Prepared Cooperatively By The Geological Survey
United States Department of the Interior
And The
North Carolina Department of Water and Air Resources

AUGUST 1968

Ref 6

# GEOLOGY AND GROUND-WATER RESOURCES OF THE MURPHY AREA, NORTH CAROLINA

By

Chester L. Dodson

## ABSTRACT

The Murphy area, in the southwest corner of North Carolina, includes Cherokee, Clay, Graham, and Swain Counties, 1,486 square miles entirely within the Blue Ridge physiographic province. Major streams in the area drain generally westward. Mean annual precipitation is 60 inches, and temperatures average 57°F through the year. The economy is predominantly agricultural.

The Murphy area is underlain by a metamorphic terrane. Quartzite, metaconglomerate, metagraywacke, phyllite, schist, mica gneiss, and hornblende gneiss predominate. Scattered intrusive dikes, sills, and pegmatite veins occur in these rocks, and dolomitic marble occupies a small part of the Murphy Marble belt.

Ground water in the Murphy area occurs in unconsolidated alluvium, fractures in metamorphic rocks, and solution cavities in marble. A large part of the rural population depends on springs for domestic water supplies; dug and drilled wells also provide water in rural areas. Five towns in the Murphy area are supplied by municipal water systems. The available ground-water recharge greatly exceeds the present rate of ground-water withdrawal from wells. The potential supply for utilization of ground water in the accelerating industrial development of the Murphy area is considered to be excellent.

Fifty-two water analyses were made to determine the chemical quality of the ground water in the Murphy area. Generally, ground water is soft and slightly acid, containing less than 100 parts per million dissolved solids, and less than 0.3 ppm iron. Dissolved solids are greatest in water from drilled wells and least in water from dug wells and springs. Chemical analyses show that ground water in the Murphy area can be divided into five types; to a limited extent, these types can be mapped, by use of pattern diagrams, and correlated with lithology.

Table 2. Comparison of precipitation at seven stations in the Murphy area

Ref 6

| Station | Murphy | Andrews | Meyers Chapel | Nanta-hala | Santeetlah Dam | Bryson City | Ela |
|---|---|---|---|---|---|---|---|
| Precipitation (inches): | | | | | | | |
| Average annual | 55.7 | 61.9 | 51.8 | 60.7 | 56.1 | 50.2 | 53.6 |
| 1961 | 62.2 | 67.6 | 55.1 | 67.9 | 60.7 | 56.5 | 66.8 |
| 1962 | 59.5 | 62.6 | 59.3 | 62.9 | 57.6 | 45.6 | 52.0 |

## Physiography

The Murphy area is in the Blue Ridge physiographic province (Fenneman, 1938, p. 163-194), which is characterized by abundant mountain summits and divides at altitudes between 5,000 and 6,000 feet above sea level. About half of the Great Smoky Mountains are in the area. Maximum relief of the area is about 5,560 feet. The lowest point is the surface of Galderwood Lake on the Little Tennessee River at the Tennessee State line at about 1,086 feet above sea level; the highest point is 27 miles distant on Clingmans Dome at 6,642 feet above sea level. Local relief of 2,000 feet is not uncommon. Within a distance of a mile in Cherokee County between Weatherman Bald and Junaluska Creek, the relief is about 2,400 feet, and within a distance of 4 miles in Graham County between Hangover and the mouth of the Cheoah River, the relief is 4,000 feet.

The mountains are remnants of a former highland that has undergone repeated cycles of uplift and erosion. In each cycle, the valleys have been cut deeper, and some of the material deposited in the former bottoms of valleys is not high on the mountain sides. In much of the area, the main streams are flowing in narrow channels cut in fresh rock about 200 to 500 feet below benches that are remnants of a valley bottom. The rocks of the benches are deeply weathered, and alluvial deposits are commonly present. Some small tributaries still flow at the former valley levels. A few small streams, such as

Tulula Creek in Graham County, flow in an old valley that has been abandoned by a major stream. Much of the alluvium along present-day streams was derived from older alluvium.

The Hiwassee and Little Tennessee Rivers, which flow westward, drain all the area except the eastern end of Clay County, which is drained by the southward-flowing Tallulah River. The gradients of streams in the area are steep. The gradient of the Hiwassee River is about 12 feet per mile, the gradient of the Little Tennessee is about 15 feet per mile, but the gradients of tributaries are much steeper; the gradient of the Cheoah River in Graham County is more than 50 feet per mile. The chief secondary streams are the Nantahala and Tuckasegee Rivers, tributary to the Little Tennessee River, and the Nottely and Valley Rivers, tributary to the Hiwassee River.

# GEOLOGY

Rocks underlying the Murphy area are metamorphic, and slightly more than 90 per cent of them are metamorphosed sedimentary rocks. All are of Precambrian or Cambrian (?) age except possibly some minor rocks such as dikes, veins, or pegmatites. Quartzite, metaconglomerate, metagraywacke, phyllite, schist, mica gneiss, granite gneiss, and hornblende gneiss are the most common rocks in the area. The rocks can be placed into six general categories--the Great Smoky Group, rocks of the Murphy Marble belt, a unit of mica schist and gneiss, a unit of granite gneiss, one of hornblende gneiss, and one of ultramafic rocks. Rocks of the Great Smoky Group are characterized by quartzite, metaconglomerate, and metagraywacke, but the group also contains small areas of other rock types. The Great Smoky Group crops out in about 50 per cent of the area, mostly in Swain, Graham, and western Cherokee Counties. Rocks in the Murphy Marble belt are chiefly phyllite and fine crystalline schist, but marble and white or very light-gray quartzite are conspicuous. Rocks of the marble belt crop out in about 30 per cent of the area from near the Little Tennessee River in Swain County southwestward to the Georgia State line and from Tusquitee Creek in Clay County to near Hanging Dog Creek in Cherokee County. The mica-schist and gneiss unit, the hornblende-gneiss unit, and the ultramafic rocks crop out in the eastern part of Clay County. Most of the granite gneiss is in Swain County. Dikes, sills, pegmatites, and a quartzite unit intrudes most of these units.

The rocks are mapped as 14 rock units, which are described in the following section. Contacts between all adjoining units are gradational and are less specific in many places than shown on the geologic map (fig. 4).

is
f
ris-
n
,
ay
rt
s
ains
tz-

ed.
ite,

quitee
-

ise
rac-
the

-
bly
the
rocks
act
between
ple

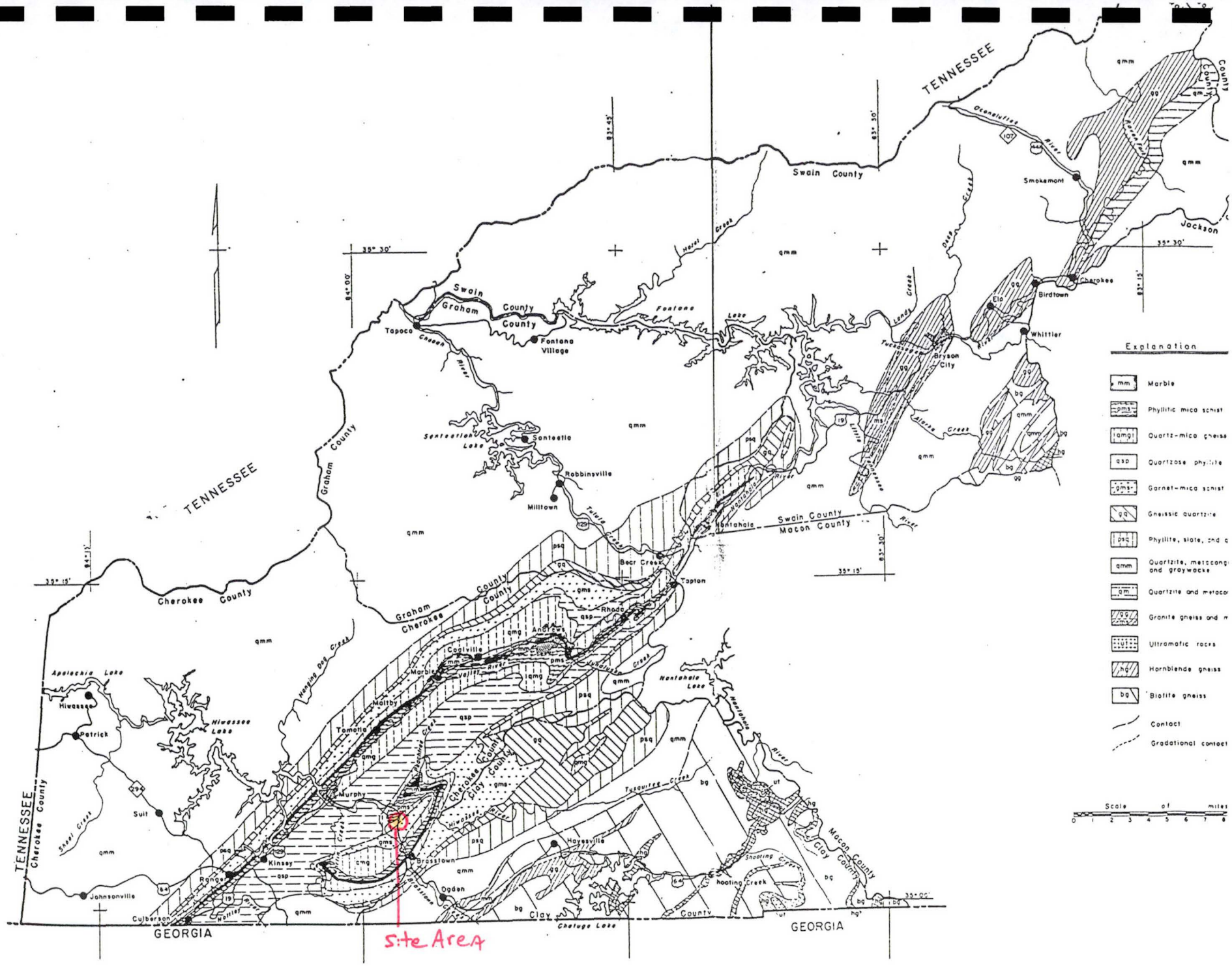



Figure 4.- Geologic map of the Murphy area, North Carolina

## Quartz-mica gneiss

The quartz-mica gneiss unit comprises many rock types. West of Andrews and Murphy (fig. 4), it is mostly a quartz-biotite-sericite gneiss and gneissic quartzite. East of Andrews and Murphy, it is mostly a quartz-mica schist that contains beds of quartz-mica gneiss and gneissic quartzite, but east of Marble and extending a few miles northeast and southwest, it is a staurolite-quartz-mica schist. Northeast of Andrews, both the schist and gneiss grade into a banded, very fine-grained, gneissic, quartz-mica schist that contains rock similar to both and also beds of quartzite. In the Peachtree-Brasstown-Martins Creek area, the unit is mostly quartz-mica gneiss; but it is much more schistose than it is west of Murphy and Andrews. Similar rock crops out in a small area in northwestern Clay County. All these rocks are included in one unit because they are probably facies of the same formation. The quartz-biotite-sericite gneiss is characteristic of the unit and occurs in all parts of it. Crystal-clear quartz grains are characteristic of the unit. That quartz-mica gneiss is the dominant rock west of Andrews and Murphy and that it occurs in lesser amounts east of Andrews and Murphy and northeast of Andrews can be explained by an eastward facies change from coarser to finer sediments.

Shearing appears to have been much greater to the east than to the west of Andrews and Murphy, but the appearance may be due more to differences in composition of the original sedimentary rock than to tectonics. The shearing appears to have been very great northeast of Andrews. Shearing is shown by crushing of quartz, sericitization, and formation of gneissic and linear structures, which appear greater east of Murphy and Andrews and northeast of Andrews, but the finer grain size of rock may be due to finer grained original sediments rather than to greater shearing. The original rock probably ranged from a laminated sandstone or siltstone to sandy and silty shale that contained beds of sandstone and siltstone. Much of the gneissic texture may be due more to alternating laminae of sandy or silty shale and very fine-grained, quartzose sandstone than to metamorphism. The rocks west of Andrews and Murphy may actually

be in a different formation from the rocks east of Andrews and Murphy, but the definition of units for the purposes of this study was based chiefly on lithologic similarities or rock type, so that even if two formations are involved, only one unit would be mapped.

The contacts of the unit are gradational generally across a broad interval. The unit was not observed in contact with the marble at any place, although the geologic map shows it to be so (fig. 4). Mica schist is also between the unit and the marble, but the mica schist is almost everywhere too thin to show on the geologic map.

The quartz-mica gneiss and schist unit crops out in eastern Cherokee County, southeastern Graham County, southwestern Swain County, and western and northwestern Clay County (fig. 4). The unit ends southwest of Murphy by grading into the phyllite, quartzite, and schist unit and the mica schist unit. Most of the outcrop area of the unit is in the mountains, but much of it in Cherokee County is in valleys or in areas of moderate relief. The geologic map is highly generalized in the Peachtree-Brasstown-Martins Creek area, because deep weathering and poor exposures make precise mapping difficult.

Ground water occurs in fractures in the rocks of the unit. The rocks of the unit are brittle and have been highly sheared so that fractures are abundant. Few wells obtain water from this unit, however, Cherokee County well 4 is representative of these wells. It is 175 feet deep and contains 48 feet of casing. The reported yield by bailing is 15 gpm. During 1962 the static water level ranged between 2.3 and 3.8 feet below land surface (fig. 9). The well is in quartz-mica schist that includes some quartz-mica gneiss and is located in the bottom of a small valley. Because they are more abundantly fractured, wells in quartz-mica gneiss or gneissic quartzite probably will yield more water than wells in the schist. The water level is lower and fluctuates less in well 4 than in wells located on hills or mountains. Almost all wells in the formation are in valleys so that well 4 is probably representative of existing wells. Adequate supplies of water for homes, farms, and small industrial plants can be obtained from the unit.

The ground water from quartz-mica gneiss is soft and contains less than 0.30 ppm iron. All but one sample contained less than 25 ppm dissolved solids. Chemical composition of the water is calcium bicarbonate and calcium sodium bicarbonate.

Rocks immediately east of these quartzite beds are too weathered to be positively identified. The unit is so thin that it is represented on the geologic map only by a wide black line across the mica-schist unit where the outcrop of that unit is sufficiently wide for the quartzite to be shown.

Ground water occurs in the quartzite unit in fractures and in spaces along bedding planes, but no well is known to obtain water from it.

Cherokee County spring 2A flows from the quartzite. According to local citizens, it is one of the few springs in the Murphy area that continued to flow during the drought of 1925. During 1962, the flow ranged from 10 to 30 gpm (fig. 9). The spring flows from slicken-sided fractures in the quartzite. Fractures are abundant in the quartzite, and wells in it can be expected to supply homes, farms, and small industrial plants.

One water sample was obtained in quartzite from Cherokee County spring 2A. This water was soft and contained 15 ppm dissolved solids and no iron.

## Unconsolidated deposits

Unconsolidated deposits overlying bedrock may be aquifers, but none are major aquifers in the Murphy area. Sand and gravel deposits on the high, deeply weathered benches that occur in the area may aid recharge of fractured-rock aquifers in some areas, but ordinarily they are so thin that they are of little hydrologic consequence. Generally, the more recent valley fill is so poorly sorted that its permeability is too low to yield much water. Gravel-pit bottoms several feet lower than a streambed may remain dry when within less than 20 feet of the stream because the valley fill is so impermeable. The source of water in many dug wells, however, is at the contact between the unconsolidated material and bedrock. The material of the valley fill ranges in size from micaceous silt or clay to boulders.

Along Tuluhah Creek near Robbinsville, Graham County, some wells have been drilled only to, or slightly below, bedrock. Yields from these wells are adequate for homes. Graham County well 19 is an

Ref 6

example of such a well. It is 90 feet deep and contains 90 feet of casing. The reported yield is 48 gpm as determined by bailing, and the water level is 15 feet below land surface. Graham County well 17 near well 19, produced artesian flow immediately after it was drilled. The confining bed that causes artesian conditions probably is the impermeable valley fill. Well 17 is 145 feet deep and contains 109 feet of casing. The reported water level was 2 feet below land surface after the pump was installed, and the yield is 30 gpm as determined by bailing. Graham County wells 1, 2, 3, and 7 are dug in this valley fill (table 13, fig. 15). The aquifers of these wells are sand and gravel immediately overlying bedrock.

Many, probably most, of the springs in the Murphy area flow from deposits on top of bedrock. Clay County spring 2A is an example of such springs, but the yield from this spring is extraordinarily high. During 1962, the low flow, in November, was about 50 gpm and the high flow, in March, was more than 100 gpm. This spring flows from colluvial gravel and boulders of hornblende gneiss, which are probably underlain by clay. Other springs flow from both unconsolidated deposits and bedrock. The fluctuation of flow from such springs is very great. Graham County spring 1A and Cherokee County spring 1A are examples. During 1962, flow of spring 1A ranged from 0.7 to 60 gpm and the flow of spring 1A ranged from 2 to 55 gpm (table 8, fig. 9). The yield during times of high flow is probably from deposits on bedrock and during times of low flow it may be from fractures in bedrock.

Dug wells in the Murphy area obtain water mostly from weathered bedrock or residual material. These wells may be more than 100 feet deep. Yields are generally adequate to supply homes and small farms except during times of drought. Clay County well 6 and 8 and Swain County well 1 are representative of wells in weathered bedrock (table 13, fig. 15). Well 6 is 39.7 feet deep, well 8 is 30.1 feet deep and well 1 is 35 feet deep. Yields are not known. During 1962, the water level of well 6 ranged between 29.7 and 34 feet below land surface, well 8 ranged between 26.5 and 29.8 feet (fig. 14), and well 1 ranged between 3.6 and 26.3 feet (fig. 14). Data on dug wells in

the Murphy area are generally unavailable, because records of depths and water levels are seldom kept, and most dug wells are sealed by thick concrete covers so that measurements cannot be made.

Deposits of poorly sorted valley fill are present in the Governors Island Community near Bryson City and along Alarka Creek in Swain County, along Tusquitee Creek, Clay County, along Tululah Creek, Graham County, and intermittently along Valley River and its tributaries above Murphy, Cherokee County.

Remnants of old valley bottoms form benches along the sides of valleys, and are commonly veneered by a thin deposit of sand and gravel. The Murphy business district is located on a gravel-covered bench. This same bench is only slightly above the level of Peachtree Creek at Peachtree. No well is known to obtain water from these gravel deposits, for they lie ordinarily above the water table.

Unconsolidated deposits are general throughout most of the mountainous part of the area; few large outcrops of bedrock occur. In part, these deposits may be composed of gravity- or stream-transported sand, gravel, and boulders from the deposits on the benches, but most of the deposits are composed of rock fragments derived from the underlying bedrock and transported only a short distance, mostly by gravity. Spring flowing from these deposits supply many of the homes and farms in the narrow valleys of the area.

## Miscellaneous rocks

Minor bodies of other types of rock occur in the Murphy area. Diorite or metadiorite sills are locally associated with the mica-schist unit, especially at its contact with the quartz-mica gneiss and schist unit. A few gabbro dikes or sills occur locally in the quartzite, metaconglomerate, and metagraywacke unit. A diorite-like rock that has been termed "pseudodiorite" by Keith (1913, p. 684-685) occurs in all units of the area except the marble and white quartzite. Quartz veins and veins of quartz-mica-feldspar pegmatite are common in rocks of the Murphy area.

Although forming a very small part of the rocks in the Murphy area, these minor rocks may be important to the hydrology of the area. Because the diorite is somewhat soluble, especially where it

Ref 6

contains a carbonate-mineral, small cavities are likely to form along fractures, and some of the better wells in the mica schist unit may obtain the water from this rock. Highly fractured quartz veins and pegmatites are the aquifers for some, perhaps many, wells drilled in the other rock units. Graham County well 20 is in the quartzite, metaconglomerate, and metagraywacke unit, which is characteristically moderate gray. The yield of well 20 is reported to be 30 gpm with little drawdown during 3½ hours of pumping. The driller reported "vermiculite and harder light-colored rock during last 10 feet of depth" in Clay County well 1. Crystals of muscovite about 1 inch in diameter were obtained from the well cuttings. The rock is a quartz-mica pegmatite in mica ~~schist~~ within the biotite-gneiss unit. The yield is reported to be too great to be determined by bailing, which indicates a high yield of ground water from pegmatite veins. Similar wells with high yields have been reported by drillers and well owners in the Murphy area. Cherokee County well 16 probably obtains water from a quartz vein. A thick quartz vein is exposed along the northeast bank of the Hiwassee River southwest of the well.

## Geologic Structure

Except where changed by local folding, layers or beds of rocks in the Murphy area strike northeast and dip steeply southeast. The strike is about N 45° E; the dip ordinarily ranges between 50 and 90° SE. The strike of the foliation of the rock is about N 60° E. Dominantly, the rocks are tightly folded and overturned to the northwest. Locally, the rocks are complexly folded, and the local folds may be only a few inches across. Complex folding associated with rock-unit contacts is an example of small folds. An example of the larger folding is the structure associated with the marble and related rocks, including the phyllite, slate, and quartzite unit and units between it and the marble. Detailed structure has not been determined in this study, but the larger folds are shown on the geologic map (fig. 4) by the deviation of contact boundaries away from the regional strike. Curving of the granite-gneiss contacts is due to discontinuity of the unit; however, and small-scale deviations may be due to changes in topography rather than to folding.

Examples of such folding can be seen in the Andrews, Peachtree-Brasstown-Martins Creek, Fires Creek, Buck Creek, Almond, and Tululah areas.

Because isoclinal folding is dominant in the area, relative ages of the rocks are uncertain. Foliation commonly masks the bedding, and it is difficult to determine if a fold is a syncline or an anticline. Whether the marble unit occurs in a syncline or an anticline is controversial (Van Horn, 1948, p. 19-20). In this study, the structure is assumed to be a syncline because the synclinal interpretation is more generally accepted; however, sufficient evidence to prove the type of structure is lacking.

Fracturing is abundant in rocks in the Murphy area, and locally the rocks are highly fractured. Jointing and cleavage are the most abundant types of fractures, but minor faulting is common. Physical evidence of major faulting has not been recognized during this study. Although, Keith (1907) mapped several major faults in the Murphy area. Van Horn (1948. p. 20) suggests that the major faults are not present. Similarity and intergradation of rock units in the area make doubtful any evidence of faulting except the visible presence of the fault itself. The absence of a rock unit is probably only the result of non-deposition or a change in lithology. Time allotted to this reconnaissance study does not permit an adequate resolution of the problem, and poor exposures prevent mapping the supposedly minor faults seen, therefore, no faults are shown on the geologic map (fig. 4).

Regional jointing is not as conspicuous as cleavage. Many of the rocks are so highly fractured that classification of the fracturing could be done only with much difficulty. Some of the quartz veins and pegmatites appear to be crushed as do some rocks near contacts. Zones of fractured rock as much as 300 feet thick occur at widely separated intervals. Some examples of these zones are; in Jim Bell Gap on the Joe Brown Highway about 0.9 mile northwest of the Murphy town limit; in a road cut on U. S. 64, about 0.6 mile east of the Clay-Cherokee County line; in a U. S. Forest Service road cut on Fires Creek about 1½ miles northeast of the Fires Creek

Ref 6

Game Refuge headquarters; and in a road cut about 3.7 miles west of Hayesville along U. S. Route 64. The zones are interpreted as fractures along which some lateral faulting has occurred. They are possibly zones of shear and gash fractures associated with a fault. Poor exposures prevent mapping them, but they apparently are nearly parallel to the strike of the bedding.

# GROUND-WATER HYDROLOGY

## Hydrologic Cycle

Water is being exchanged between the earth and the atmosphere constantly. The heat energy of the sun and the force of gravity accomplish the exchange. Water evaporates from the ground, from the vegetation, and from the surfaces of lakes, reservoirs, rivers, and oceans and becomes atmospheric water vapor, a gas. The water vapor condenses, sometimes freezes, to form clouds; then, falls as rain, snow, sleet, or hail. The water that falls to earth is called precipitation, or it may be called rainfall because most of the precipitation is rain. Part of the precipitation runs off into streams, lakes, or other bodies of water and may eventually reach the oceans. Part of it evaporates and part is transpired by plants; these processes are called "evapotranspiration". Part of the water seeps into the ground, saturates the soils and rocks, and eventually flows from springs or by other means may reach the surface again and be returned to the atmosphere as water vapor. Water circulates from earth to atmosphere to earth repeatedly. The exchange of water between earth and atmosphere is called the hydrologic cycle.

## Occurrence of Ground Water

Rocks in the outer crust of the earth generally contain open spaces or voids called interstices that range in size from the very small spaces between particles of clay to spaces that may be tens of feet across, such as solution cavities in marble. The ratio of the aggregate volume of open spaces in a rock to its total volume is the porosity of the rock (Meinzer, 1923b, p. 191). If the open spaces are interconnected, water may be transmitted through the rock. The permeability of a rock is a measure of its capacity for transmitting water under pressure. The permeability of a rock is measured by the rate at which it will transmit water through a given cross section under a given difference of pressure per unit of distance (Meinzer, 1923a, p. 28). Rocks that do not transmit water are impermeable.

Ref 6

If the water in the zone of saturation is confined under sufficient pressure beneath impermeable rock so that it will rise in a well above the base of the upper confining layer, it is artesian water. The water may rise above land surface, thus being a flowing artesian well.

"The permeable rocks that lie below a certain level are generally saturated with water under hydrostatic pressure. Their interstices are filled with water. These saturated rocks are said to be in the 'zone of saturation'."- Meinzer (1923a, p. 29). Ground water is that part of the subsurface water that is in the zone of saturation (Meinzer, 1923a, p. 38). The water table is the upper surface of the zone of saturation in ordinary permeable rock, and where the upper surface is formed by impermeable rock, the water table is absent (Meinzer, 1923a, p. 30). An aquifer is a rock formation, group of formations, or part of a formation that is water bearing (Meinzer, 1923b, p. 30). The term "water bearing" does not refer to the water that a formation may contain but to the water that the rock will yield to wells and springs.

In the Murphy area, nearly all the water-filled interstices are fractures except in the unconsolidated deposits. The porosity of the metamorphic rock itself is nearly non-existent. Other than the marble unit, the aquifers that yield the largest quantities of water are impermeable rocks that contain abundant fracture zones or fractured quartz veins, pegmatites, or quartzite units. The solution cavities in the marble formed along fractures. About 9 percent of the rainfall in the Murphy area percolates downward through the soil cover and rock fractures above the water table and reaches into the zone of saturation.

On a mountain, the rain water moves downward through fracture zones and along cleavage, planes, joints, and bedding planes, moving from rock unit to rock unit, being blocked and diverted by impermeable barriers many times before finally being discharged by springs, wells, or into a stream. Rainfall in valleys follows similar but shorter paths.

In the Murphy area, the bedrock units are locally so impermeable that either little water can enter them or they cannot transmit all the water available. Under such conditions, the unconsolidated alluvial and colluvial deposits on top of the bedrock may be saturated. Many springs flow from colluvium where these conditions prevail. Most of the annual yield of Cherokee County Spring 1A and Swain County Spring 1A is from colluvium overlying bedrock that is not sufficiently permeable to absorb the material rainfall. More than half of the springs in the mountains are of this type.

Water from precipitation percolates through unconsolidated deposits covering the marble, or is transmitted along fractures in adjacent rocks, and fills solution cavities in the marble in the zone of saturation. Because the cavities are large, resistance to flow in them is less than in fractures; therefore, yields of wells in the marble unit can be expected to exceed yields from other units in the area. Large cavities are not common, however, and many wells will yield no more than those in other units. Fractures are locally sparse, and almost all wells drilled where fractures are sparse, will yield little water. Very high (greater than 100 gpm) and also very low yields (less than 5 gpm) can be expected from wells in the marble unit.

Because the rocks are dipping steeply, an aquifer such as a fractured quartzite bed or the marble unit may be confined to a long narrow area. Quartz veins and pegmatites also dip steeply and thus would be similar to quartzite beds. Local folding, such as that in the Marble-Andrews area, may reduce the dip and make the aquifers available for development over a larger area.

Occurrence of ground water in the Murphy area is very complex, and each rock unit contains many local aquifers so that only a general knowledge of the ground-water hydrology can be obtained during a reconnaissance study. The marble unit, quartzite unit, beds and units of white or light gray quartzite, and veins of quartz or pegmatite are important as aquifers in the area. Fracturing along contacts forms aquifers. Notable examples are the contact zones between the ultramafic rocks and the hornblende-gneiss units, between the hornblende-gneiss and the biotite-gneiss units, and

Ref 6

between the granite gneiss unit and adjoining units. The very complexly folded and fractured zone in the quartzite metaconglomerate, and metagraywacke unit near its contact with the granite gneiss is an especially good aquifer near Bryson City, Swain County. Thick fractured zones like those noted on Fires Creek, in Jim Bell Gap, on Joe Brown Highway, and along U. S. 64 in western Clay County are probably excellent aquifers, although no well is known to obtain water from them. Clay County well 11 is possibly in the fractured zone on Fires Creek. The reported yield as determined by bailing was 30 gpm (table 10).

The quantity of water stored in the zone of saturation is constantly changing. The fluctuations can be compared to fluctuations in surface-water reservoirs such as those used for generation of electric power and for flood control. The zone of saturation is also referred to as the ground-water reservoir. Fluctuations of water in the zone of saturation are reflected by changes in the water table, which in turn are reflected in changes in the water levels of wells and the flow of springs. Observation wells and springs in the Murphy area were measured periodically so that changes in water level might be used to evaluate the availability of ground water. Figure 9 shows hydrographs of several wells and springs compiled during the period of this study.

Many factors cause changes in water levels in wells. Some wells reflect the effects of distant earthquakes. Pumping of adjacent wells causes the water level in a well to fluctuate. In some areas, pumping is continually lowering the water table, but this does not occur anywhere in the Murphy area.

If a well is near a large reservoir whose water level fluctuates, the water level in the well will fluctuate. Surfaces of bodies of water are the base levels for the water table in aquifers connecting with these bodies of water. Changes in the surface water levels are reflected in ground water levels. Water levels in Clay County wells 1 and 2 are influenced by fluctuations in Chatuge Lake (fig. 12); however, water does not flow from the reservoirs to the wells. The surface of the water in the wells is at a higher altitude than the lake surface, and the ground water flows toward the lake.

The greatest fluctuations are caused by changes in precipitation and evapotranspiration, which are the only factors that significantly affect the quantity of ground water in storage on a regional scale. Water levels in most of the observation wells in the Murphy area are highest and the flow of springs is greatest during March (fig. 9, 11, 12, 14, and 16). By May 1, nearly all water levels and flows are lowering and continue to lower until November or December. Most of them are rising by January 1, but a few delay until later. Only very heavy rains during the summer and early fall can reverse the trend. Winter rains end at about the time the downward trend begins, but the weather becomes warmer, the growing season starts, and evapotranspiration maintains the downward trend by discharging ground water into the atmosphere. In the fall, the trend is reversed when the growing season ends. Some of the deviation from the general trend shown in figures 9, 11, 12, 14, and 16 can be explained by delay in precipitation moving from the land surface to the aquifer or by the time required for adjustments within the aquifer before a given well is influenced. Clay County wells 1 and 2 are influenced by the artificially controlled rise and fall of Chatuge Lake.

The effects of precipitation are shown by the differences in water levels in wells in early 1962 as compared to water levels in early 1963 (fig. 9, 11, 12, 14, and 16). The heavy rainfall in December 1961 resulted in a rapid rise in water levels in most wells in the Murphy area. A higher rainfall in September 1962, as compared to August and October, resulted in a notable fluctuation in some wells; for example, Graham County well 1 and Cherokee County well 5 (fig. 14 and 9). Precipitation recharges the ground-water reservoir, and either raises the water table or slows its downward trend.

A change in water level indicates a change in the quantity of ground water in storage and the quantity available. For each one percent of the rock that is water bearing, a change of one foot in the water level represents a change in storage of about 3,000 gallons per acre or about 2 million gallons per square mile. No data are available to indicate what percentage of the rock in the Murphy area is water bearing, but it is probably less than 5 per cent. Locally, it may be much greater in some aquifers, especially in marble.

The amount of rainfall primarily controls the quantity of ground water available. About 9 percent of the rainfall in the Murphy area becomes ground water. This is more than 144,000 gallons per acre each year. Ground water stored in the zone of saturation from precipitation in years past is many times the annual rainfall. Because of complex hydrologic and economic factors, not all of this water can be recovered by wells and springs.

Local availability of ground water is of more practical significance than a real availability. A water supply ordinarily can be economically transported only a short distance. The yield of a single well or the yield of several wells in a well field may determine the practical availability of ground water. In the Murphy area, the reported yield exceeds 30 gpm in less than 5 percent of the wells for which data are available. If the yield of a well exceeds the maximum rate of bailing, which often is about 30 gpm, a driller may report only the maximum rate, or a driller may not report the yield if it far exceeds the maximum rate of bailing. Because of these factors, many wells may yield more during short periods than it is indicated; however, if pumped continuously, the true yields will ordinarily prove to be much less than yields determined by bailing so that it is likely that the capacity of no more than about 5 percent of the wells does exceed 30 gpm. Pumping tests possibly will reveal that a higher percentage of yields exceed 30 gpm, and if wells are carefully planned, the percentage probably will increase. Only tentative conclusions can be reached using the data available.

The yields of springs in the area vary greatly (fig. 9). Table 3 summarizes the data collected on the five springsobserved during 1962. For ordinary purposes, the low flow indicates the practical supply of the spring. At low flow during 1962, Clay County spring 1A was yielding 288 gallons per day, about sufficient for a rural home. Only Cherokee County spring 2A and Swain County spring 1A can be expected to flow during times of extreme drought. According to several citizens of Murphy, spring 1A continued to flow during 1925, a year of abnormally low rainfall, and supplied much

of the water for the townspeople. It was one of the few springs in the area that continued to flow that year. Because more than half the water supplies outside the towns are from springs and shallow wells, a critical water supply problem may develop during another drought as severe as the drought of 1925.

The daily consumption of ground water in the Murphy area in 1963 is estimated to be less than 1½ mgd (million gallons per day). At the time of lowest water levels in wells and lowest spring flows during 1962, ground-water sources, including undeveloped springs, probably would have supplied more than 10 mgd if fully utilized. During times of extreme drought, probably less than 1 mgd could be supplied from existing sources, mostly from deep wells. Supplies will be adequate during the foreseeable future except during extreme drought. Wells are being drilled in increasing numbers.

Table 3. - Comparison of Spring Flow in the Murphy Area

| Spring | Flow, gallons per minute | | | |
|---|---|---|---|---|
| | Average* | High | Low | Ratio, high to low |
| Cherokee County 2A | 20.0 | 30. | 10.0 | 3:1 |
| Clay County 1A | 1.8 | 5 | 0.2 | 25:1 |
| Graham County 2A | 1.4 | 5 | 0.5 | 10:1 |
| Graham County 1A | 13.0 | 60 | 0.7 | 85:1 |
| Swain County 1A | 14.0 | 23 | 4.0 | 5:1 |

*Average of monthly measurements from high to low flow.

More than half the known wells were drilled since 1946. As more wells are drilled and less dependence is put on springs, the critical aspect of droughts will lessen.

The temperature of ground water approximates the average yearly temperature where the well is located. The temperature of ground water increases with an increase of depth to the aquifer. Few data are available that can be used to determine the temperature of water that can be obtained from wells in the Murphy area. Measurements under controlled pumping conditions are required to determine accurate temperatures. Several of the observation wells were measured

Ref 6

# CHEMICAL QUALITY OF GROUND WATER

By

R. L. Laney

Water quality is dependent upon the amount and kind of dissolved mineral constituents in the water. Rain water seeping downward through soil and rocks contains gases dissolved from the atmosphere, the soil, and organic matter. Carbon dioxide, the principal dissolved gas, in water forms a weak acid which acts as a solvent on practically all minerals.

Although many factors affect the amount and kind of chemical constituents dissolved in ground water, the two most important factors in the Murphy area are the chemical and physical nature of the rocks and the duration of contact between the water and the mineral grains of the rock.

Minerals are dissolved when rocks undergo chemical weathering. Most chemical constituents go into solution in one or two forms: as cations (positively charged particles) and as anions (negatively charged particles). Iron may be in water as a cation or as colloidal-sized particles. Silica is in nonionic form in most natural water. Chemical analyses of water measure the amount of cations, anions, and nonionic material in solution. Unless otherwise noted, amounts of individual constituents in water are reported in parts per million (ppm) which is the concentration by weight of each constituent in a million unit weights of water.

Nearly all ground waters sampled in the Murphy area are suitable for most domestic and industrial purposes. Range in concentration, arithmetic mean (average and median (a value above and below which lie half of the cases reported) for principal constituents and selected characteristics of ground water are included in table 4. A discussion follows of each constituent commonly reported in water-analyses.

## Silica ($SiO_2$)

Silica is derived from the weathering or chemical breakdown of silicate minerals which constitute most of the rocks in the

Analyses in parts per million

| Constituents | Low | High | Mean | Median |
|---|---|---|---|---|
| Silica ($SiO_2$) | 3 | 32 | 12 | 9.5 |
| Iron (Fe) | .00 | 1.0 | .13 | .06 |
| Copper (Cu) | .00 | .22 | .04 | .03 |
| Calcium (Ca) | .2 | 27 | 4.8 | 2.4 |
| Magnesium (Mg) | .3 | 49 | 2.5 | 1.2 |
| Sodium (Na) | .3 | 8.1 | 2.5 | 2.0 |
| Potassium (K) | .2 | 4.5 | 1.0 | .9 |
| Bicarbonate ($HCO_3$) | 4 | 294 | 29 | 18 |
| Sulfate ($SO_4$) | .2 | 20 | 1.9 | .2 |
| Chloride (Cl) | .1 | 9.3 | 1.8 | 1.2 |
| Nitrate ($NO_3$) | .0 | 15 | 1.7 | .2 |
| Hardness (as $CaCO_3$) | 2 | 265 | 23 | 13 |
| Dissolved solids | 12 | 247 | 43 | 32 |
| Hydrogen ion concentrations (pH) | 5.0 | 8.4 | 6.3 | 6.3 |
| Specific conductance in micromhos at 25°C | 10 | 479 | 60 | 43 |

Table 4. Range in concentration, arithmetic mean, and median of concentrations of constituents in ground water in the Murphy area.

## WATER QUALITY RELATED TO SOURCE

The amounts and types of mineral constituents dissolved in ground water from the Murphy area differ according to the source of the water. Water from springs, drilled wells, and dug wells differs somewhat in the amount and type of dissolved constituents. Table 5 shows the range, the arithmetic mean, and the median of concentrations of dissolved solids, chloride, and nitrate in water from springs, drilled wells, and dug wells. Nitrate and chloride are included because excessive concentrations of each (more than .1 and 3 ppm respectively) in ground water in the Murphy area are indicative of possible pollution.

Figure 6 shows the mediam concentration of dissolved solids, chloride, and nitrate from the three ground-water sources in the Murphy area. The principal difference in the composition of ground water from the three sources is the amount of dissolved solids. Median concentrations of dissolved solids in water from drilled wells exceeds those from springs and dug wells about 2 times. In general, the duration of water-rock contact is greatest for water from drilled wells and least in water from springs, which accounts for the difference in dissolved solids. Median chloride concentrations are greatest in water from dug wells and least in water from springs, although the range is not extreme. Median nitrate concentrations in water from the three sources are roughly equal. Of the three ground-water sources, dug wells normally are the most susceptible to pollution. However, on the basis of the concentrations of chloride and nitrate, there is little indications of pollution of ground-water supplies in the Murphy area.

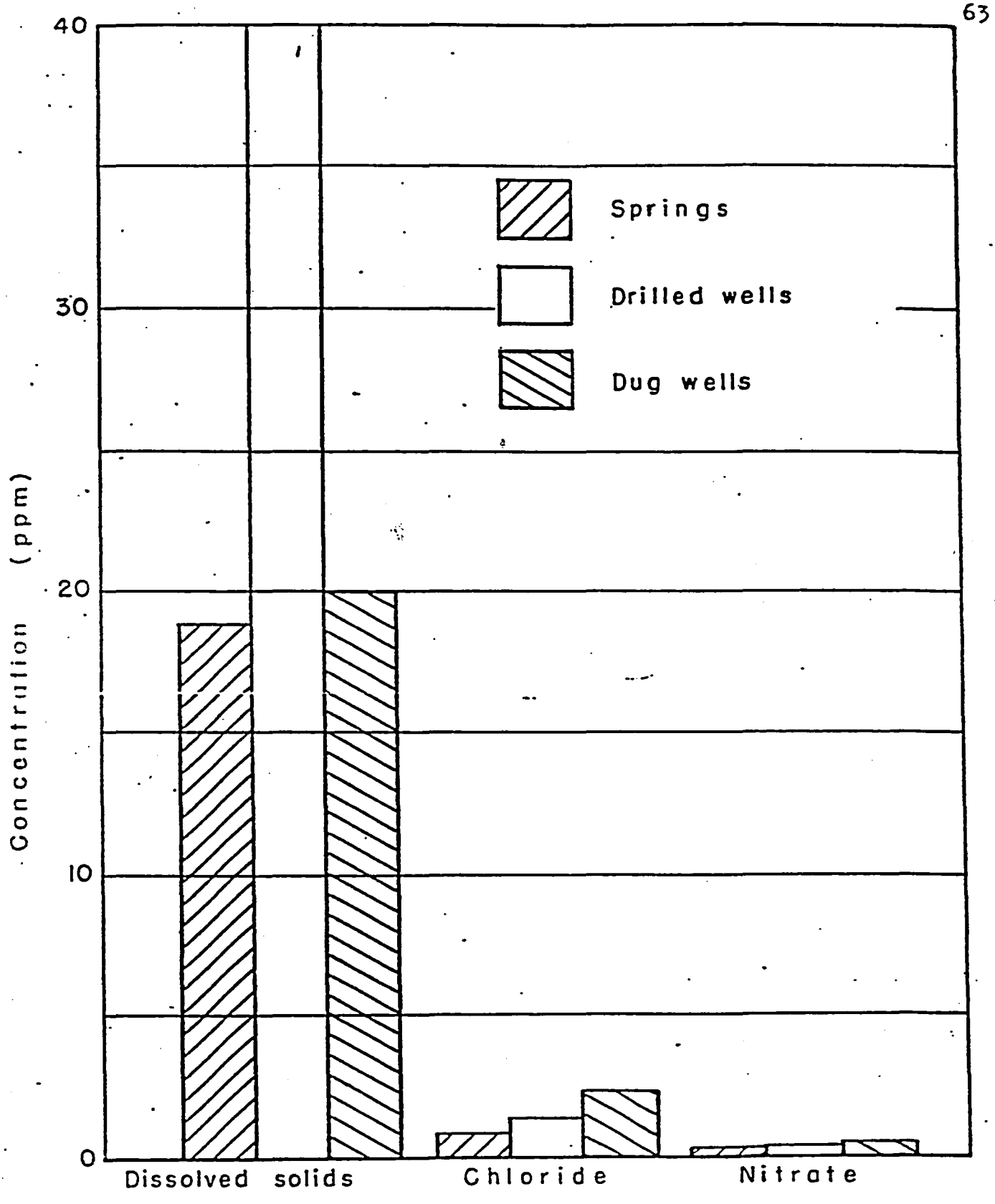



Figure 6 — Median concentrations, in parts per million, of total dissolved solids, chloride, and nitrate in water from springs, drilled wells, and dug wells in the

Ref 6

Constituents in parts per million (ppm)

| | | Low | High | Mean | Median |
|---|---|---|---|---|---|
| Springs | Dissolved solids | 12 | 54 | 26 | 18 |
| | Cl | 0.3 | 3.3 | 1.2 | 0.9 |
| | $NO_3$ | 0.1 | 14 | 2.0 | 0.1 |
| Drilled wells | Dissolved solids | 13 | 247 | 50 | 40 |
| | Cl | 0.1 | 9.3 | 1.9 | 1.1 |
| | $NO_3$ | 0.0 | 15 | 1.7 | 0.2 |
| Dug wells | Dissolved solids | 13 | 86 | 34 | 20 |
| | Cl | 0.1 | 5.5 | 2.1 | 2.1 |
| | $NO_3$ | 0.0 | 7.2 | 1.4 | 0.6 |

Table 5 .—Range, arithmetic mean, and median of concentrations of dissolved solids, chloride, and nitrate in ground water in the Murphy area.

## RELATIONSHIPS OF CHEMICAL COMPOSITION OF GROUND WATER TO LITHOLOGY

Chemical analyses are commonly reported in parts per million (ppm). Expressions in parts per million are a convenient means of expressing the results of an individual water analysis or of comparing selected constituents among several water analyses. However, relating the chemical composition of ground water to the geology requires a method of comparing the relative amounts of chemical constituents in one water to those in another. Results of water analyses in equivalents per million (epm) are more useful for this purpose than parts per million.

Expressions of equivalent-weight units or equivalents per million are based on the concept of chemical equivalence. In any waters the sum of the cations in epm equals the sum of the anions in epm. Equivalents per million for an ion may be calculated by multiplying ppm by an appropriate factor. A method using emp to show the general chemical characteristics of ground water is illustrated by the pattern diagrams in figure 7. Cations in epm are plotted to the left of the zero line and anions in epm are plotted to the right. The plotted points are connected and the resulting patterns are characteristic of waters of different chemical composition.

Chemical analyses of ground water in the Murphy area generally can be subdivided into five basic patterns or types. Bicarbonate is the major anion in all five types. The distinction between types is determined by the relative amounts of calcium, magnesium, and sodium. The pattern diagram of each water type in figure 7 does not necessarily represent actual amounts of chemical constituents in a particular water, but instead shows relative amounts of ions in equivalents per million which are typical of each groundwater type (see fig. 8). For example, dissolved solids in ground water classed as type 1 vary from 17 to 247 ppm. Generally, water types cannot be determined from water containing less than 20 ppm dissolved solids.

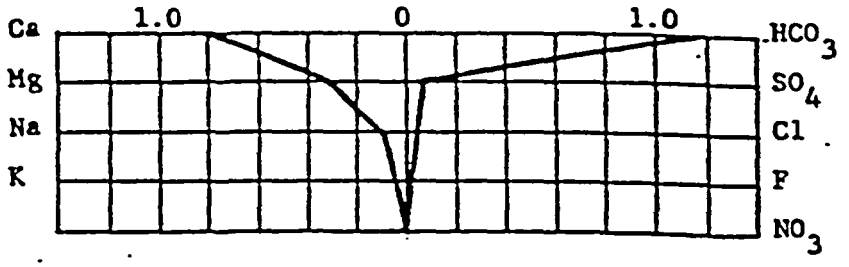
Ref. 6

| ROCK UNITS | WATER TYPES | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | V |
| Biotite gneiss | 1 | | | | 1 |
| Hornblende gneiss and ultramafic rock | 1 | | | | 4 |
| Granite gneiss and mica schist | | | | 2 | |
| Granite gneiss | 2 | 1 | 3 | | |
| Mica schist | 2 | | | | |
| Quartzite, metaconglomerate, and metagraywacke | 2 | 2 | 3 | | 3 |
| Garnet-mica schist | 1 | 1 | 1 | | 1 |
| Quartzose phyllite | | | | | 1 |
| Quartz-mica gneiss | 2 | | 1 | 1 | |
| Phyllitic-mica schist | | | | | 1 |
| Marble | 4 | | | | 1 |
| Quartzite | 1 | | | | |
| Alluvium | 2 | | | | |

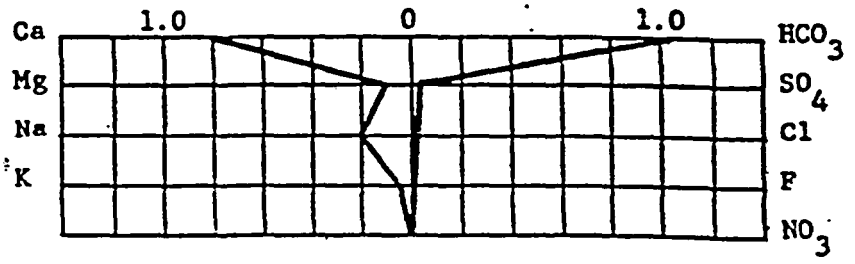
Table 6. Number of analyses representing five water types versus rock units in the Murphy area. Analyses of ground water with less than 20 ppm dissolved solids are not included.

Equivalents per million

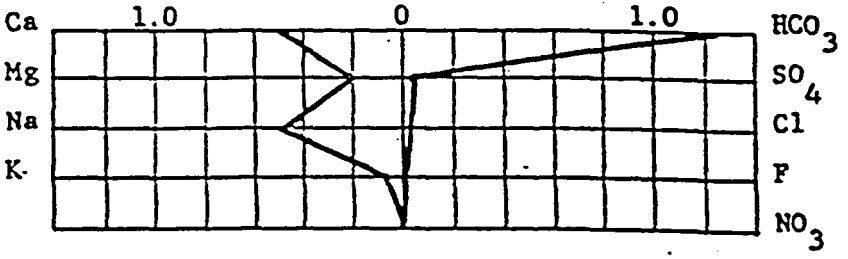
Type I - calcium, magnesium, sodium bicarbonate



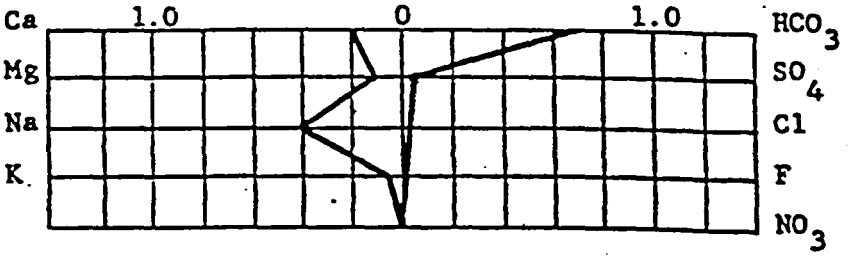

Type II - calcium, sodium, magnesium bicarbonate




Type III - calcium, sodium, magnesium bicarbonate




Type IV - sodium, calcium magnesium bicarbonate




Type V - magnesium, calcium, sodium bicarbonate

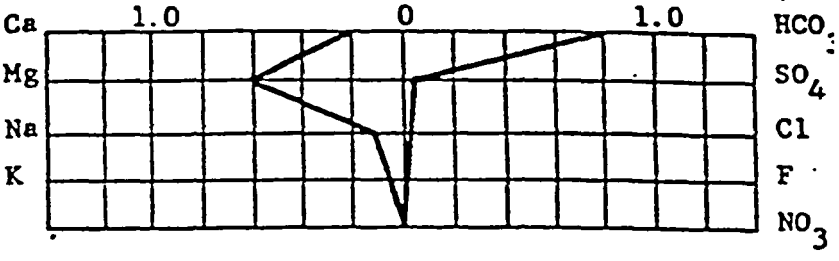



Figure 7.- Pattern diagrams illustrating the five basic ground-water types in the Murphy area.

Ref 6

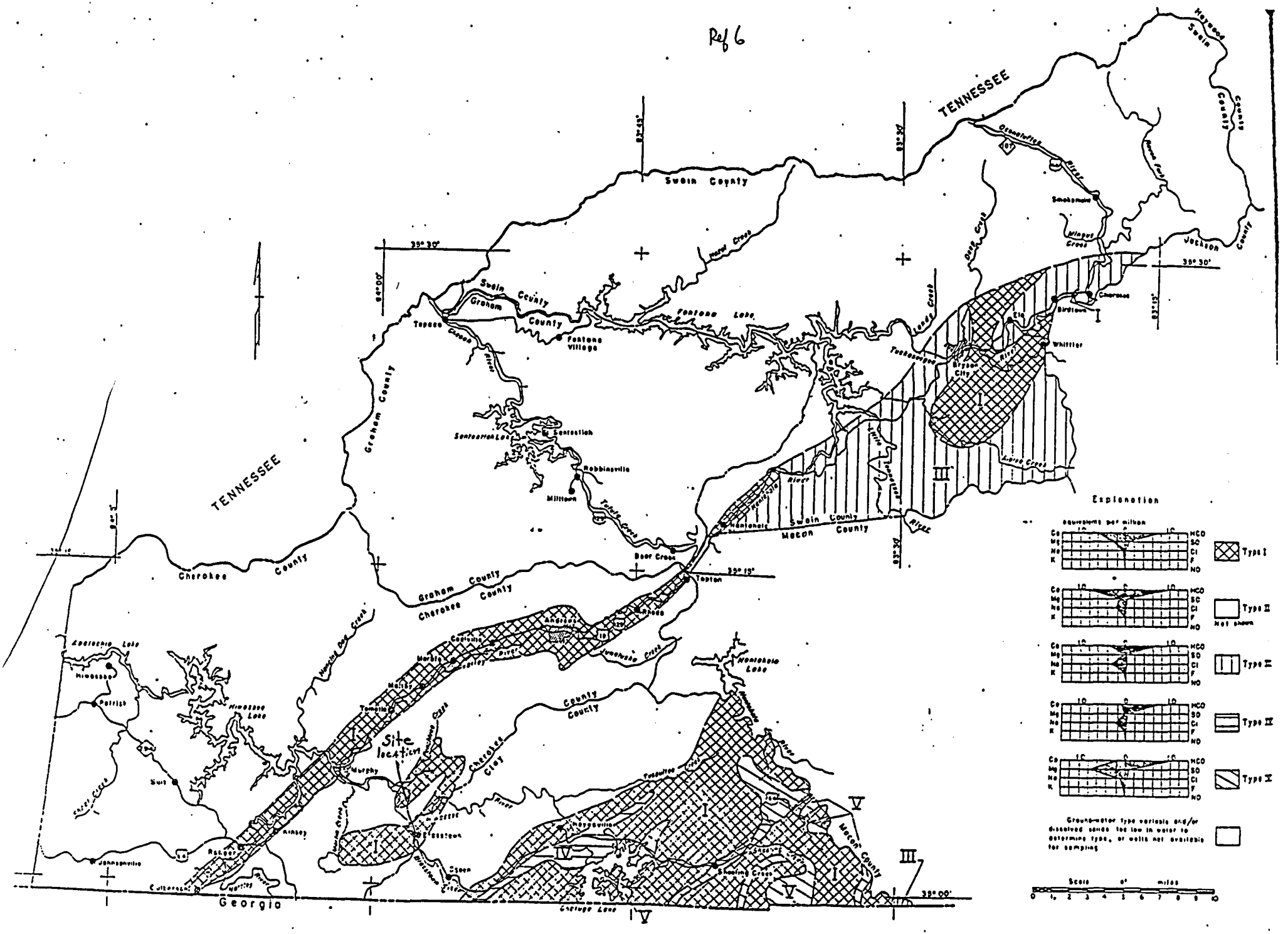



Figure 8.-Water-type map of Swain, Graham, Cherokee, and Clay Counties, North Carolina.

## Type I Ground Water

The significant characteristics of type I are the predominance of calcium resulting in a calcium bicarbonate water and the relative abundance of magnesium and sodium. Water of this type results from the solution of colcite, dolomite, calcic plagiocluse, feldspars, hornblende, and other calcium-bearing minerals. Type I water occurs in most rock types from which a water sample was obtained. Marble is the only rock type which contains type I predominantly.

In some rock units in the Murphy area small amounts of calcite (calcium carbonate) occur disseminated throughout the rock. Calcite dissolves more readily than the silicate minerals, therefore, an analysis of ground water from a rock unit containing a small amount of calcite may show a relatively high percentage of calcium. The solution of calcite could mask the effect of the more abundant, but less soluble, silicate minerals.

## Type II Ground Water

Although type II is a calcium bicarbonate water, it is distinguished from type I by the relative amounts of magnesium and sodium. Sodium exceeds magnesium and calcium exceeds the sum of both sodium and magnesium. Type II occurs in the granite gneiss, garnet-mica gneiss, and the quartzite, metaconglomerate, and metagraywacke unit.

## Type III Ground Water

Type III is a calcium sodium bicarbonate water with sodium and calcium being about equal and magnesium the least abundant of the three principal cations. It occurs in granite gneiss, quartz-mica gneiss and schist, garnet-mica schist and phyllite, and the quartzite, metaconglomerate, metagraywacke unit. Relatively high concentrations of sodium indicate the presence of sodic feldspars. Generally, type III is associated with rocks which have a granite composition.

Ref 6

## SUMMARY OF QUALITY OF WATER

Ground-water quality in the Murphy area depends primarily upon the amount and type of dissolved gases in rainfall and ground water, the chemical composition of rock and soil, and the duration of water-rock contact.

Nearly all ground water sampled in the Murphy area is suitable for most domestic and industrial purposes. Iron concentrations in water greater than the recommended maximum of 0.3 ppm occur at scattered locations. Eighty-eight percent of the ground water analyzed for iron contained less than 0.3 ppm.

The amount of dissolved solids, chloride, and nitrate differs somewhat according to the source of the water. Based on median concentrations, water from drilled wells contain more than two times the dissolved solids as water from dug wells and springs, and water from dug wells contains slightly greater amounts of nitrate and chloride as water from drilled wells and springs. Lack of excessive chloride and nitrate concentrations in ground water indicates that there is very little pollution of ground-water supplies in the Murphy area.

Pattern diagrams, based primarily on the ratios of calcium, magnesium, sodium, and bicarbonate expressed in equivalents per million, are used to divide the analyses of ground water into five types:

Type I. Calcium, magnesium, sodium bicarbonate;
Type II. Calcium, sodium, magnesium bicarbonate;
Type III. Calcium sodium, magnesium bicarbonate;
Type IV. Sodium, calcium, magnesium bicarbonate; and
Type V. Magnesium, calcium, sodium bicarbonate.

Hornblende gneiss, ultramafic rock mica schist, alluvium, and marble contain primarily one characteristic type of water. Nearly all rock units contain more than one type of ground water.

Water types can be mapped but they extend across and change within boundaries of rock units. Lack of complete water-type-lithology correlation is caused by changes in mineral composition within the rock units and/or mixing of different types of water.

Ref 6

# COUNTY DESCRIPTIONS

## Cherokee County

(Area: 454 square miles. 1960 population: 16,335)

Cherokee County is the westernmost county of North Carolina. It is bounded by Tennessee and Georgia and by Clay, Macon, and Graham Counties, North Carolina, (fig. 1). Cherokee is the most populous and the second largest county in the Murphy area. The population of Murphy, the county seat of Cherokee County, and the largest town in the area of this study, was 2,235 in 1960. The area of study is designated the Murphy area because it is customary in the ground-water program in North Carolina to name the areas of study for the largest town or city in the area. The second largest town in the county and in the area is Andrews, population 1,404 in 1960. Smaller towns and villages in the county include Marble and Culberson. The economy of the county is chiefly agricultural but is becoming industrial at an increasing rate. Most of the industry is textile related; but mining, quarrying, timbering, and manufacturing of wood products are also included.

The county is in the Blue Ridge physiographic province. Nearly all the area is mountainous, but the area between Andrews and Murphy is in a strikingly broad valley. Local relief is great. The maximum relief in the county is about 3,800 feet from the Hiwassee River at the Tennessee line to the summit of either Weatherman Bald or Grassy Top. The Hiwassee River and its chief tributaries, the Valley and Nottely Rivers, drain the county. Peachtree Creek flows in a broad valley. Other prominent streams include Little Brasstown, Junaluska, Hanging Dog, and Martins Creek. Hiwassee Lake and Appalachia Lake, reservoirs of the Tennessee Valley Authority, are within the county.

## Geology

In the western half of Cherokee County, the bedrock is the quartzite, metaconglomerate, and metagraywacke unit; in the eastern half it is the quartzite, phyllite, schist, gneiss, and marble units in the Murphy Marble belt (fig. 4). The marble lies in the valleys of the Nottely and Valley Rivers from Culberson to Topton and in the valleys of Peachtree and Martins Creeks. Except locally, all the rocks dip steeply southeastward. The dip is less steep in the Andrews-Marble area and in the Martins Creek-Peachtree area where the geologic structure is more complex than is general.

## Ground Water

About 78 percent of the domestic water supply in Cherokee County is ground water. Springs supply the greatest number of families, but wells supply the greatest quantity of water. About half the wells are dug wells and half are drilled wells. Most of the drilled wells are 6 inches in diameter and are between 100 and 200 feet deep. A few wells are 8 inches in diameter, and at least one is more than 400 feet deep. Nearly all wells were drilled since 1950. The dug wells may be as much as 90 feet deep, but most of them are between 25 and 40 feet deep. The most common diameter of dug wells is about 36 inches, but many of them are square and are about 48 inches across. About as many wells are dug each year as are drilled.

Springs are generally used for water supplies wherever available. The minimum flow that can be expected from most of the springs is less than 1 gpm; however, the minimum flow of several springs, such as Cherokee County Spring 2A, probably exceeded 5 gpm during the driest known period, the fall of 1925. Almost all springs ceased flowing during that year.

The chief aquifers are fractured zones in bedrock. Large yields are obtained from crushed quartz veins or quartz-mica pegmatite. The greatest yields can be obtained from solution cavities in the Marble Unit. The reported yield of Cherokee County well 15 is 60 gpm from the marble. The drawdown at 60 gpm is reported to be "not

noticeable." The low yield during 1962 from Cherokee County Spring 2A in the Quartzite Unit was 10 gpm; the high yield was 30 gpm.

## Chemical quality of ground water

Analyses of ground water from Cherokee County are shown in table 9. No ground water was sampled which contained more than 0.3 ppm iron. Wells 1, 3, 5, and 16 have water with high chloride and nitrate concentrations.

## Municipal supplies

Murphy and Andrews have the only municipal water systems in Cherokee County. Supplies in the other towns are obtained from privately owned wells or springs. Murphy and Andrews obtain their municipal water from surface-water sources.

### Murphy

The Murphy Water Works obtains water from two sources--the Hiwassee River and Marble Creek. The capacity of the treatment plant on the Hiwassee River is 1 mgd. The capacity of the pressure filter on the supply from the reservoir on Marble Creek is about 420,000 gpd. Storage capacity in the reservoir on Marble Creek is 1,250,000 gallons when the reservoir is full. Storage capacity of treated water from both sources is 500,000 gallons. Consumption, including a very high leakage loss, is about 300,000 gpd. Maximum consumption recorded was about 400,000 gpd. Distribution is by gravity to 800 taps in 1963.

### Andrews

The town of Andrews obtains water from a 400,000-gallon reservoir on Beaver Creek. Storage capacity of the reservoir for treated water is 100,000 gallons. Distribution is by gravity to 525 taps in 1963. Consumption is about 80,000 gallons per day.

## Industrial supplies

Most of the industrial supplies are from the Murphy and the Andrews municipal systems. A single textile plant is supplied by a well. Location of the marble unit, the aquifer of the greatest

Ref 6

expected yield, is favorable to development of industrial supplies. The marble occurs in the principal valleys near the railroads, highways, and towns. Possible sources of industrial cooling water are inactive talc mines and marble quarries. Under some circumstances, active mines or quarries perhaps could supply cooling water.

TABLE 7 RECORDS OF WELLS IN CHEROKEE COUNTY, N. C.

| Well No. | Location Latitude, N., and Longitude, W. | Owner | Type of Well | Depth (ft) | Diameter (in) | Depth of casing (ft) | Water-bearing material | Water level (ft) | Yield (gpm) | Drawdown (ft) | Topography | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 34° 59' 57"<br>84° 04' 14" | H. W. Hughes | Dug | 44.7 | 6 | 2 | Alluvium Residuum | 33.2 | ---- | ---- | Hillside | Observation well. Water level on 11-1-61. |
| 2 | 35° 00' 20"<br>84° 18' 10" | Wolf Creek School | Drilled | 212 | 6 | 40 | Quartzite | 80.9 | 20 | ---- | Hilltop | Observation well. Well obstructed in May 1962. |
| 3 | 35° 11' 38"<br>84° 08' 19" | Unaka School | --do-- | 212 | 6 | --- | ---do--- | 32.1 | ---- | ---- | Valley side | Observation well. Yield inadequate at times for pupils. |
| 4 | 35° 04' 40"<br>84° 02' 35" | Duncan Oil Company | --do-- | 175 | 6 | 48 | Quartz-mica gneissic schist | 3.9 | 15 | ---- | Valley Bottom | Observation well. Water level on 11-29-61 supplies petroleum bulk plant and an animal hospital. |
| 5 | 35° 04' 15"<br>84° 01' 20" | Paul Nave | --do-- | 181 | 6 | 23 | Phyllite and quartzite | 50.0 | 30 | ---- | Hillside | Observation well. Water level on 11-30-61. |
| 6 | 35° 05' 41"<br>83° 57' 00" | J. M. Reece | --do-- | 120 | 6 | 100 | Mica Schist | 46.0 | ---- | ---- | Hilltop | Observation well. Water level on 12-5-61. |
| 7 | 35° 10' 55"<br>83° 54' 37" | Herman H. West | --do-- | 330 | 6 | 300 | Marble | 54.2 | ---- | ---- | Hillside | Observation well. Water level on 12-8-61. |
| 8 | 35° 00' 59"<br>84° 10' 56" | Ranger School | Drilled | 186 | 6 | --- | Mica Schist phyllite, quartzite | 30 | ---- | ---- | Hillside | Supplies 345 pupils. |
| 9 | 35° 06' 10" | Hiwassee Dam School | --do-- | 170 | 8 | 104 | Quartzite | ---- | 40 | ---- | Valley side | Supplies 633 pupils. |
| 10 | 35° 05' 28"<br>83° 50' 46" | Peachtree School | --do-- | 210 | 6 | --- | Marble | 25 | ---- | ---- | Valley Flat | ---------- |
| 11 | 35° 01' 25"<br>84° 01' 52" | Martins Creek School | Dug | 27 | 30 | 27 | Alluvium | 20 | ---- | ---- | Ridge top | Supplies 200 pupils. |
| 12 | 35° 10' 41"<br>83° 55' 12" | Marble School | Drilled | 213 | 6 | 105 | Marble | ---- | 30 | ---- | Valley Flat | ---------- |
| 13 | 35° 04' 19"<br>84° 01' 18" | Mrs. Ben E. Warner, Sr. | --do-- | 210 | 6 | 80 | Phyllite and quartzite | 70 | 0 | ---- | Hilltop | Water level in November 1960. |
| 14 | 35° 02' 16"<br>83° 58' 03" | Little Brasstown Baptist Church | --do-- | 145 | 6 | 131 | Mica Schist | 78.4 | ---- | ---- | Hilltop | Water level on 12-1-61. |



Pg 6

TABLE 7. - RECORDS OF WELLS IN CHEROKEE COUNTY, N. C.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 35° 11' 21"<br>83° 50' 59" | Frank Carringer | --do-- | 103.0 | 6 | 113 | Marble | 40.4 | 60 | "Small" | Valley side | Water Level on 12-6-61. |
| 16 | 35° 08' 02"<br>84° 02' 12" | Texana School | --do-- | 455 | 6 | 30 | Quartz-mica, gneiss, quartz vein | 100 | ---- | ---- | Hill-top | Supplies school and 14 houses. |
| 17 | 35° 08' 42"<br>84° 05' 52" | Hugh E. Howard | --do-- | 200 | 6 | 18 | Quartzite | 60 | 5 | ---- | Hill-side | Water level on 4-1-59. |
| 18 | 35° 11' 29"<br>83° 00' 30" | E. A. Wood | --do-- | 100 | 6 | --- | Quartz-mica gneiss | 15.0 | ---- | ---- | Hill-side | Water level on 12-4-58. Inadequate supply. |
| 19 | 35° 10' 43"<br>83° 55' 20" | Monroe Garrett | --do-- | 105 | 6 | 65 | Marble | ----- | ---- | ---- | Valley flat | ---------- |
| 20 | 35° 10' 38"<br>83° 55' 33" | James Bryson | Dug | 47 | 36 | 39 | Residuum on marble | 12.2 | ---- | ---- | Valley flat | Supplies service station. |
| 21 | 35° 10' 40"<br>83° 55' 35" | Vernon Bryson | Drilled | 250 | 6 | 25 | Marble | 25 | 15 | ---- | Valley flat | Water level in fall of 1955. |
| 22 | 35° 04' 03"<br>83° 55' 33" | Nantahala Power Co. | --do-- | 89 | 6 | --- | Quartz-mica gneiss | ----- | ---- | ---- | Valley side | ---------- |
| 23 | 35° 06' 38"<br>84° 00' 39" | George F. Size, M.D. | --do-- | 123 | 6 | 70 | Mica schist | 40 | 40 | ---- | Small valley | Very high iron content. |
| 24 | 35° 03' 50"<br>84° 01' 11" | Earl C. Van Horn | --do-- | 238 | 6 | 180 | Phyllite and quartzite | 45 | 20 | ---- | Hill-side | ---------- |
| 25 | 35° 04' 29"<br>84° 03' 02" | Charlie Hughes | --do-- | 204 | 6 | 116 | Mica schist | 100 | 4½ | ---- | Hill-top | ---------- |
| 26 | 35° 04' 40"<br>83° 57' 30" | Max Blakemore | --do-- | 141.5 | 6 | 81 | Mica schist | 68.4 | 13 | ---- | Hill-side | Water level on 1-20-63. |
| 27 | 35° 12' 02"<br>83° 51' 22" | Lee D. Nichols | --do-- | 118 | 6 | 94 | Quartz-mica gneiss | 30 | 30 | ---- | Valley side | |

Pg 6

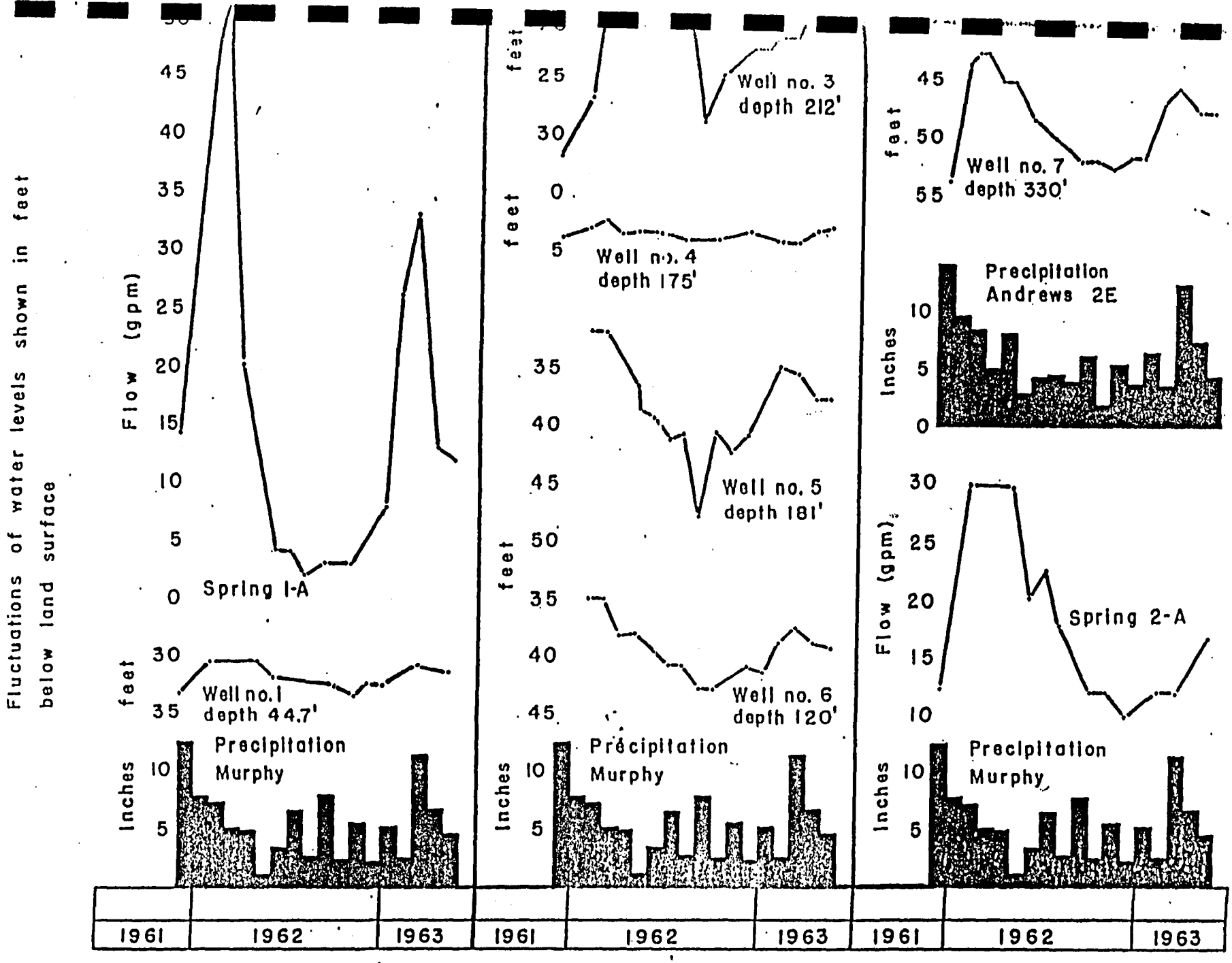



Figure 9. Fluctuation of water levels in observation wells, flow of observation springs, and monthly precipitation in Cherokee County, N. C.

TABLE 8 RECORDS OF SPRINGS IN CHEROKEE COUNTY, N. C.

| Well No. | Location Latitude, N and Longitude, W | Owner | Type of Well | Depth (ft) | Diameter (in) | Depth of casing (ft) | Water-bearing material | Water level (ft) | Yield (gpm) | Drawdown (ft) | Topography | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A | 35° 09' 21" 84° 02' 30" | Walter McDonald | Spring | --- | --- | --- | Quartzite and alluvium | --- | 14 | --- | Hillside | Observation spring. Supplies white church school. Flow on 12-1-61. |
| 2-A | 35° 05' 18" 84° 02' 28" | Hadley E. Dickey | Spring | --- | --- | --- | Quartzite | --- | 12 | --- | Hillside | Observation spring. Flow on 12-8-61. Extraordinarily dependable. Fluctuation of flow is small. |

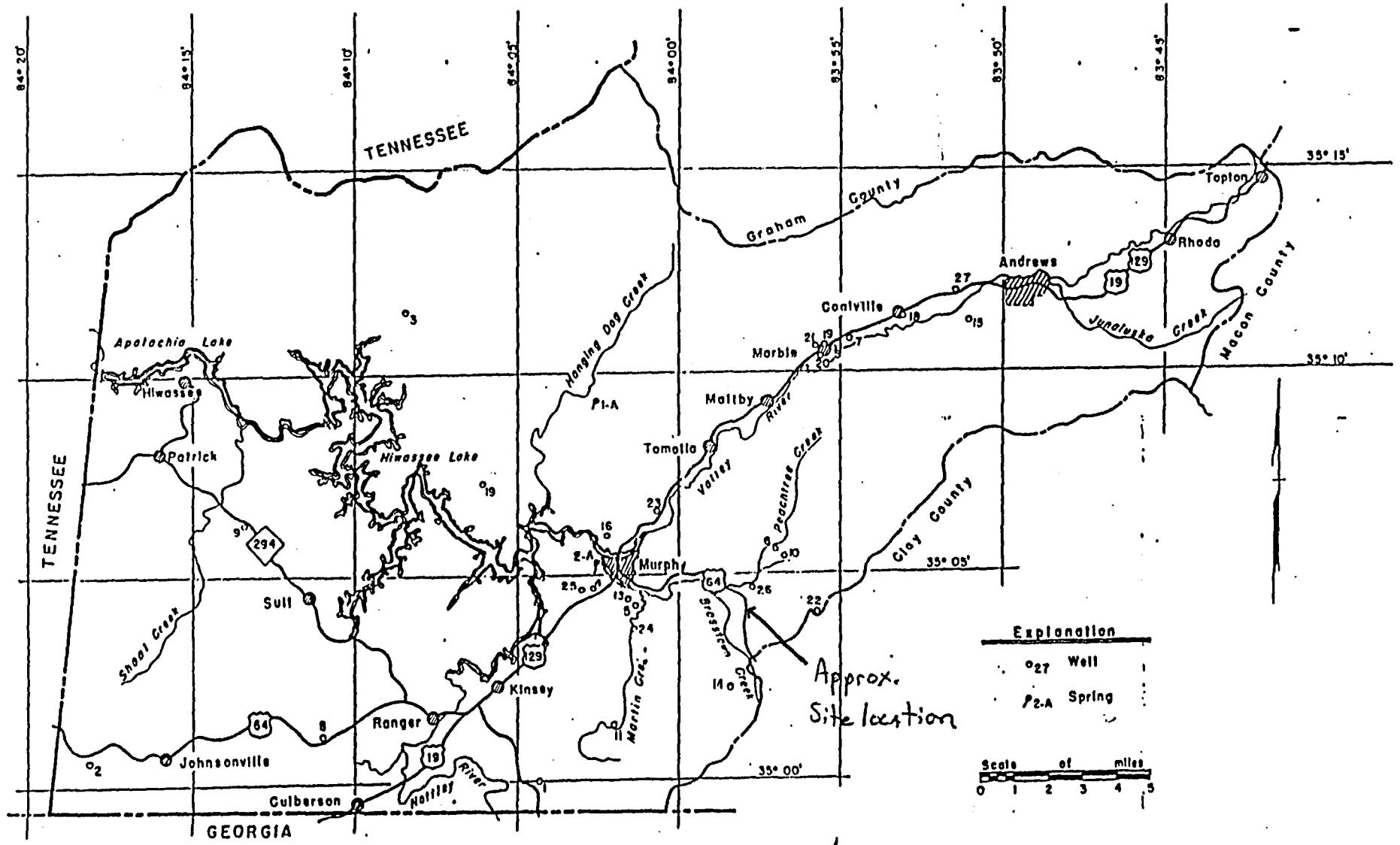



Figure 10__. Locations of wells and springs in Cherokee County, North Carolina



Pg 6

TABLE 9.- CHEMICAL ANALYSES OF GROUND WATER FROM CHEROKEE COUNTY

| Rock type[y] | Water type[z] | Source and depth (ft.)[z] | Date of collection | Silica ($SiO_2$) | Aluminum (Al) | Iron (Fe) | Manganese (Mn) | Copper (Cu) | Zinc (Zn) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Lithium (Li) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_3$) | Phosphate ($PO_4$) | Dissolved solids: Residue at 180°C | Dissolved solids: Calculated | Hardness as $CaCO_3$: Calcium, Magnesium | Hardness as $CaCO_3$: Non-carbonate | Specific conductance (micromhos at 25°C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | C | Dr- 45 | May 15, 1962. | 4.8 | 0.0 | 0.03 | 0.03 | 0.04 | 0.2 | 0.4 | 1.8 | 8.1 | 1.7 | 0.0 | 6 | 0.2 | 9.3 | 0.0 | 15 | 0.0 | 43 | 45 | 8 | 4 | 69 | 5.0 | 5 |
| mm | I | Dr-212 | May 16..... | 14 | .0 | .06 | .01 | .03 | .1 | 3.5 | 1.5 | 2.8 | 1.4 | .0 | 18 | .2 | 3.0 | .0 | 4.5 | .0 | 43 | 40 | 15 | 0 | 50 | 6.6 | 5 |
| mg | IV | Dr-175 | May 16..... | 19 | .0 | .30 | .01 | .02 | .6 | 4.0 | 2.8 | 7.2 | .5 | .0 | 41 | 2.2 | 3.0 | .0 | .0 | .0 | 61 | 59 | 22 | 0 | 76 | 6.8 | 10 |
| qp | V | Dr-181 | May 16..... | 5.9 | .1 | .15 | .06 | .04 | 2.9 | 4.0 | 5.3 | 2.3 | 4.5 | .0 | 22 | 6.4 | 5.8 | .0 | 12 | .0 | 66 | 60 | 32 | 14 | 90 | 5.8 | 5 |
| ms | I | Dr-120 | May 15..... | 4.8 | .0 | .00 | .01 | .02 | .1 | 7.5 | .7 | .3 | .3 | .0 | 28 | .2 | .9 | .0 | .0 | .0 | 28 | 29 | 22 | 0 | 47 | 6.2 | 5 |
| ms | V | Dr-186 | May 16..... | 12 | .0 | .03 | .02 | .06 | .1 | 1.2 | 1.2 | 2.2 | 1.1 | .0 | 13 | .4 | 2.0 | .0 | 3.4 | .0 | 29 | 30 | 8 | 0 | 31 | 5.7 | 5 |
| mm | II | Dr-170 | May 16..... | 11 | .0 | .09 | .03 | .11 | .0 | 4.0 | .7 | 1.5 | 1.2 | .0 | 15 | 5.2 | 1.0 | .0 | .3 | .2 | 31 | 32 | 13 | 0 | 41 | 6.4 | 5 |
| mm | V | Dr-210 | May 15..... | 5.2 | .2 | .03 | .04 | .01 | .0 | 25 | 49 | 1.8 | .7 | .0 | 294 | 16 | 4.3 | .0 | .0 | .0 | 217 | 247 | 265 | 24 | 479 | 7.2 | 10 |
| a | I | Du- 27 | May 15..... | 6.0 | .0 | .00 | .00 | .04 | .0 | 6.7 | 3.5 | .7 | .3 | .0 | 40 | .2 | .1 | .0 | .0 | .0 | 37 | 38 | 31 | 0 | 68 | 6.6 | 10 |
| mm | I | Dr-213 | May 16..... | 9.0 | .0 | .06 | .00 | .00 | .0 | 27 | 2.8 | 2.6 | .9 | .0 | 86 | 11 | 3.2 | .1 | .0 | .0 | 102 | 99 | 70 | 8 | 170 | 8.1 | 10 |
| mm | I | Dr-455 | Dec. 5..... | 14 | -- | .07 | -- | -- | -- | 6.2 | 2.8 | 3.2 | 1.4 | -- | 26 | 3.6 | 4.5 | .2 | 5.7 | -- | -- | 55 | 27 | 6 | 76 | 6.0 | -- |
| mm | I | Dr-200 | Dec. 5..... | 16 | -- | .06 | -- | -- | -- | 7.6 | 2.4 | 4.5 | 1.2 | -- | 47 | .8 | 1.8 | .2 | .2 | -- | -- | 58 | 29 | 0 | 73 | 6.7 | -- |
| mm | D | S | May 16..... | 7.0 | .1 | .00 | .01 | .02 | .0 | .6 | .3 | 1.0 | .7 | .0 | 7 | .2 | 1.3 | .0 | .0 | .0 | 16 | 15 | 3 | 0 | 14 | 5.9 | 5 |
| q | I | S | May 16..... | 7.3 | .0 | .00 | .00 | .00 | .0 | 1.5 | .5 | .6 | .5 | .0 | 9 | .2 | .3 | .0 | .0 | .1 | 18 | 15 | 6 | 0 | 18 | 6.3 | 5 |

y Rock Type

bg-biotite gneiss
hg-hornblende gneiss
ur-ultramafic rocks
gg-granite gneiss
ms-mica schist
qmm-quartzite, metaconglomerate, and metagraywacke
gms-garnet-mica schist
qp-quartzose phyllite
qmg-quartz-mica gneiss
pms-phyllitic-mica schist
mm-marble.
q-quartzite
a-alluvium

z Water Type

I-calcium, magnesium, sodium bicarbonate
II-calcium, sodium, magnesium bicarbonate
III-calcium-sodium, magnesium bicarbonate
IV-sodium, calcium, sodium bicarbonate
V-magnesium, calcium, sodium bicarbonate
D-dissolved solids too low to reflect effects of lithology upon water composition
C-excessive chloride and/or nitrate masks effects of lithology upon water composition

z Source

S-spring
Dr-drilled well
Du-dug well

Ref. 7

STATE OF NORTH CAROLINA

DEPARTMENT OF NATURAL RESOURCES AND COMMUNITY DEVELOPMENT

# CLASSIFICATIONS AND WATER QUALITY STANDARDS

# ASSIGNED TO

# THE WATERS OF THE HIWASSEE RIVER BASIN

DIVISION OF ENVIRONMENTAL MANAGEMENT

RALEIGH, NORTH CAROLINA

Reprint from North Carolina Administrative Code: 15 NCAC 2B .0302
Current through: September 1, 1981

Ref 7

eference Material to Regulation 15 NCAC 2B. 0302 Hiwassee River Basin, entitled CLASSIFICATION D WATER QUALITY STANDARDS ASSIGNED TO THE WATER OF HIWASSEE RIVER BASIN, has been amended -86 as follows:

| e of Stream | Description | Class | Index No. |
|---|---|---|---|
| WASSEE RIVER* | From Andrews Dam to Town of Murphy Raw Water Supply Intake | WS-III | 1-(36) |
| ritton Creek | From source to Andrews Water Supply Intake | WS-I | 7-52-29-(1) |
| eaver Creek | From source to Andrews Water Supply Intake | WS-III Tr | 1-52-30-(1) |
| reeman Branch | From source to Beaver Creek | WS-III Tr | 1-52-30-2 |
| Holland Creek | From source to a point 0.5 mile above mouth | WS-III Tr | 1-52-30-5-(1) |
| Branch | From source to Dan Holland Creek | WS-III Tr | 1-52-30-5-2 |
| ove Branch | From source to Dan Holland Creek | WS-III Tr | 1-52-30-5-3 |
| e Branch | From source to Big Cove Branch | WS-III Tr | 1-52-30-5-3-1 |
| e Creek | From source to Murphy Water Supply Intake | WS-I | 1-52-66-(1) |
| lian Branch | From source to Murphy Water Supply Intake | WS-I | 1-52-66-3-(1) |
| SSEE RIVER (Hiwassee below elevation 1525) | From mouth of Bearpaw Creek to Hiwassee Dam | WS-III&B | 1-(65) |

tributaries to segments of Hiwassee River classified A-II will be classified C, unless herwise noted.

| Name of Stream | Description | Classification Class | Classification Date | Index No. |
|---|---|---|---|---|
| Clabber Branch | From source to Pinelog Creek | C | 7/1/61 | 1-42-6-2 |
| Payne Branch | From source to Brasstown Creek | C | 7/1/61 | 1-42-7 |
| Will Mason Branch | From source to Brasstown Creek | C | 7/1/61 | 1-42-8 |
| Greasy Creek | From source to Brasstown Creek | C | 7/1/61 | 1-42-9 |
| Buchanan Branch | From source to Brasstown Creek | C | 7/1/61 | 1-42-10 |
| Little Brasstown Creek | From source to Brasstown Creek | C | 7/1/61 | 1-42-11 |
| Pinhook Branch | From source to Little Brasstown Creek | C | 7/1/61 | 1-42-11-1 |
| Stamey Branch | From source to Pinhook Branch | C | 7/1/61 | 1-42-11-1-1 |
| John Mason Branch | From source to Pinhook Branch | C | 7/1/61 | 1-42-11-1-2 |
| Ricks Branch | From source to Little Brasstown Creek | C | 7/1/61 | 1-42-11-2 |
| Frankum Branch | From source to Ricks Branch | C | 7/1/61 | 1-42-11-2-1 |
| Tweed Branch | From source to Little Brasstown Creek | C | 7/1/61 | 1-42-11-3 |
| Clayton Branch | From source to Little Brasstown Creek | C | 7/1/61 | 1-42-11-4 |
| Garringer Branch | From source to Little Brasstown Creek | C | 7/1/61 | 1-42-11-5 |
| Brendle Branch | From source to Little Brasstown Creek | C | 7/1/61 | 1-42-11-6 |
| Bevins Branch | From source to Brendle Branch | C | 7/1/61 | 1-42-11-6-1 |
| Jenkins Branch | From source to Brasstown Creek | C | 7/1/61 | 1-42-12 |
| Donaldson Branch | From source to Brasstown Creek | C | 7/1/61 | 1-42-13 |
| McCombs Branch | From source to Hiwassee River | C | 9/1/74 | 1-43 |
| Peachtree Creek | From source to Hiwassee River | C | 7/1/61 | 1-44 |
| Goldstring Branch | From source to Peachtree Creek | C | 7/1/61 | 1-44-1 |
| Panther Branch | From source to Peachtree Creek | C | 7/1/61 | 1-44-2 |
| Painter Branch | From source to Peachtree Creek | C | 7/1/61 | 1-44-3 |
| Fate Puett Cove Creek | From source to Peachtree Creek | C | 7/1/61 | 1-44-4 |
| Burl Branch | From source to Fate Puett Cove Creek | C | 7/1/61 | 1-44-4-1 |
| Truett Branch | From source to Fate Puett Cove Creek | C | 7/1/61 | 1-44-4-2 |
| [illegible] Branch | From source to Peachtree Creek | C | 7/1/61 | 1-44-5 |
| Elliott Branch | From source to Peachtree Creek | C | 7/1/61 | 1-44-6 |
| Pipes Branch | From source to Peachtree Creek | C | 7/1/61 | 1-44-7 |
| Mill Branch | From source to Pipes Branch | C | 7/1/61 | 1-44-7-1 |
| Gregory Branch | From source to Pipes Branch | C | 7/1/61 | 1-44-7-2 |
| Moody Branch | From source to Peachtree Creek | C | 7/1/61 | 1-44-8 |
| Slow Creek | From source to Peachtree Creek | C | 7/1/61 | 1-44-9 |
| Barnett Branch | From source to Slow Creek | C | 7/1/61 | 1-44-9-1 |
| Messer Branch | From source to Slow Creek | C | 7/1/61 | 1-44-9-2 |
| Graham Branch | From source to Slow Creek | C | 7/1/61 | 1-44-9-3 |
| Snead Branch | From source to Slow Creek | C | 7/1/61 | 1-44-9-4 |
| Cornwell Branch | From source to Snead Branch | C | 7/1/61 | 1-44-9-4-1 |
| Fall Branch | From source to Hiwassee River | C | 7/1/61 | 1-45 |
| Seibold Branch | From source to Fall Branch | C | 7/1/61 | 1-45-1 |
| Burnthouse Branch | From source to Hiwassee River | C | 7/1/61 | 1-46 |
| Will Scott Creek | From source to Hiwassee River | C | 7/1/61 | 1-47 |
| Hampton Creek | From source to Hiwassee River | C | 7/1/61 | 1-48 |
| Harshaw Branch | From source to Hampton Creek | C | 7/1/61 | 1-48-1 |
| Campground Branch | From source to Hampton Creek | C | 7/1/61 | 1-48-2 |
| Martin Creek | From source to Hiwassee River | C | 7/1/61 | 1-49 |
| Mag Ashe Branch | From source to Martin Creek | C | 7/1/61 | 1-49-1 |
| George Creek | From source to Martin Creek | C | 7/1/61 | 1-49-2 |
| Right Prong Martin Creek | From source to Martin Creek | C | 7/1/61 | 1-49-3 |
| HIWASSEE RIVER (Hiwassee Lake below elevation 1525) | From Town of Murphy Raw Water Supply Intake to Laurel Creek | C | 7/1/61 | 1-(50) |
| McColl Branch | From source to Hiwassee Lake | C | 9/1/74 | 1-51 |
| Valley River | From source to Hiwassee Lake | C Tr | 7/1/61 | 1-52 |
| Powder Burnt Branch | From source to Valley River | C Tr | 7/1/73 | 1-52-1 |
| Long Branch | From source to Valley River | C Tr | 7/1/73 | 1-52-2 |

Ref 7



examiner or examiners, will adopt its final action with respect to the assignment of classifications applicable to the waters under consideration. The commission will publish such action, together with the effective date for the application of the provisions of General Statute 143-215.1 and 143-215.2, as amended, as a part of the commission's official regulations.

(8) The final action of the commission with respect to the assignment of classification with its accompanying standards shall contain the commission's conclusions relative to the various factors given in General Statute 143-214.1(d), and shall specifically include the class or classes to which such specifically designated waters in the watershed or watersheds shall be assigned on the basis of best usage in the interest of the public.

(A) Freshwater Classifications.

(i) Class WS-I; waters protected as water supplies which are in natural and uninhabited or predominantly undeveloped (not urbanized) watersheds; no point source discharges are permitted and local land management programs to control nonpoint source pollution are required; suitable for all Class C uses;

(ii) Class WS-II; water protected as water supplies which are in low to moderately developed (urbanized) watersheds; discharges are restricted to primarily domestic wastewater or industrial non-process waters specifically approved by the commission; local land management programs to control nonpoint source pollution are required; suitable for all Class C uses;

(iii) Class WS-III; water supply segment with no categorical restrictions on watershed development or discharges; suitable for all Class C uses;

(iv) Class B; suitable for swimming, primary recreation and all Class C uses;

(v) Class C; suitable for secondary recreation and fish propagation;

(B) Tidal Salt Water Classifications.

(i) Class SA; suitable for commercial shellfishing and all other tidal salt water uses;

(ii) Class SB; suitable for swimming and primary recreation and all Class SC uses;

(iii) Class SC; suitable for secondary recreation and fish propagation;

(C) Supplemental Classifications.

(i) Trout waters; suitable for natural trout propagation and maintenance of stocked trout;

(ii) Swamp waters; waters which have low velocities and other natural characteristics which are different from adjacent streams;

(iii) Nutrient sensitive waters; waters requiring limitations on nutrient inputs;

(iv) Outstanding Resource Waters (ORW); unique and special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses.

(b) In determining the best usage of waters and assigning classifications of such waters, the commission shall consider the criteria specified in General Statute 143-214.1(d).

(c) When revising the classification of waters, the division will collect water quality data within the watershed for those instances which require more stringent control than required by the existing classification. However, such sampling may be limited to only those parameters which are suspected to be present in significant quantities.

(d) The rules contained in Section 2B .0100, 2B .0200 and 2B .0300 which pertain to the series of classifications and water quality standards shall be known as the "Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina."

History Note: Statutory Authority G.S. 143-214.1;
143-215.3(a)(1);
Eff. February 1, 1976;
Amended Eff. February 1, 1986; January 1, 1985;
September 9, 1979.

.0102 USE OF CLASSIFICATIONS AND WATER QUALITY STANDARDS

History Note: Statutory Authority G.S. 143-214.1;
Eff. February 1, 1976;
Repealed Eff. January 1, 1985.

.0103 ANALYTICAL PROCEDURES

Tests or analytical procedures to determine conformity or nonconformity with standards will, insofar as practicable and applicable, conform to the guidelines by the Environmental Protection Agency codified as 40 CFR, Part 136, which are adopted

Ref. 9

SOIL & MATERIAL ENGINEERS, INC. ENGINEERING-TESTING-INSPECTION

349 East Blackstock Road, Spartanburg, S.C. 29301 Phone (803) 574-2360

November 12, 1986

Clifton Precision Company
Route 1 Box 160
Murphy, North Carolina 28906

Attention: Mr. Mike Hogshead

Subject: Monitoring Well Installation
Clifton Precision
Murphy, North Carolina
1261-86-195

Dear Mike:

Please consider this notification of installation of three monitoring wells at the referenced project. A request for installation was submitted by Clifton Precision, Murphy, North Carolina. Attached are our Boring Logs and Well Schematics.

A copy has been provided for submission to North Carolina DHEC.

Should you have questions regarding the contents of this letter or further information is needed, please feel free to call us.

Sincerely,

SOIL & MATERIAL ENGINEERS, INC.

John Whitehead

John Whitehead
Geologist

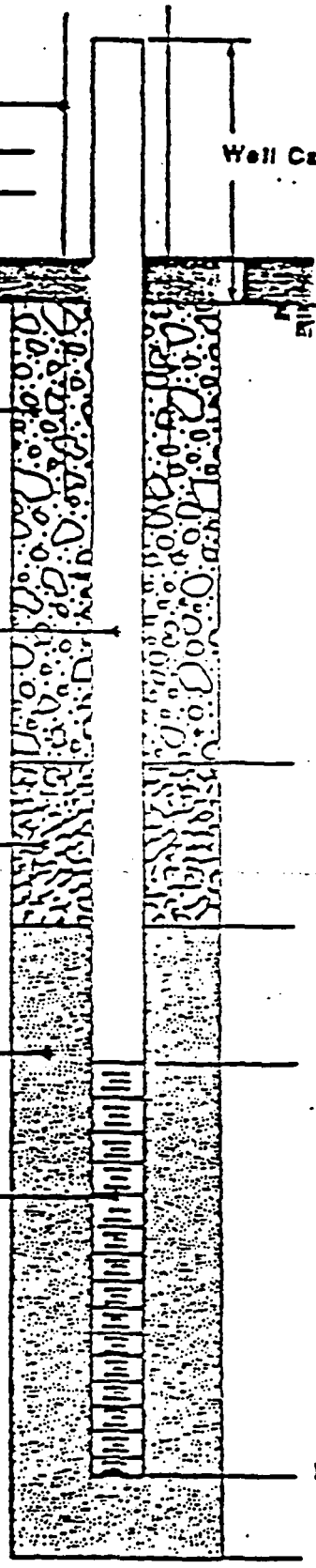
JW/cg

# MONITORING WELL SCHEMATIC

Ref 9

WELL NO. MW-1
Date Completed 10-7-86
Project No. 1262-86-195

O.D. OF CASING 2"
LENGTH OF SCREEN 10'
SCREEN OPENING SIZE 0.010



Protective Casing
Protective Casing Length 5'
Protective Casing Stickup 2.5'

Well Casing Stickup 2'

Ground Surface Elev. 0.0'

Grout
Portland
(Type)

Casing
2" SCH 40 PVC
(Size and Type)

Depth to Top of Bentonite 9'

Bentonite
Pellets
(Type)

Depth to Top of Gravel/Sand 11'

Gravel/Sand

Depth to Top of Screen 13'

Screen

Depth to Bottom of Screen 23'

Total Depth 23.5'

NOTE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

# MONITORING WELL SCHEMATIC

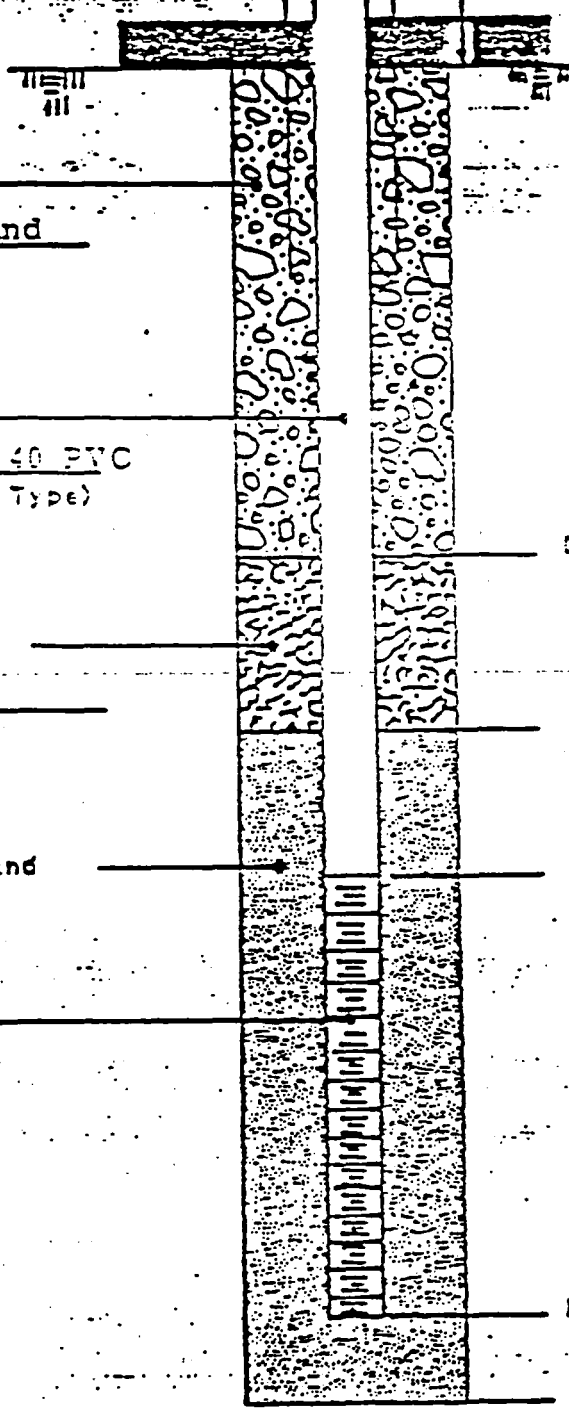
Pg 9

WELL NO. MW-2
Date Completed 10-7-86
Project No. 1262-86-195

O.D. OF CASING 2"
LENGTH OF SCREEN 10'
SCREEN OPENING SIZE 0.010

Protective Casing
Protective Casing Length 4'
Protective Casing Stickup 2'

Well Casing Stickup 1.5'



Ground Surface Elev. 0.0'

Grout
Portland
(Type)

Casing
2" SCH 40 PVC
(Size and Type)

Depth to Top of Bentonite 0.5'

Bentonite
Pellets
(Type)

Depth to Top of Gravel/Sand 1.5'

Gravel/Sand

Depth to Top of Screen 3'

Screen

Depth to Bottom of Screen 13'

Total Depth 13.5'

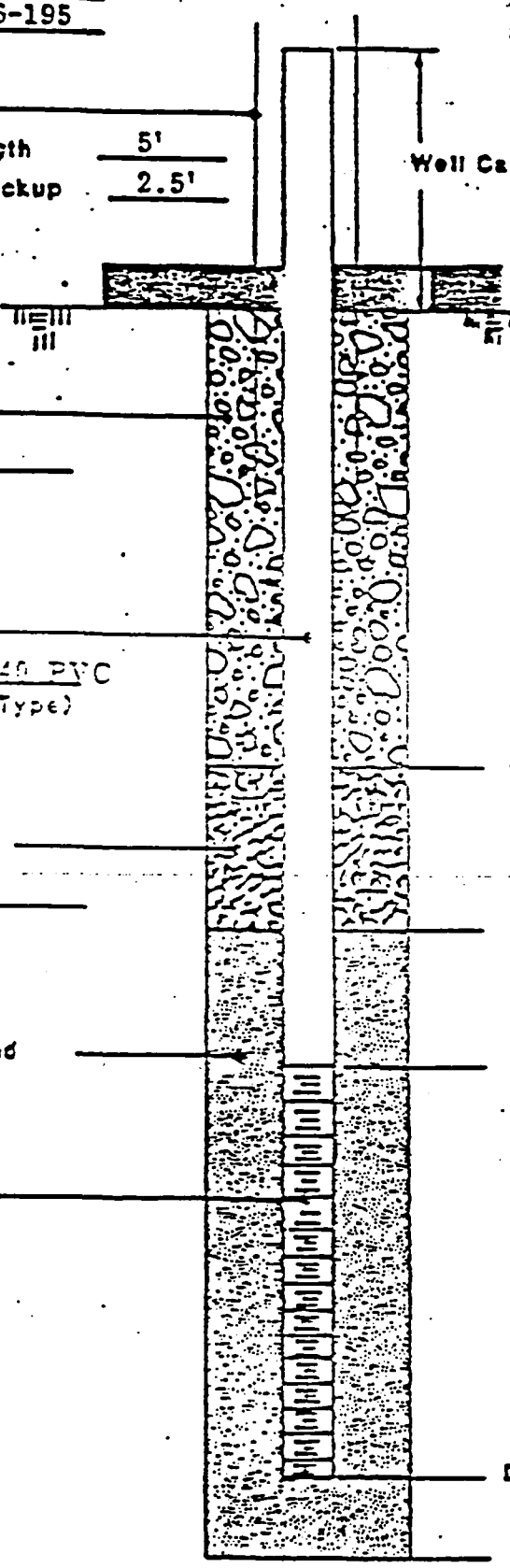
NOTE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

# MONITORING WELL SCHEMATIC

Ref 9

WELL NO. MW-3
Date Completed 10-7-86
Project No. 1262-86-195

O.D. OF CASING 2"
LENGTH OF SCREEN 10'
SCREEN OPENING SIZE 0.010



Protective Casing
Protective Casing Length 5'
Protective Casing Stickup 2.5'

Well Casing Stickup 2'

Ground Surface Elev. 0.0'

Grout
Portland
(Type)

Casing
2" SCH 40 PVC
(Size and Type)

Depth to Top of Bentonite 9'

Bentonite
Pellets
(Type)

Depth to Top of Gravel/Sand 11'

Gravel/Sand

Depth to Top of Screen 13'

Screen

Depth to Bottom of Screen 23'

Total Depth 25'

TE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

# SOIL BORING AND WELL RECORD

Ref 9

Clifton
tion: Precision Murphy County: _____ Job No.: 1262-86-195 Boring or Well No. Well #1
N.C.
ed by: Donnahoo Drilled by: Donnahoo Grid Coord.: _____ Lat.-Long.: _____
Started: 10-7-86 Boring Depth: 23.5' Static Water Level _____
Completed: 10-7-86 Well Depth: 23' Permeability Tests: _____
ing Method: HSA Casing: 2" SCH 40 PVC Gravel Pack: Sand
elopment Method: SAP Screen: 2" PVC 0.010 Slot Seal: Bentonite Pelle
Samples: Auger Cuttings Grout: Portland
hysical Logs: _____ Chem. Analysis: Yes

| Elev. | Depth | Description | Construction Details (ft.) 5 10 20 30 40 60 80 |
|---|---|---|---|
| | 10 | Soft to Stiff Yellow Brown Fine Sandy Silty CLAY | |
| | 20 | | |
| | | Boring Terminated @ 23.5' | |

# SOIL BORING AND WELL RECORD

Ref 9

Clifton

tion: Precision Murphy N.C. County: _____ Job No.: 1262-86-195 Boring or Well No.: Well #2

ged by: Donnahoo Drilled by: Donnahoo Grid Coord.: _____ Lat.-Long.: _____

Started: 10-7-86 Boring Depth: 13.5' Static Water Level 8.0'

Completed: 10-7-86 Well Depth: 13.0' Permeability Tests: _____

illing Method: HSA Casing: 2" SCH 40 PVC Gravel Pack: Sand

elopment Method: SAP Screen: 2" PVC 0.010 Slot Seal: Bentonite Pellets

Samples: Auger Cuttings Grout: Portland

hysical Logs: _____ Chem. Analysis: Yes

| Elev. | Depth | Description |
|---|---|---|
| | | Crushed Stone |
| | | Soft Gray Micaceous Fine Sandy CLAY |
| | 10 | Very Hard Dark Gray Fine Sandy CLAY |
| | | Boring Terminated @ 13.5' |
| | 20 | |

Clifton

# SOIL BORING AND WELL RECO

Ref 9

tion: Precision Murphy, N.C. County: _____ Job No.: 1262-86-195 Boring or Well No.: Well#

ed by: Donnahoo Drilled by: Donnahoo Grid Coord.: _____ Lat.-Long.: _____

e Started: 10-7-86 Boring Depth: 25.0' Static Water Level 18.5'

e Completed: 10-7-86 Well Depth: 23.0' Permeability Tests: _____

ling Method: HSA Casing: 2" SCH 40 PVC Gravel Pack: Sand

elopment Method: SAP Screen: 2" PVC 0.010 Slot Seal: Bentonite Pelle

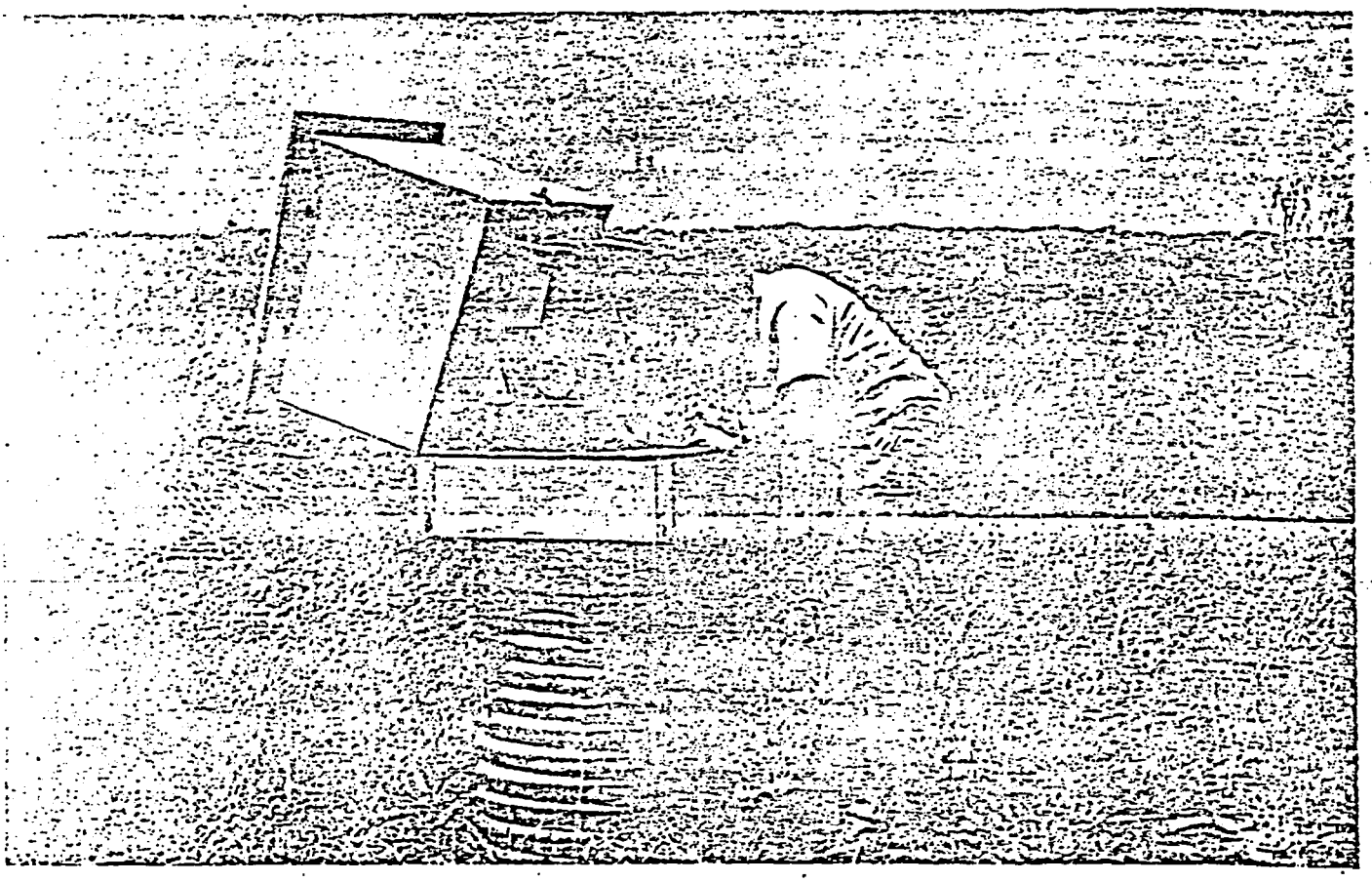
Samples: Auger Cuttings Grout: Portland

ysical Logs: _____ Chem. Analysis: Yes

| Elev. | Depth | Description | |
|---|---|---|---|
| | | Loose Brown Micaceous Fine Sandy SILT | |
| | 10 | Very Soft Brown Micaceous Fine Sandy Silty CLAY | |
| | 20 | | |
| | | Boring Terminated @ 25.0' | |

Ref 10

# Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina

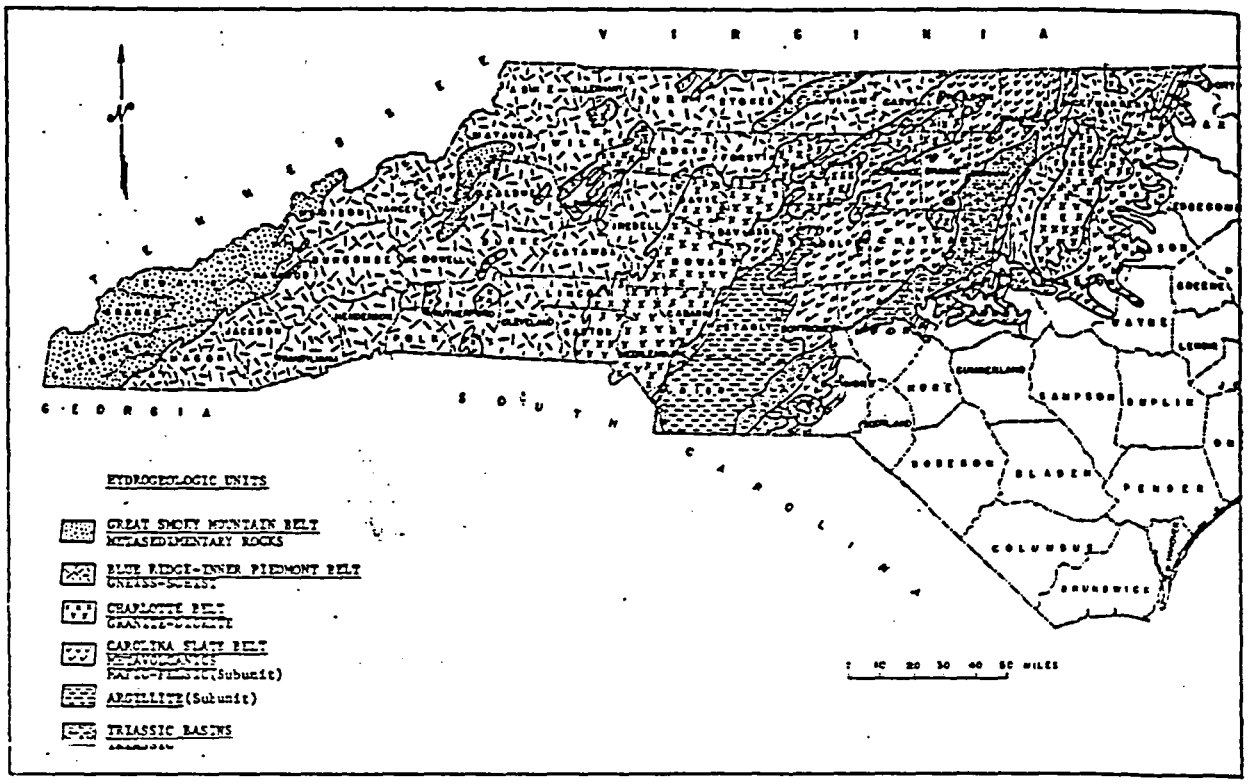


U.S. GEOLOGICAL SURVEY
WATER RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 80-44

Prepared in cooperation with the
North Carolina Department of Natural
Resources and Community Development

Ref 10

# Rock Units and Aquifers in the Piedmont and Mountains




The rocks underlying the Piedmont and mountains can be divided into two groups: (1) bedrock, and (2) saprolite (or residuum). The saprolite underlies the land surface and ranges in thickness from a foot or two near bedrock outcrops to more than 100 ft. Bedrock underlies the saprolite and is the parent rock from which the saprolite was derived in the process referred to as weathering.

Many stream valleys, especially those of larger streams, are underlain by a layer of material similar in composition to saprolite. This material, which has been deposited by the streams during floods, is correctly referred to as *alluvium*. However, to avoid unnecessary complications, we will lump the alluvium in with the saprolite for the purpose of this discussion.

The bedrock underlying the Piedmont and mountains consists of many different types of igneous and metamorphosed igneous and sedimentary rocks. The Generalized Geological Map of North Carolina accompanying the discussion of WATER-BEARING ROCKS divides the bedrock in the Piedmont and mountains into six units. The 1:500,000 scale Geologic Map of North Carolina, published in 1958, divides the bedrock in the same area into 48 different units. But, a much larger number of units have been identified and are shown on large scale geologic maps.

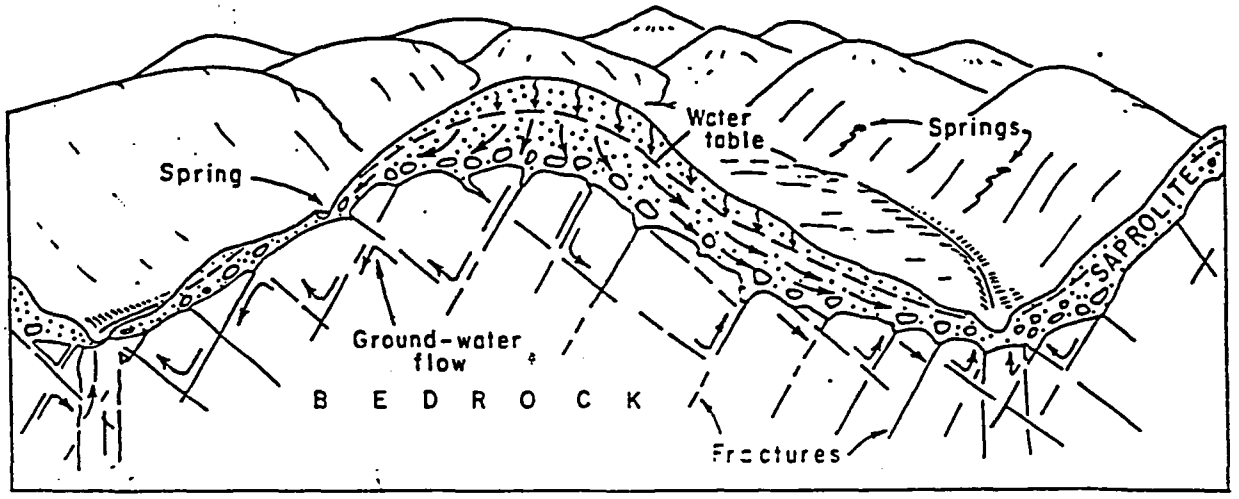
The bedrock units differ from each other in mineral composition and other geologic characteristics. Fortunately, these differences do not result in large differences in hydraulic characteristics so that it is possible to combine the bedrock units into a relatively small number of hydrogeologic units.

The accompanying map shows the hydrogeologic units into which the bedrock in the Piedmont and mountains has been divided by the U.S. Geological Survey and the North Carolina Groundwater Section.

The most productive hydrogeologic units are the Great Smoky Mountain belt and the Blue Ridge-Inner Piedmont belt. The least productive units are the Carolina Slate Belt and the Triassic Basins. The Charlotte Belt is intermediate in productivity.

Ref 10

# Ground-Water Situation in the Piedmont and Mountains




The *saprolite* (weathered rock) that forms the land surface in the Piedmont and mountains consists of unconsolidated granular material. It thus contains water in the pore spaces between rock particles.

The *bedrock*, on the other hand, does not have any significant intergranular (primary) porosity. It contains water, instead, in sheet-like openings formed along fractures (that is, breaks in the otherwise "solid" rock). Fractures in bedrock are of two types: (1) *joints*, which are breaks along which there has been no differential movement; and (2) *faults*, which are breaks along which the adjacent rocks have undergone differential movement.

Faults are formed during earthquakes and generally contain larger and more extensive openings than those developed along joints. Joints, however, are far more numerous than faults.

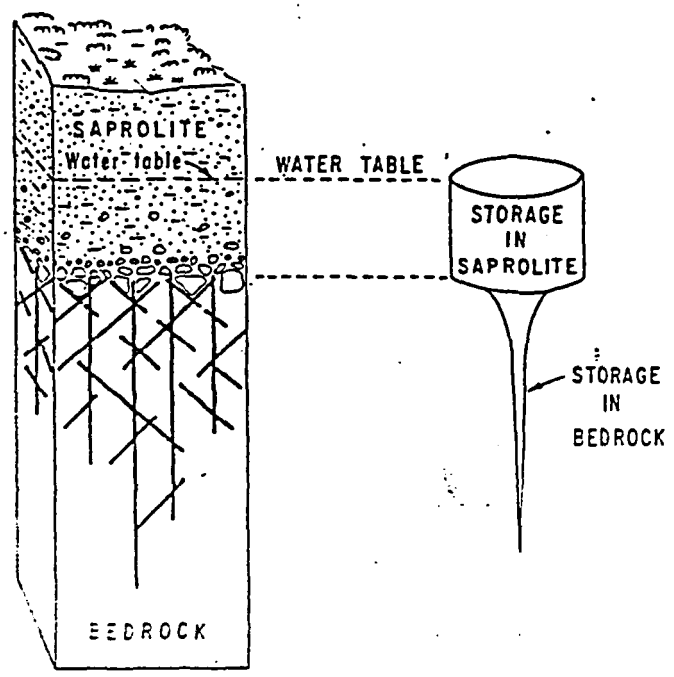
Fractures (joints and faults) are more abundant under valleys, draws, and other surface depressions than under hills. In fact, geologists assume that it is the presence of fractures that determined the position of valleys in the first place. Fractures tend to be more closely-spaced and the openings developed along them tend to be larger near the surface of the bedrock. Most fractures appear to be non water-bearing below a depth of 300 to 400 ft. Large water-bearing openings, penetrated below this depth are probably associated with faults.

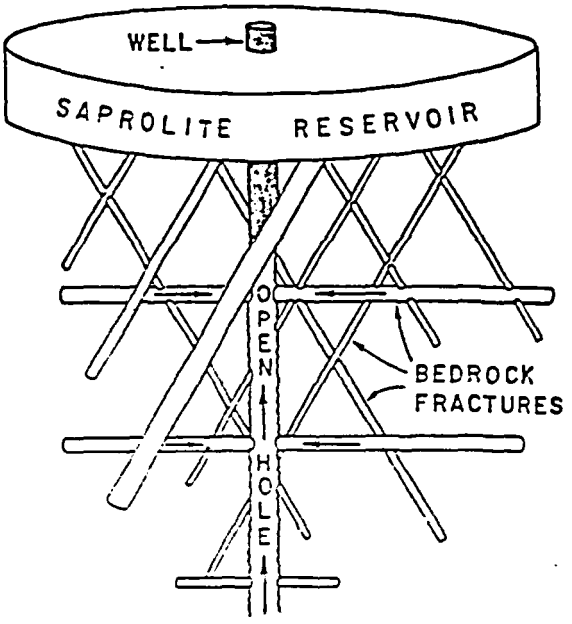
The ground-water system in the Piedmont and mountains is recharged by precipitation on the interstream areas. A part of the precipitation infiltrates through the unsaturated zone to the water table, which normally occurs in the saprolite.

Ground water moves laterally and downward through the saprolite to points of ground-water seepage (springs) on the hillsides and to the streams in the adjacent valleys. Some of the water in the saprolite also moves downward into the bedrock and, thereafter, through the fractures to the adjacent valleys.

Ref 10

# Hydraulic Characteristics of the Piedmont and Mountain Ground-Water System




One of the most basic concepts of ground-water hydrology is that aquifers function both as reservoirs, in which water is in storage, and as pipelines, which transmit water from one point to another. This is referred to as the *reservoir-pipeline concept.* This concept forms a useful basis on which to discuss the hydraulic characteristics of the Piedmont and mountain ground-water system.

The reservoir (storage) function of aquifers depends on the porosity. The pipeline function depends on the hydraulic conductivity and the thickness of the aquifer. The approximate range in porosity and hydraulic conductivity for the saprolite and bedrock is shown in the following table.

| Rock type | Porosity in percent | Hydraulic conductivity in feet per day |
|---|---|---|
| Saprolite | 20-30 | 1-20 |
| Bedrock | 0.1-1 | 1-20 |

The above values suggest that the principal difference between saprolite and bedrock is in water-storage capacity. In other words, the saprolite has the capacity to store a much larger quantity of water than does the bedrock. This is not the entire story, however.

As we noted above, the capacity of an aquifer to transmit water depends both on hydraulic conductivity and on aquifer thickness. The part of the bedrock containing water-bearing fractures is several times thicker than the saprolite.

Ref 10

We can then, without great error, view the ground-water system in the Piedmont and mountains as consisting of a saprolite reservoir overlying a bedrock pipeline consisting of numerous small, interconnected pipes. In the vicinity of a pumping well the bedrock fractures ("pipes") convey water from the saprolite reservoir to the well.

The yield of a well drawing from fractured bedrock depends on several factors. The most important of these are believed to be:

1. The number, size, areal extent, and degree of interconnection of the fractures penetrated by the well,
2. The thickness of saturated saprolite in the vicinity of the well and the specific yield of the saprolite, and
3. The hydraulic conductivity of the saprolite and the nature of the hydraulic connection between the saprolite and the bedrock.

The number and the size of the fractures control the rate at which water can enter the well. The areal extent and degree of interconnection of the fractures control the size of the area that supplies water to the well.

The thickness and the specific yield of the saprolite determines the volume of water available from storage in the saprolite. The hydraulic conductivity of the saprolite and the nature of the hydraulic connection between the saprolite and the bedrock determines the rate at which water can drain from the saprolite into the bedrock fractures.

Ref 10

## Hydraulic Conductivity of Selected Rocks

| Material | Hydraulic conductivity (rounded values) (ft/day) | [(gal/day)/ft²] | (meters/day) |
|---|---|---|---|
| Coarse sand | 200 | 1500 | 60 |
| Medium sand | 130 | 1000 | 40 |
| Silt | 1 | 5 | 0.2 |
| Clay | 0.001 | 0.01 | 0.0004 |
| Limestone (Castle Hayne) | 300 | 2000 | 80 |
| Saprolite | 5 | 50 | 2 |
| Granite and gneiss | 5 | 50 | 2 |
| Slate | 3 | 25 | 1 |

Hydraulic conductivity replaces the term "field coefficient of permeability" and should be used when referring to the water-transmitting characteristic of material in quantitative terms. It is still permissible to refer in qualitative terms to "permeable" and "impermeable" material.

PROBLEM - Determine the hydraulic conductivity of the confined aquifer shown in the preceding drawing in both feet per day and gallons per day per square foot.

(1) Solution in feet per day

(Equation) (Q) (A) (dl/dh)

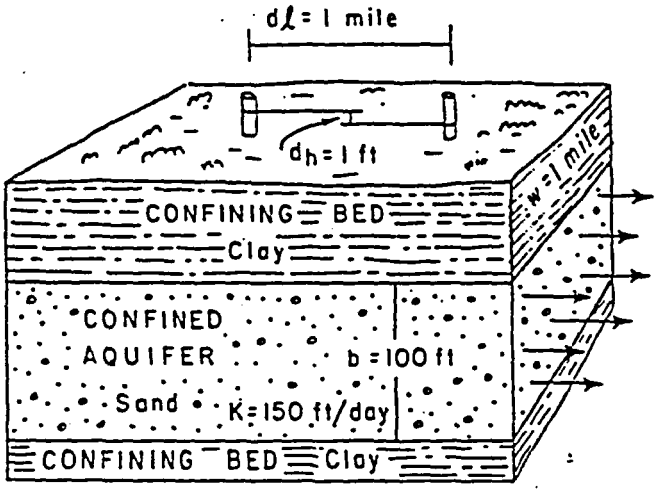
$$K = \frac{Qdl}{Adh} = \frac{150\ ft^3}{day} \times \frac{1}{ft^2} \times \frac{1\ ft}{1\ ft} = \frac{150\ ft^3}{day\ ft^2} = 150\ ft/day$$

(2) Conversion of feet per day to gallons per day per square foot

$$\frac{150\ ft^3}{day\ ft^2} \times \frac{7.5\ cal}{ft^3} = 1125\ (gal/d)/ft^2$$

Ref 10

# Transmissivity




The capacity of an aquifer to transmit water is referred to as its transmissivity. The *transmissivity* (T) of an aquifer is equal to the hydraulic conductivity of the material comprising the aquifer multiplied by the thickness of the aquifer. Thus

$$T = Kb \qquad (1)$$

where T is transmissivity,
K is hydraulic conductivity, and
b is aquifer thickness.

As was the case with hydraulic conductivity, transmissivity is also defined in terms of a unit hydraulic gradient.

If we combine equation 1 with Darcy's law (see HYDRAULIC CONDUCTIVITY), the result is an equation that can be used to calculate the quantity of water moving through a width, w, of an aquifer. Thus,

$$Q = KA\frac{dh}{dl} = K(bw)\frac{dh}{dl} = (Kb)w\frac{dh}{dl}$$

$$Q = Tw\frac{dh}{dl} \qquad (2)$$

Equation 2 is also used to calculate transmissivity, where the quantity of water (Q) discharging from a known width of aquifer can be determined as, for example, with streamflow measurements. Rearranging terms, we obtain

$$T = \frac{Q\,dl}{w\,dh} \qquad (3)$$

The units of transmissivity, as can be demonstrated with the preceding equation, are

$$T = \frac{(ft^3\ day^{-1})\ (ft)}{(ft)\ (ft)} = \frac{ft^2}{day}$$

Because transmissivity depends both on K and b, its value is different in different aquifers and from place to place in the same aquifer.

**Average Values of Hydraulic Conductivity, Thickness, and Transmissivity for Selected Aquifers in North Carolina**

| Aquifer | Hydraulic Conductivity (ft./day) | Thickness (ft.) | Transmissivity (ft²./day) |
|---|---|---|---|
| Post-Yorktown deposits | 50 | 20 | 1000 |
| Yorktown Formation | 50 | 40 | 2000 |
| Castle Hayne Limestone | 300 | 100 | 30000 |
| Cretaceous deposits | 20 | 200 | 4000 |
| Saprolite | 5 | 50 | 250 |
| Granite and gneiss | 5 | 200 | 1000 |

Transmissivity replaces the term "coefficient of transmissibility" because, by convention, an aquifer is transmissive and the water in it is transmissible.

PROBLEM - Determine the quantity of water (Q) moving through the segment of the confined aquifer shown in the preceding drawing in both ft.³/day and gal./day.

**(1) Calculation of transmissivity**

$$T = Kb = \frac{150\ ft}{day} \times \frac{100\ ft}{1} = \frac{15{,}000\ ft^2}{day}$$

**(2) Solution in ft.³/day**

$$Q = Tw\frac{dh}{dl} = \frac{15{,}000\ ft^2}{day} \times \frac{5280\ ft}{1} \times \frac{1\ ft}{5280\ ft} = \frac{15{,}000\ ft^3}{day}$$

**(3) Conversion of ft³./day to gal./day**

$$\frac{15{,}000\ ft^3}{day} \times \frac{7.5\ gal}{ft^3} = 112{,}500\ gal/day$$

Ref. 11

4 March 1987

TO: File

FROM: Stan Atwood SA

RE: Tri-County Community College

I spoke with Dr. Leon Tatham, Dean of Instruction, who supplied the following information:

1. The 55-gallon drum, marked trichloroethylene, that was found in the machine shop contains motor oil. The drum has apparently been there for 10 to 15 years; its origin is unknown.

2. The machine shop was opened in 1981 or 1982; prior to this it was used for storage.

3. The DOT used this building earlier as a maintenance shed and garage. Pits inside the building were used for servicing vehicles.

4. There are two wells on-site; one under the water tower (270 ft. deep, water level less than 20 ft.), and one next to the body shop (depth not reported).

5. The campus property totals 77 acres. The property line runs to the river.

SA/tb/0187b

# NORTH CAROLINA ATLAS

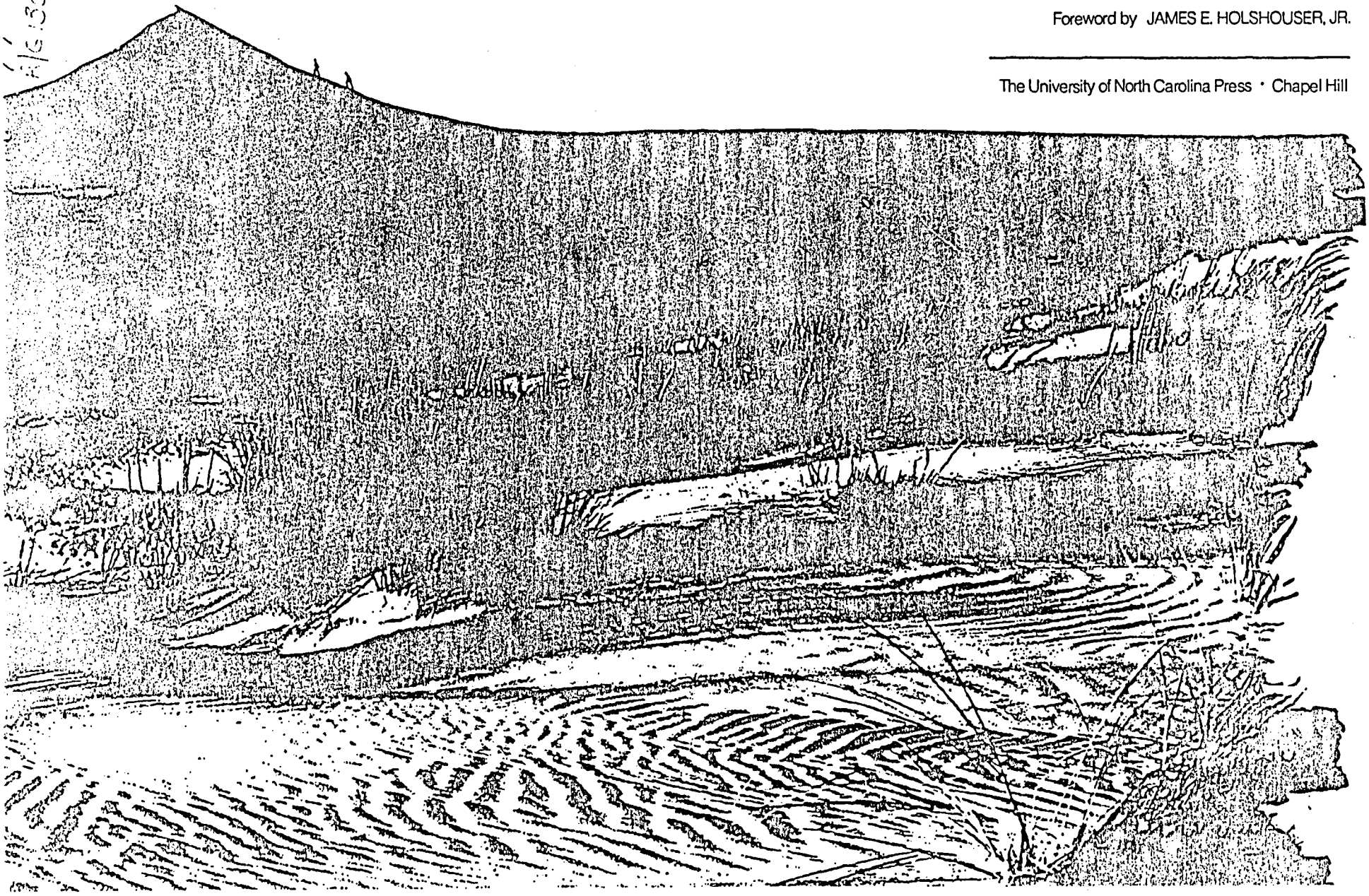
## PORTRAIT OF A CHANGING SOUTHERN STATE



Edited by JAMES W. CLAY
DOUGLAS M. ORR, JR.
ALFRED W. STUART

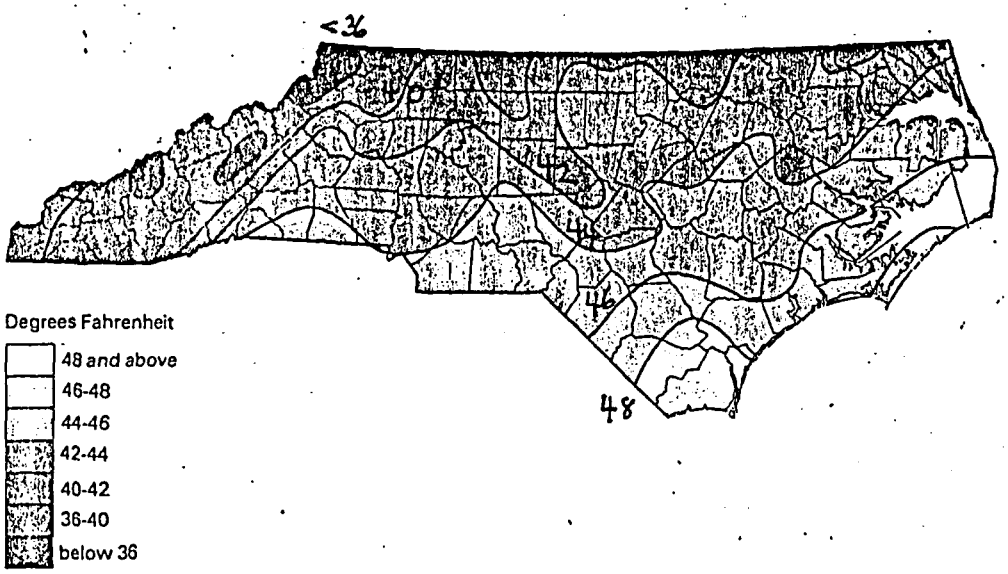
Foreword by JAMES E. HOLSHOUSER, JR.

The University of North Carolina Press · Chapel Hill



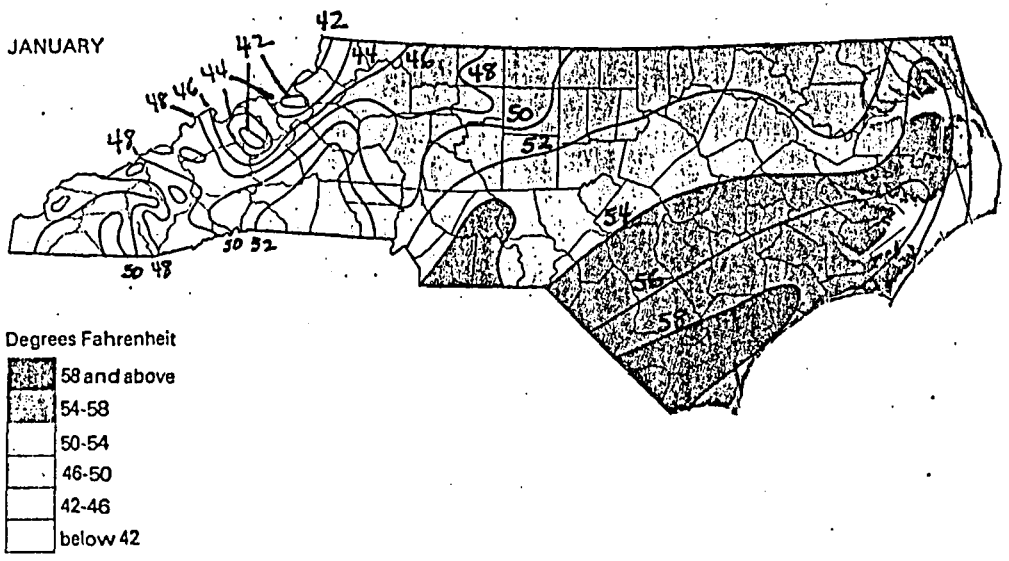
Ref 12

Figure 5.2. Average January Temperatures in N.C.




Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

Figure 5.3. Mean Maximum Temperature in N.C.




Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

## Seasonal Changes in Climate

**Winter** The alternate passage of low- and high-pressure systems over the state during winter months results in changing weather conditions. Moisture and warmer temperatures are characteristically associated with frequently passing low-pressure cells. Lows are followed by polar highs, which bring lower temperatures and clear skies. However, even when under the influence of these polar highs, temperatures seldom fall below 10° F., and midday temperatures reach into the forties, making the winter season very tolerable by northern standards.

January average temperatures shown in Figure 5.2 illustrate the mildness of winters. Only at the highest elevations do temperatures average below freezing. The mean temperature for January at Mount Mitchell is 28.7° F., the lowest in the state. Yet, at Asheville, located on the lee side of the mountains, temperatures for January average 39.4° F.

Nowhere else in North Carolina is the local contrast in temperatures as great as in the western counties. Temperature contrasts are least where the climate is mildest. Hatteras, on the Outer Banks, has a January mean of 48.0° F., and only thirteen days each year when temperatures of 32° F. and below are recorded.

The tendency for January isotherms to parallel the coast shows the influence of the Atlantic Ocean. Wilmington, in southeastern North Carolina, the most subtropical area in the state, exemplifies the maritime effect. This coastal city has a January mean temperature of 47.8° F., and an average of only eight days during January when temperatures dip to 32° F. or less, as compared with eighteen days at Raleigh and nineteen at Asheville.

In the Piedmont, latitude is the primary control on temperature, and the isotherms maintain a zonal pattern. As might be expected, temperature averages lie between those exhibited by the surrounding regions. Charlotte has a mean January temperature of 42.3° F., Greensboro, 39.0° F., and Raleigh, 42.7° F.

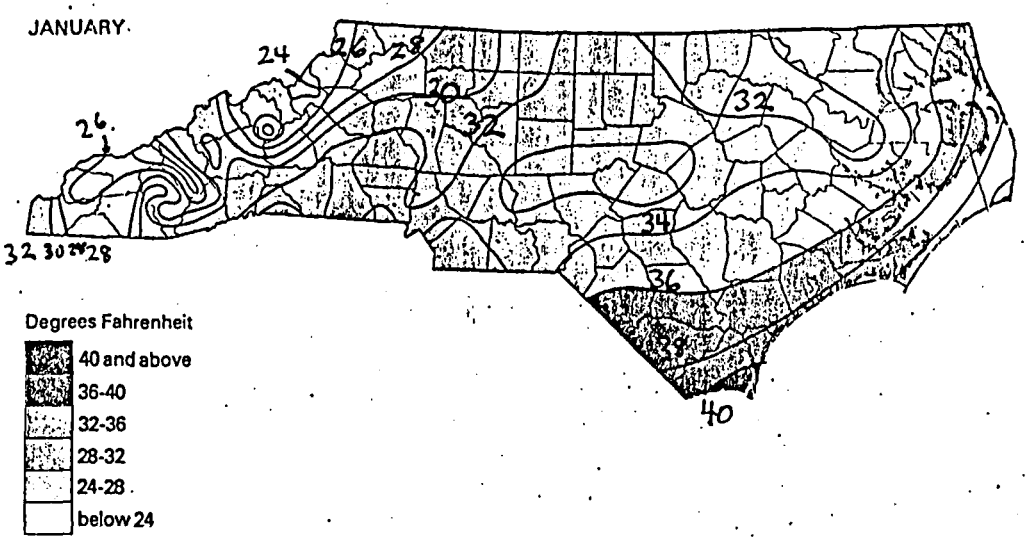
However, whereas Asheville averages eighty-three days each year when temperatures drop below freezing, Winston-Salem has freezing temperatures eighty-eight days annually, and Greensboro has eighty-four days with freezing temperatures.

**January Mean Maximum and Minimum Temperatures** Figure 5.3 illustrates the temperature pattern across North Carolina on a typical afternoon of the coldest month. The cool waters of the East Coast are responsible for the isotherms taking an abrupt inland turn to the north before resuming the northeast-southwest pattern usually found on temperature maps. This distribution indicates that midday temperatures in January are highest a short distance inland from the coast unlike the pattern of mean temperatures that indicates a smooth gradient from the coast westward. Also, in the mountains, isotherms of mean maximum temperature are more numerous and some "islands" or "pockets" of cool temperatures exist. The greater ranges of temperature are associated with mountain valleys where nights are cold and days are warm, causing patterns of maximum temperatures to contrast significantly with mean temperature distributions.

The moderating effect of the ocean becomes evident in Figure 5.3, where January mean minimum temperatures are shown. Isotherms on this map reflect characteristic nighttime temperatures. The pattern reveals that temperatures are milder along the coast and decrease inland fairly rapidly. Once again, the temperature pattern is more complex in the highlands region. Generally, mean minimum temperatures are well below freezing in the Mountain region, at freezing levels throughout the Piedmont, and above freezing in the Coastal Plain. A comparison of Figures 5.3 and 5.4 indicates that during January the daily range of temperature is about 20° F. everywhere in the state.

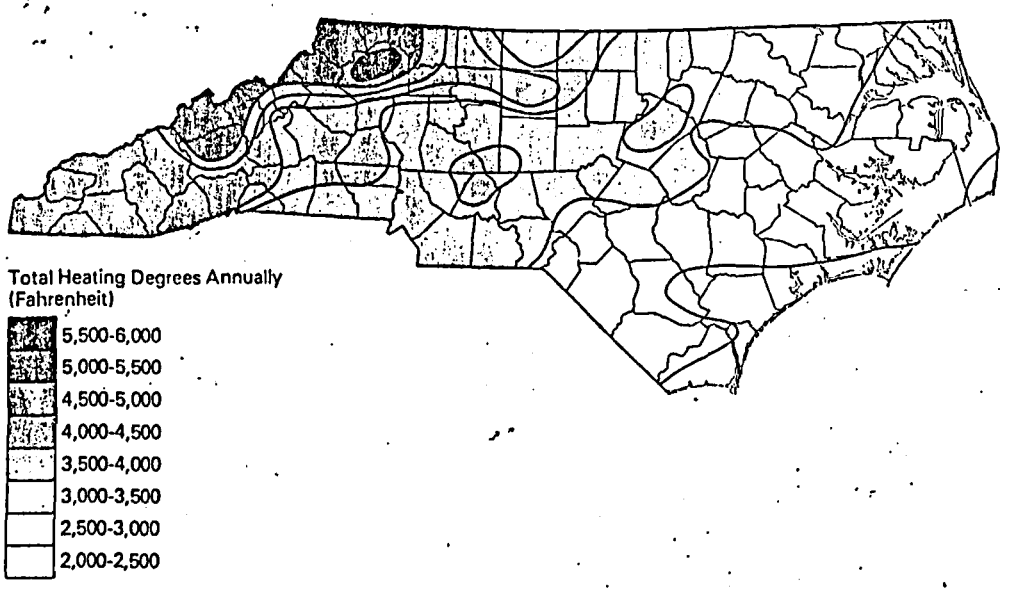
**Average Annual Heating Degree Days** There are climatically significant measurements of heat energy variation other than the direct determination of temperature, the cyclical occurrence of certain temperature levels, or the periodicity of temperature realms. These measurements relate to temperature efficiency in terms of human comfort or plant growth. One of these less common indexes is the *heating degree day*. This measurement is a cold season index and is based on the assumption that a temperature of 65° F. within a building is the minimum thermal threshold for normal human comfort. The negative departure of daily mean temperature from this standard figure is recorded as heating degree day units. For example, a daily temperature average of 40° F. would be listed as twenty-five heating degree days. Developed by heating engineers, this index permits a relatively accurate measurement of fuel consumption, and removes the guesswork from the calculation of fuel needs. The accumulation of heating degree day units at given locations is totaled annually and averaged for a period of years. To those persons interested in climate, this indirect measurement of heat energy provides additional insight into the thermal environment.

**Figure 5.4. Mean Minimum Temperature in N.C.**




Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

**Figure 5.5. Average Annual Heating Degree Days in N.C.**




Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

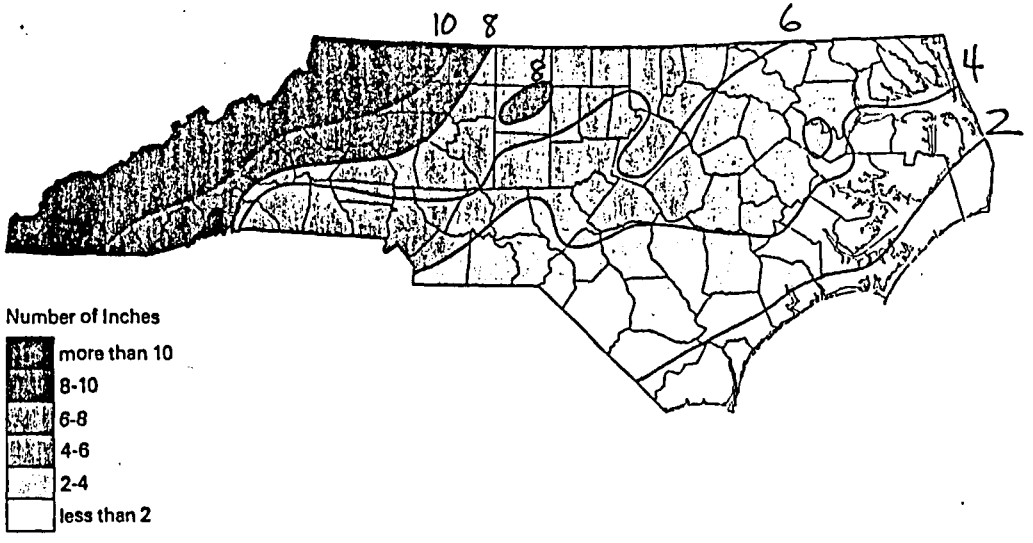
When high-pressure systems (anticyclones) dominate, clear to partly cloudy weather prevails. Receiving, on the average, 50 to 60 percent of total possible sunshine, North Carolina receives more hours of winter sunshine than do states to the north and to the immediate west. Sunshine is more prevalent in the southeast around Wilmington, and diminishes rapidly as the Mountains are approached. The Mountains receive about one-third less sunshine than does the rest of North Carolina.

**Spring** For many North Carolinians, this season is the most preferable of all. With the northward shifting of the noon sun, the storm track normal to North Carolina during the winter retreats northward and fewer and fewer cyclonic storms occur. Cold spells are less numerous and periods of high temperatures and balmy days become longer and more pronounced. Rainfall diminishes slightly in April, but increases toward the summer as cyclonic activity gives way to thundershowers and their heavy downpours. Although more precipitation is received in the state during May and June, there are fewer hours and days in which rainfall occurs, indicating a higher precipitation intensity.

Mean temperatures range from the fifties in April to the seventies in June for all places save those at high elevations. The days are marked by cool nights and warm afternoons with relative humidities at optimal levels for human comfort. As the daylight period lengthens, sunshine percentages and totals increase to their highest values for the year. For the eastern two-thirds of the state, sunshine during April, May, and June is received approximately 70 percent of the time and in amounts exceeding three hundred hours for the latter part of the season.

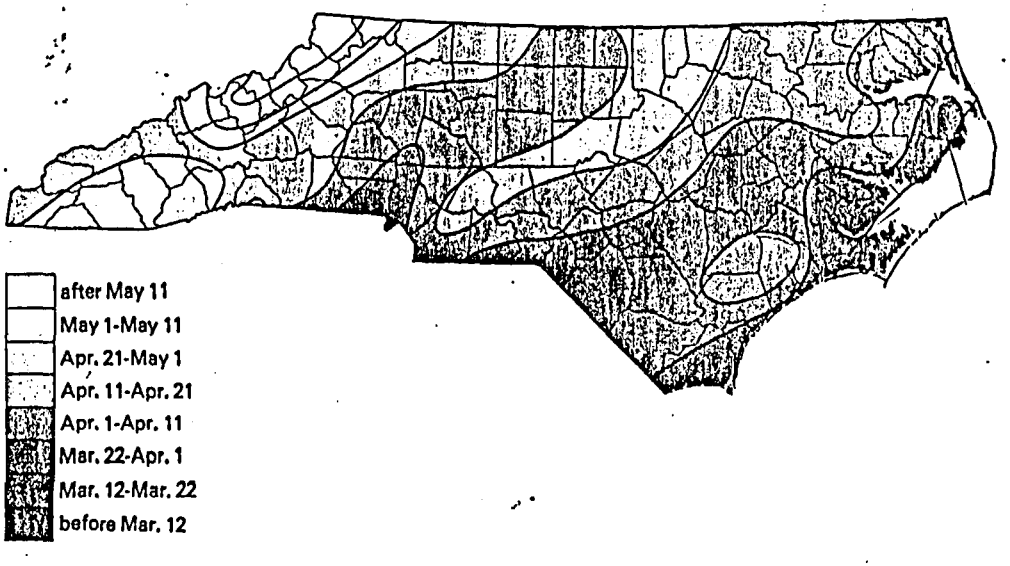
**Average Date of the Last Freeze in Spring** As illustrated by Figure 5.8, the beginning of the freeze-free season varies across the state from 1 March to 10 May, a difference in time of over two months. As expected, the milder climate along North Carolina's coast engenders early dates, whereas the more severe climate of the Mountains retards the start of the freeze-free period longer than elsewhere. In most areas of the Coastal Plain, the last spring freeze generally occurs by the first of April. The Piedmont has its last freezes between 1 and 10 April, about ten to fifteen days later than the Coastal Plain. In the Mountains, there is greater variation in mean dates for both the beginning and the end of the freeze season. Because air chills more quickly at higher elevations, and because cold air is denser than warm air, the cold air drains into the valleys where it is contained and continues to lose heat by radiation. The result of this process is that in certain Mountain areas some valleys are more often colder than their slopes at intermediate altitudes. Lying between the below-freezing temperatures of the valleys and the higher elevations are "verdant" or "thermal" belts.

**Figure 5.7. Average Annual Snowfall in N.C.**




Source: U.S. Department of Commerce, *Climatological Summary*, 1966.

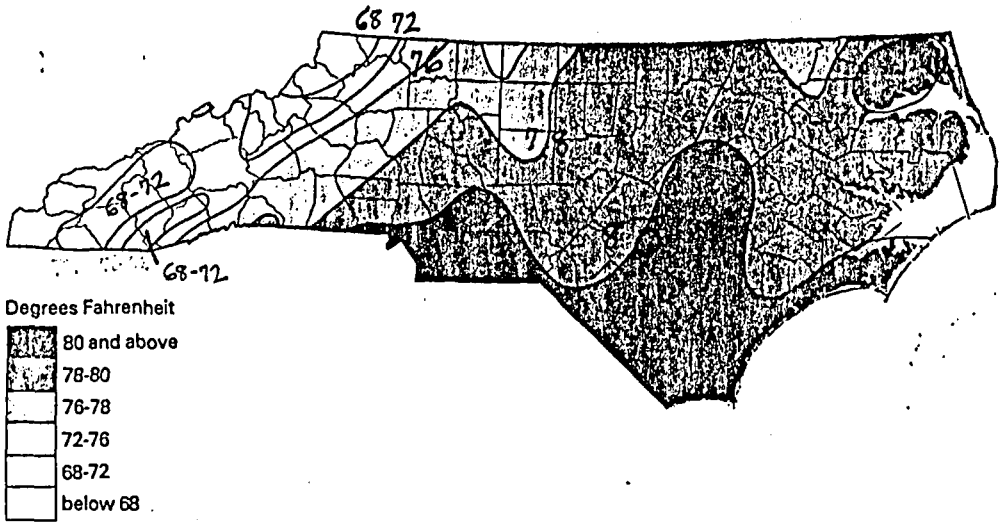
**Figure 5.8. Average Date of Last Freezing Temperature in N.C.**




Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

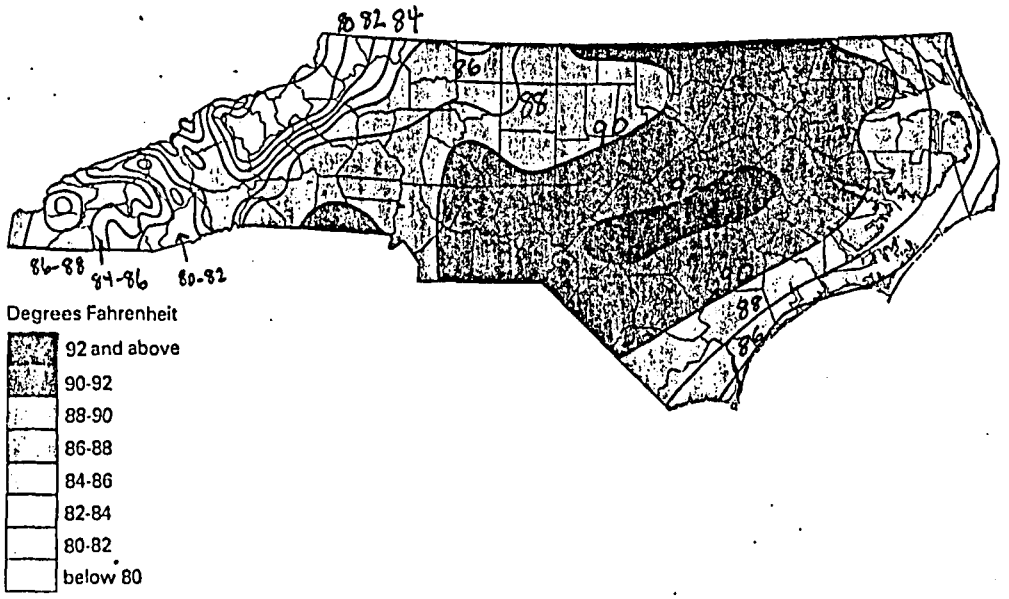
Ref 12

Figure 5.9. Average July Temperature in N.C.




Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

Figure 5.10. Mean Maximum July Temperature in N.C.




Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

These strip-like regions have longer freeze-free seasons and thereby show earlier dates for the end of the freeze period than their surroundings. They support frost-susceptible vegetation long after the greenery has disappeared in nearby areas. Often in early winter or even in midwinter a contrasting belt of green flanked above and below by brown may be seen. These green belts are characteristically located along slopes that face the winter sun, are protected from cold northern winds, and have cold air drainage to lower valleys. The blossoming of dogwood and redbud moves across the state in a pattern similar to that of the end of the freeze season to blanket North Carolina with color and beauty.

**Summer** Summer is characterized by its high temperatures, high humidities, high amounts of rainfall, and high physiological stress. Except for the amelioration of these climatic elements in the Mountains, and the relief afforded by sea breezes along the coast, elsewhere in the state summer is a season of extremes. Mean monthly minimum temperatures for July and August are in the upper seventies and eighties and mean maximum temperatures reach into the nineties.

However, to quote a popular adage, "it's not the heat but the humidity," and North Carolina's temperatures in combination with the high water vapor amounts prevalent during the summer months are definitely uncomfortable. In addition, high sunshine percentages and a predominance of southerly winds tend to aggravate an already unpleasant climatic condition. Only the periodic passage of cool, dry air masses from the north and sea breezes in the coastal areas alleviate the discomfort of summer weather for North Carolina's low-lying counties.

**July Average Temperatures** The pattern of mean temperatures in July is similar to the pattern in January (Figure 5.9). However, in the Piedmont and Coastal Plain, isotherms are fewer in number and farther apart. In the Mountains, the reverse is true. The widespread isotherms east of the Mountains indicate that temperature averages across central and eastern North Carolina exhibit little contrast. From the western Piedmont to the coast, the difference in mean temperatures is only 4° F. Although the influence of the ocean is not evident in the arrangement of isotherms, the high temperatures of the Coastal Plain are made less severe by the cooling power of the sea breeze. Hatteras, on the Outer Banks, records a temperature of 90° F. on the average of only one day each year, while Wilmington, a short distance from the coast, has an occurrence of 90° F. temperatures about twenty-four days annually. In contrast with these locations, Raleigh and Winston-Salem mean temperatures for July are slightly lower, but the average number of days on which a temperature of 90° F. or above is experienced increases to more than forty.

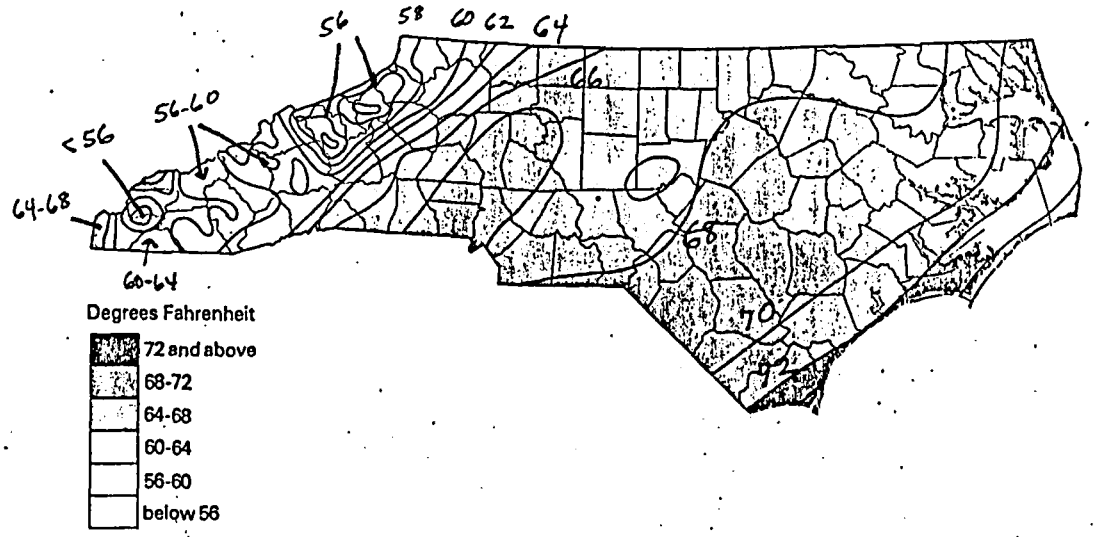
In the Mountains, the effects of altitude reduce mean temperature values sharply. The temperature gradient in July is even steeper than in January. East to west across Caldwell County, mean temperatures drop from 76° F. to 68° F. and Mount Mitchell remains the coolest site in the state with a July average of 59° F. At Asheville, the warmest month averages 73.8° F. and only seven days during the summer show temperatures reaching to 90° F. With daily minimum temperatures in the fifties and sixties the allure of the Mountains for summer recreation becomes evident.

**July Average Maximum and Minimum Temperatures** The temperatures typically recorded during an afternoon in July are shown in Figure 5.10. In the Coastal Plain, isotherms representing mean maximum temperature are aligned parallel to the shoreline signifying the effect of the cool ocean and sea breeze. At Cape Hatteras, the summer daytime maximum is 84° F. Inland, temperatures increase and reach their highest values in the Fayetteville area where scorching temperatures in excess of 92° F. are experienced. In the Piedmont, maximum temperatures average between 88° F. and 92° F. Toward the Mountains, midday highs drop to more pleasant levels. In Swain and Haywood counties, afternoon temperatures are generally in the low seventies and most western counties record mean July maximums under 80° F.

Although isotherms of mean minimum temperature exhibit a pattern similar to the pattern of maximum July temperatures, in the outer Coastal Plain absolute temperature values are reversed (Figure 5.11). Minimum temperatures represent nighttime conditions and their distribution indicates that the effect of the ocean is to warm adjacent areas. Farther inland, the more rapidly cooling land causes the temperatures to be lower. Thus the maps showing average July maximum and minimum temperatures portray the daily relative change in influence from ocean to land and back again along the coastal fringe of North Carolina. Over the Piedmont and the Inner Coastal Plain, July average minimums show little change with distance, ranging only 4° F. from 66° F. to 70° F. In the Mountains, 50° F. and 60° F. temperatures indicate the characteristically cool weather associated with this region during summer nights.

Summer is the season of greatest precipitation in North Carolina. Thunderstorms are the predominant mechanism for precipitation delivery and occur mainly in the afternoon or evening. They come on an average of ten to twelve days per month. July and August show the highest rainfall amounts with many sections of the state reporting 5 to 7 inches of rain for each of these months. The coastal region around Wilmington and the southwestern counties are the rainiest areas in the state having over 8 inches of precipitation and an average of fourteen rain days in July. By August the hurricane season has arrived and these storms may contribute a significant percentage of rainfall to monthly totals and continue to do so well into the fall.

**Figure 5.11. Mean Minimum July Temperature in N.C.**

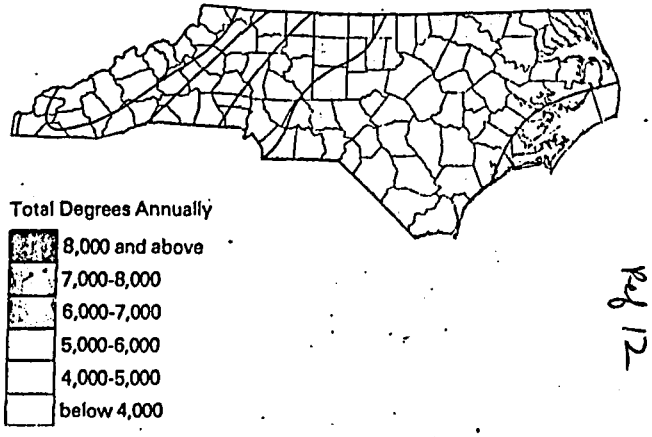



Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

**Average Growing Degree Days** Similar in its derivation to the heating degree day concept, the *growing degree day* is based on the positive departure of mean daily temperature from an established temperature value representing the start of the active growth period for plants.

Although each plant has its own base temperature for seed germination and active growth, a mean daily temperature of 40° F. will represent the beginning of the growth period for most crops. To determine growing degree day units for example, a daily mean temperature of 50° F. will indicate ten growing degree days or a 10° F. departure from the base minimum of 40° F. These units are then accumulated for the year and averaged over a period of time to provide us with the data for preparing Figure 5.12. Since each plant requires a certain amount

**Figure 5.12. Average Annual Growing Degree Days in N.C.**



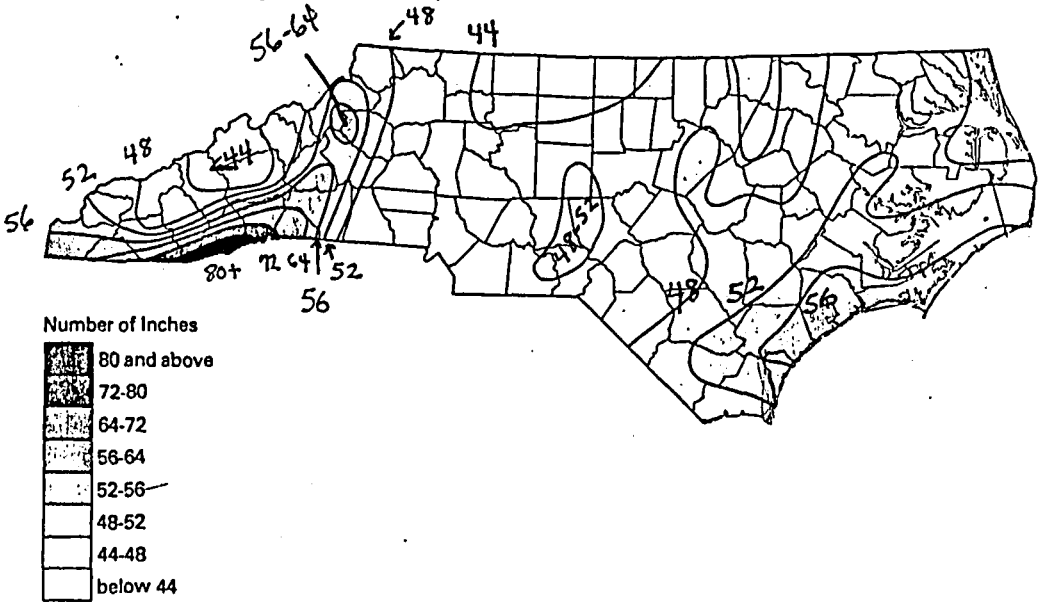

Source: U.S. Department of Commerce, *Climatological Summary*, 1966.

Pg 12

Autumn is the driest season of the year and rainfall amounts drop below 3 inches throughout central and eastern North Carolina during October and November. Cyclonic activity increases as thunderstorms become less frequent until by late November they seldom occur.

As illustrated in Figure 5.14, freezes begin early in October in the Mountains and slowly move eastward toward the coast. In early December, the freeze-free season reluctantly comes to a close in the Wilmington-Southport area. Deciduous trees begin their dormancy period and the color of the state gradually changes from the quiet greens of summer to the fiery reds and brilliant yellows of fall. By late autumn the highlands, now a mottled brown and green, show an occasional sprinkling of white as temperatures in the Mountains fall below freezing and the possibility of snow increases. However, in the Piedmont and Coastal Plain, tennis, sailing, and picnicking, for example, continue into November and football games played late in the season are often attended by fans dressed in warm-season attire.

**Figure 5.15. Average Annual Precipitation in N.C.**




Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

### Annual Precipitation and Humidity

Although a considerable variation in the distribution of rainfall exists throughout the state, everywhere precipitation is high (Figure 5.15). In the Coastal Plain, rainfall totals average from 44 to 55 inches; the highest amounts were received at the Outer Banks. Across the Piedmont, yearly rainfall averages range from 43 to 48 inches, with the northern and southern sectors having the lower totals. The greatest variability in rainfall distribution is found in the Mountains. Here, south-facing slopes along the North Carolina-South Carolina border receive as much as 80 inches of precipitation each year. Nearby, Asheville, lying in a sheltered valley, records only 37 inches, the lowest rainfall average reported in the state. More commonly, average annual precipitation in the Mountains ranges from 44 to 58 inches. For the state as a whole, an average total of 50 inches is representative.

The distribution of rainfall throughout the year is reasonably uniform. Although there are no pronounced wet and dry seasons, a profile of average annual precipitation indicates a bimodal distribution, i.e., two periods of higher rainfall separated by two periods during the year when rainfall amounts are lower than the norm. Generally, the highest precipitation totals are associated with the summer months. In the fall, the season of the least rainfall, the lowest yearly totals usually occur in October or November. Precipitation increases slightly during the winter season and then decreases to a secondary low in April. This precipitation regime is common to the state and varies only slightly from place to place.

Although rainfall is heaviest in the summer, evaporation and transpiration losses are also great. Consequently, the summer season is deficient in its supply of soil moisture and irrigation may be required to sustain crop needs.

Although it is considered to be a wet state, North Carolina nevertheless has its occasional "bout with drought." Recently, the Piedmont and Inner Coastal Plain suffered through an especially severe drought. In 1968, negative rainfall departures amounting to as much as 26 inches were computed by individual stations within this area. On the other hand, 1972 proved to be an abnormally wet year. During that year, Raleigh, which has an average annual precipitation of 46.35 inches, experienced a total rainfall of 51.74 inches. Raleigh's weather records may be used to illustrate the variations in yearly precipitation amounts. In the capital city, annual totals have varied from a low of 30 inches in 1933 to a high of 64 inches in 1936. On a monthly basis, rainfall variation for July has ranged from 12.36 inches in 1931 to as little as 0.38 inches in 1953. Yet precipitation variability in North Carolina is moderate compared with those states where rainfall totals are significantly less and consequently precipitation patterns and regimes are more unpredictable.

**Average Number of Days with 0.01 Inches of Precipitation or More** Figure 5.16 shows the pattern of days with measurable precipitation in North Carolina. The Mountains have the greatest number of days with measurable precipitation, averaging 10 to 20 more rainy days per year than the coast and 20 to 30 days more than the southern Piedmont. In the northwest corner of the state precipitation occurs 4 out of every 10 days. By contrast, the sandhills in the Southern Piedmont experiences precipitation on only 30 percent of the days. In fact, a "tongue" of fewer rainy days penetrates the state from south to north, through North Carolina's central counties. For the state as a whole, 125 days with measurable precipitation is a representative figure.

### Water Balance

The "wetness" or "dryness" of any region is mirrored by its natural vegetation. Indigenous plant life is an indicator of a region's precipitation effectiveness and its capacity to support plant growth. The minimal moisture requirements of plant communities are quite specific, and in situ vegetation reflects the amounts of water annually and seasonally available for its use. As the size of a bank account depends upon the balance between deposits and withdrawals, so precipitation effectiveness

Pg 12

soil moisture requirement is satisfied, additional precipitation will drain to the underground water table or run off the land as surplus water.

Figure 5.18 provides the water balance deficits for the state and shows that everywhere except for the Asheville area and the northern Piedmont, the annual water deficit is less than one inch. By contrast, Figure 5.19 gives water balance surpluses. Being a wet state, North Carolina's water budget indicates surpluses exceeding deficits by large amounts. While most of the Piedmont and Coastal Plain have surplus water up to 15 inches, the Outer Banks and the Mountains show surpluses above 15 inches. In the southwest corner of the state, water surpluses amount to as much as 30 inches.

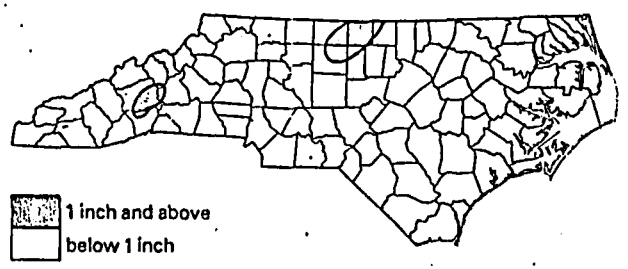
Mean annual evaporation for North Carolina is shown in Figure 5.20. Evaporation rates and totals are related to temperature, wind velocity, and relative humidity. Where temperatures are highest and humidities lowest, evaporation intensities will be greatest. Since temperatures throughout the Coastal Plain and the Piedmont are highest for the state and since humidity percentages are greater in the vicinity of the ocean, evaporation totals are lower in the Mountains and along the coast, and highest in the southern Piedmont and Coastal Plain. A comparison of the maps showing precipitation, evaporation, water surplus, and water deficit will provide the reader with a fairly complete picture of North Carolina's water balance.

### Winds and Storms

Three types of storms and their associated winds are common to North Carolina: cyclonic and convectional thunderstorms, hurricanes, and tornadoes. These storms are integral parts of the state's climatic pattern. In analyzing the importance of winds, direction and speed are major considerations.

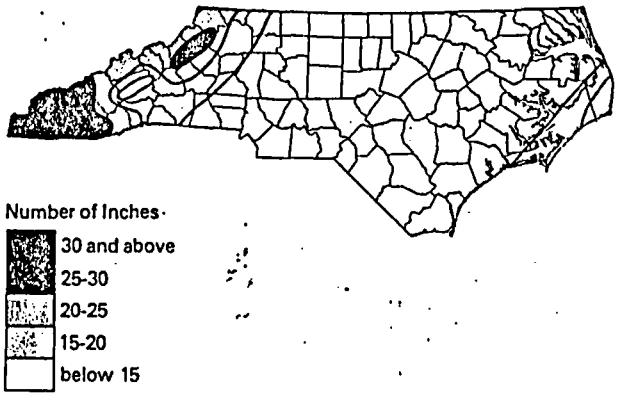
Although prevailing winds (winds that persist in blowing from one direction more so than any other) characterize given geographical areas, wind direction changes frequently. A northwesterly wind (coming from the northwest) will be, relatively speaking, a cooling and drying wind, whereas a southeasterly wind will bring warm, moist air to the state. The passage of cyclones and anticyclones with their characteristic wind patterns will change the wind's direction so that it may come across North Carolina from any point of the compass.

**Figure 5.18. Water Balance Deficit in N.C.**



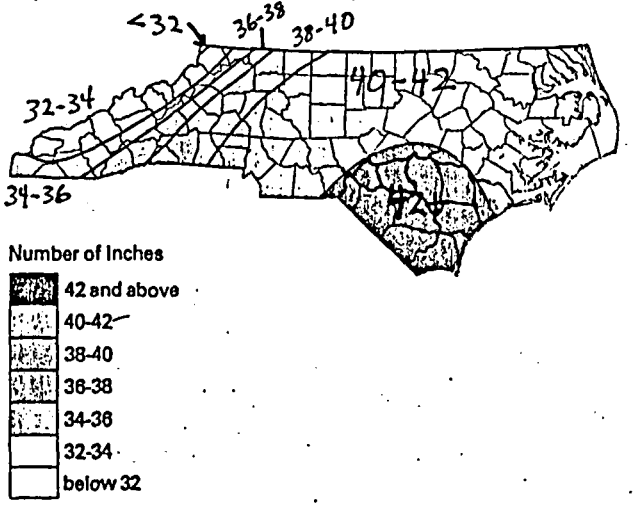

Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

**Figure 5.19. Water Balance Surplus in N.C.**




Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

**Figure 5.20. Mean Annual Evaporation in N.C.**



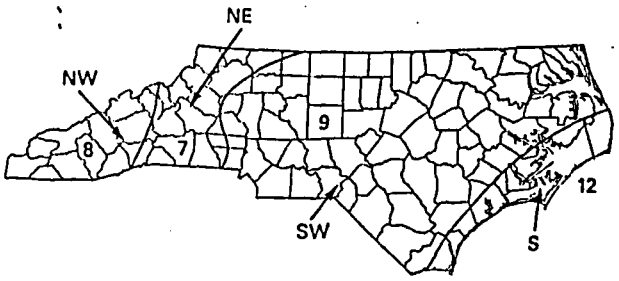

Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

The velocity of the wind is relevant to ventilation of air pollutants, evaporation rates, and thus cooling and chilling indexes. On those occasions when winds reach gale force and higher, their velocities are of singular importance because of their destructive capabilities. Damaging winds are usually associated with infrequent hurricanes and tornadoes and, at times, with severe thunderstorms.

The prevailing winds and mean wind speeds averaged for the year are given in Figure 5.21. For the eastern two-thirds of the state, winds blow most frequently from the southwest and south. Throughout the Mountains and the western Piedmont, winds prevail from northerly directions. This annual pattern of prevailing winds persists for most months of the year except September and October when winds are dominantly from the northeast. During these months, the clockwise flow of air from seasonal anticyclones lying poleward of North Carolina, and the counterclockwise winds associated with an increased number of offshore storms cause northeasterlies to prevail across the state.

Pg 12

**Figure 5.21. Prevailing Winds and Mean Annual Wind Speed in N.C.**




Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

Note: Wind speeds are noted in miles per hour.

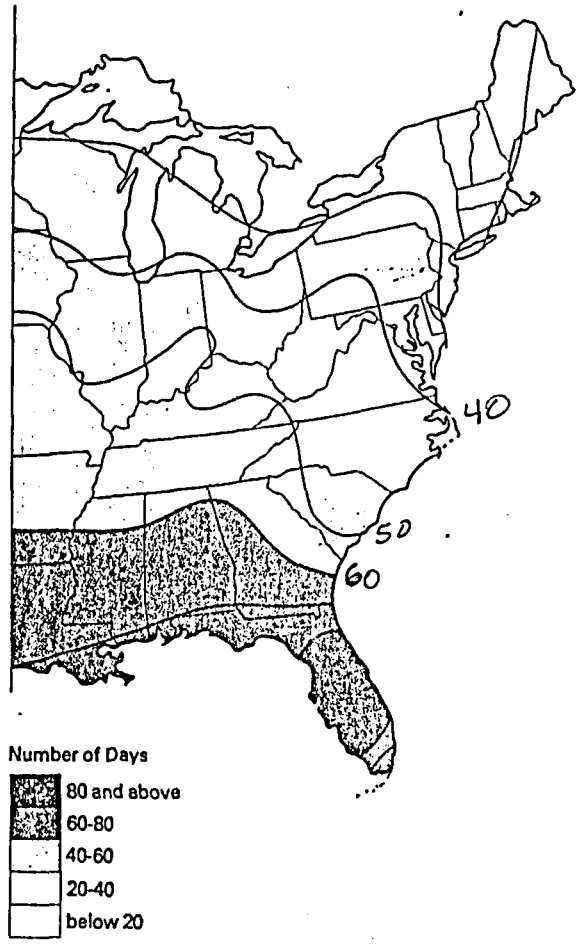
Wind speeds have been averaged for each zone of prevailing winds. Winds tend to diminish in speed westward from the coast where sea breezes and offshore storms contribute to velocities that average twelve miles per hour. Throughout the Inner Coastal Plain and the Piedmont, the mean wind speed is nine miles per hour, and in the western counties, representative wind speeds are seven and eight miles per hour. On a daily basis, wind velocities are lowest before dawn and highest around midafternoon. Seasonally, winter, with greater temperature and pressure contrasts, shows the most rapid air movement and summer is the time of lowest wind speeds.

**Thunderstorms** Thunderstorms are vertically developed storm systems that involve lightning and thunder. Produced by instability in the atmosphere, these storms are sustained by the conversion of water vapor into rain and hail, which causes the release of enormous amounts of energy. This energy results in vigorous updrafts of rapidly moving air. The intensity and turbulence of an individual thunderstorm is related to the degree of atmospheric instability and the supply of latent energy released by the condensing of water vapor. In structure, the typical thunderstorm is a collection of convective cells each averaging a mile or more in diameter. A cell is comprised of columns of rapidly rising air separated and counterbalanced by downdrafts of slower moving air. Associated with thunderstorms and their bulbous facade are heavy downpours of rain, hail, gusty and squally winds, and of course, lightning and thunder.

Because thunderstorm development and frequency is enhanced by (1) atmospheric instability that is linked to high surface temperatures, (2) atmospheric moisture that supplies the latent energy requirements, and (3) some triggering device to start the convection process, thunderstorms occur more frequently in regions of warm temperatures and high humidities. North Carolina's climate is conducive to thunderstorm development and the state experiences violent local storms forty to fifty days each year. For the United States, Florida and the Gulf Coast lead in the number of days with thunderstorms. Here, seventy to ninety days per year with thunderstorms is normal. In the northern states and along the West Coast, thunderstorm activity drops off because of colder temperatures over land and coastal waters. North Carolina's pattern of thunderstorm activity shows fewest storms off the northeast coast where coastal waters also are cooler. Inland, thunderstorms are more frequent, increasing to fifty days as the Mountains are approached. In the Mountains, the higher frequency of storm activity (all types) and the triggering supplied by mountain and frontal slopes results in the most thunderous area to be found in the state (Figure 5.22).

**Hurricanes** In the latter half of the year, the United States is visited by hurricanes. Originating over tropical oceans as small cyclones, under favorable conditions hurricanes become large, intense storm systems. Their winds exceed seventy-five miles per hour and spiral counterclockwise around an "eye" of very low pressure. Sustained by the ocean that breeds them, these storms are driven by the heat released from condensing water vapor. Covering tens of thousands of square miles, hurricanes move slowly and deliberately, at speeds between fifteen and fifty miles per hour, delivering prodigious amounts of precipitation to areas over which they pass. Moving out of the tropics, hurricanes of the Atlantic Ocean generally invade the Gulf of Mexico, or veer northward toward the middle latitudes, occasionally penetrating the continent, or skirting the coastline as far north as New England. Hurricanes are sea monsters and diminish in intensity as they move inland and away from their source of energy. Although capable of great destruction, hurricanes nevertheless benefit the southeastern states to a substantial degree. As the eastern states are subject to periodic summer droughts, the vast amounts of water delivered to this region by these giant tropical storms have served more than once to alleviate or terminate the disastrous effects of drought conditions. However, hurricanes are killer storms, and their long-range benefits are obscured by the more obvious death, destruction, and damage accompanying them. On the average, the Atlantic Ocean generates six hurricanes a

**Figure 5.22. Average Number of Days with Thunderstorms**

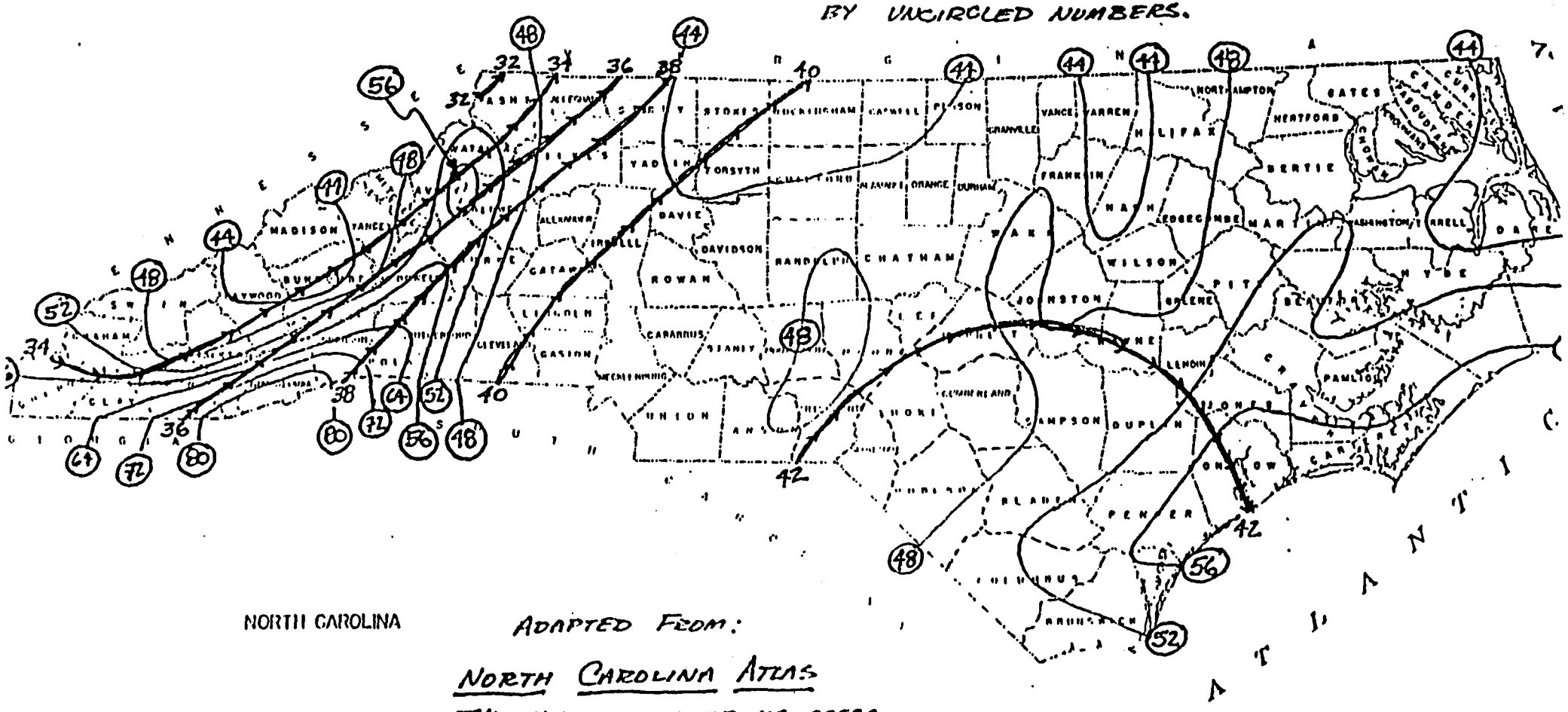



Source: Glenn T. Trewartha, Arthur H. Robinson, and Edwin H. Hammond, eds., *Elements of Geography*, 5th ed. (New York: McGraw-Hill Book Co., 1967).

year, but as many as eleven in one year have been observed. North Carolina has experienced twelve especially disastrous hurricanes since 1900. Cape Hatteras, extending as it does into the ocean, is affected by hurricanes more than any other area of North Carolina (Figure 5.23). Its low-lying sandy surface is especially vulnerable to the combined effects of high winds, high tides, and flooding associated with these storms.

# MEAN ANNUAL PRECIPITATION AND MEAN ANNUAL EVAPORATION

NOTE: PRECIPITATION ISOGRAMS ARE SOLID LINES (——) WITH INCHES OF RAINFALL GIVEN BY CIRCLED NUMBERS. EVAPORATION ISOGRAMS ARE NOTCHED LINES (→→→) WITH INCHES OF EVAPORATION GIVEN BY UNCIRCLED NUMBERS.




NORTH CAROLINA

ADAPTED FROM:

NORTH CAROLINA ATLAS
THE UNIVERSITY OF NC PRESS,
CHAPEL HILL, NC, FIGURE
5.15 PAGE 101 AND FIGURE
5.20 PAGE 103.

Pg 12

(14)

Fifth Edition, 1984



# North Carolina State Government

# Statistical Abstract

North Carolina State Data Center

Research and Planning Services
Office of State Budget and Management

Table 178

EMISSIONS INVENTORY SUMMARY (IN TONS)
FROM POINT AND AREA SOURCES, BY COUNTY
1979

| County | Particulates | | Sulfur Dioxide | | Nitrogen Oxides | | Volatile Organic Compounds and Hydrocarbons | | Carbon Monoxide | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area Sources | Point Sources | Area Sources | Point Sources | Area Sources | Point Sources | Area Sources | Point Sources | Area Sources | Point Sources |
| State Total | 953,662 | 222,263 | 43,247 | 731,157 | 334,896 | 290,035 | 560,734 | 114,695 | 2,416,683 | 150,670 |
| Alamance | 7,718 | 868 | 818 | 1,428 | 5,890 | 266 | 11,748 | 3 | 45,688 | 71 |
| Alexander | 2,150 | 633 | 173 | 128 | 1,150 | 32 | 1,634 | 535 | 6,880 | 2 |
| Alleghany | 2,168 | - | 63 | - | 611 | - | 924 | - | 3,931 | - |
| Anson | 2,537 | 201 | 183 | 2 | 1,618 | 16 | 2,700 | 92 | 10,909 | 4 |
| Ashe | 5,022 | 422 | 127 | 9 | 1,127 | 74 | 1,713 | 231 | 7,535 | 12 |
| Avery | 1,785 | 78 | 89 | 83 | 799 | 50 | 797 | 8 | 4,116 | 7 |
| Beaufort | 5,334 | 1,079 | 307 | 21,236 | 2,231 | 1,145 | 4,277 | 23 | 19,634 | 51 |
| Bertie | 2,927 | 1,688 | 144 | 316 | 1,598 | 312 | 2,107 | 63 | 11,434 | 101 |
| Bladen | 3,565 | 135 | 191 | 551 | 1,935 | 99 | 2,731 | 184 | 12,777 | 8 |
| Brunswick | 3,293 | 913 | 284 | 16,616 | 2,818 | 3,418 | 3,285 | 29,359 | 16,967 | 10,845 |
| Buncombe | 15,826 | 4,523 | 1,036 | 101,634 | 8,073 | 34,108 | 17,219 | 535 | 66,479 | 2,245 |
| Burke | 5,906 | 568 | 485 | 1,528 | 4,066 | 671 | 6,335 | 1,496 | 27,446 | 109 |
| Cabarrus | 6,136 | 765 | 581 | 2,638 | 4,775 | 1,126 | 8,704 | 998 | 45,995 | 94 |
| Caldwell | 6,070 | 3,850 | 581 | 383 | 3,408 | 435 | 4,897 | 9,680 | 19,740 | 69 |
| Camden | 707 | 3 | 47 | - | 517 | - | 825 | - | 4,021 | - |
| Carteret | 1,949 | 8 | 270 | 81 | 2,269 | 16 | 5,080 | - | 20,446 | 2 |
| Caswell | 2,438 | 899 | 124 | - | 1,160 | - | 1,516 | - | 8,431 | - |
| Catawba | 7,537 | 19,814 | 1,345 | 75,338 | 7,829 | 33,880 | 13,934 | 3,016 | 40,667 | 1,932 |
| Chatham | 4,994 | 9,679 | 349 | 12,208 | 2,464 | 9,352 | 3,999 | 756 | 15,675 | 809 |
| Cherokee | 3,332 | 90 | 104 | 1 | 1,050 | 6 | 1,750 | 1 | 7,010 | 1 |
| Chowan | 747 | 54 | 93 | 326 | 795 | 54 | 1,405 | 227 | 6,347 | 4 |
| Clay | 2,096 | - | 71 | - | 1,200 | - | 2,076 | - | 17,224 | - |
| Cleveland | 6,160 | 365 | 945 | 406 | 4,030 | 929 | 6,461 | - | 15,317 | 46 |
| Columbus | 5,840 | 1,406 | 351 | 7,735 | 3,216 | 2,082 | 4,170 | 412 | 29,162 | 12,477 |
| Craven | 6,901 | 3,558 | 399 | 6,706 | 3,677 | 2,614 | 6,682 | 1,040 | 37,914 | 7,065 |
| Cumberland | 17,810 | 586 | 1,120 | 2,927 | 9,493 | 681 | 17,624 | 834 | 90,631 | 74 |
| Currituck | 1,100 | 159 | 700 | - | 1,200 | 2 | 1,400 | - | 4,900 | - |
| Dare | 605 | 5 | 104 | 240 | 932 | 71 | 3,926 | 2 | 14,0[illegible] | 12 |
| Davidson | 10,207 | 355 | 756 | 998 | 6,301 | 629 | 10,328 | 2,470 | 44,3[illegible] | 144 |
| Davie | 2,233 | 428 | 149 | 66 | 1,259 | 31 | 5,206 | 181 | 6,9[illegible] | 5 |
| Duplin | 4,789 | 105 | 273 | 763 | 2,949 | 154 | 3,668 | 41 | 18,942 | 13 |
| Durham | 10,624 | 836 | 778 | 880 | 6,398 | 194 | 12,933 | 703 | 58,810 | 15 |
| Edgecombe | 3,302 | 3,041 | 491 | 407 | 4,010 | 81 | 4,720 | 1,367 | 21,013 | 17 |
| Forsyth | 17,830 | 928 | 2,173 | 5,837 | 16,754 | 2,152 | 24,192 | 21,498 | 95,312 | 186 |
| Franklin | 2,850 | - | 181 | - | 1,771 | - | 3,165 | 83 | 13,286 | - |
| Gaston | 10,171 | 7,566 | 1,145 | 62,730 | 8,842 | 29,610 | 15,998 | 687 | 61,199 | 1,789 |
| Gates | 1,298 | - | 69 | - | 729 | - | 740 | - | 4,277 | - |
| Graham | 842 | 44 | 39 | 60 | 364 | 19 | 479 | 3 | 2,231 | 4 |
| Granville | 5,457 | 78 | 206 | 720 | 2,277 | 1,029 | 4,013 | 515 | 19,[illegible] | 188 |
| Greene | 1,329 | 11 | 87 | - | 995 | - | 1,339 | - | 7,[illegible] | - |
| Guilford | 33,493 | 2,702 | 2,769 | 3,330 | 35,142 | 989 | 31,063 | 14,057 | 139,199 | 495 |
| Halifax | 5,044 | 1,306 | 315 | 9,556 | 2,903 | 2,495 | 5,316 | 329 | 25,552 | 10,410 |
| Harnett | 5,575 | 143 | 306 | 765 | 3,268 | 169 | 4,439 | 5 | 24,530 | 14 |
| Haywood | 4,414 | 682 | 285 | 9,768 | 2,529 | 4,703 | 5,531 | 49 | 17,166 | 43,964 |
| Henderson | 6,842 | 308 | 370 | 2 | 3,040 | 25 | 5,703 | 3 | 21,241 | 7 |
| Hertford | 2,085 | 885 | 152 | 278 | 1,410 | 2,615 | 2,278 | 54 | 11,197 | 111 |
| Hoke | 897 | 31 | 122 | 193 | 979 | 54 | 1,834 | - | 6,977 | 3 |
| Hyde | 828 | 148 | 95 | - | 814 | - | 3,074 | - | 11,064 | - |
| Iredell | 10,157 | 2,169 | 729 | 916 | 4,958 | 665 | 9,541 | 1,029 | 37,94[illegible] | 114 |
| Jackson | 4,694 | 99 | 153 | 5 | 2,007 | 30 | 3,203 | 6 | 18,941 | 8 |
| Johnston | 7,755 | 1,671 | 429 | 138 | 4,049 | 31 | 5,726 | 718 | 24,989 | 3 |
| Jones | 995 | - | 70 | - | 862 | - | 962 | - | 5,333 | - |
| Lee | 1,936 | 81 | 329 | 75 | 2,459 | 25 | 4,465 | 274 | 15,602 | 314 |
| Lenoir | 32,997 | 451 | 368 | 2,979 | 2,828 | 1,094 | 4,523 | 15 | 22,470 | 282 |
| Lincoln | 2,892 | 116 | 279 | 714 | 2,126 | 173 | 3,292 | 167 | 11,732 | 13 |
| McDowell | 2,645 | 185 | 179 | 1,042 | 1,690 | 392 | 2,698 | 230 | 12,778 | 44 |
| Macon | 3,282 | 16 | 253 | - | 2,016 | - | 3,091 | - | 16,300 | - |
| Madison | 3,444 | 1 | 160 | 14 | 1,165 | 7 | 1,442 | 2 | 7,027 | 2 |
| Martin | 3,523 | 3,738 | 93 | 18,647 | 863 | 7,719 | 1,039 | 1,093 | 5,528 | 12,789 |
| Mecklenburg | 20,607 | 3,335 | 3,503 | 3,631 | 24,745 | 813 | 36,601 | 5,707 | 156,662 | 1,758 |
| Mitchell | 1,591 | 124 | 106 | 52 | 780 | 13 | 745 | 520 | 4,161 | 1 |
| Montgomery | 1,949 | 365 | 190 | 36 | 1,465 | 31 | 3,339 | 13 | 9,172 | 23 |
| Moore | 4,418 | 97 | 265 | 71 | 2,464 | 45 | 4,295 | 60 | 18,219 | 9 |
| Nash | 5,322 | 559 | 594 | 1,203 | 4,373 | 323 | 8,567 | 309 | 35,371 | 30 |
| New Hanover | 4,042 | 4,675 | 1,080 | 35,483 | 5,411 | 13,157 | 10,379 | 8,344 | 40,872 | 855 |
| Northampton | 2,193 | 232 | 144 | 627 | 1,607 | 280 | 1,999 | 150 | 10,632 | 43 |
| Onslow | 6,007 | 39 | 485 | 49 | 4,326 | 10 | 7,447 | - | 35,340 | - |
| Orange | 6,169 | 90 | 336 | 1,194 | 2,929 | 615 | 4,846 | 97 | 20,470 | 31 |
| Pamlico | 995 | - | 91 | - | 773 | - | 1,635 | - | 6,356 | - |
| Pasquotank | 1,508 | 432 | 166 | 140 | 1,238 | 211 | 2,436 | 38 | 11,862 | 40 |
| Pender | 2,248 | - | 130 | - | 1,628 | - | 2,232 | - | 12,412 | - |
| Perquimans | 1,004 | 21 | 76 | - | 755 | - | 1,065 | - | 5,2[illegible] | - |
| Person | 4,221 | 15,859 | 195 | 73,710 | 1,533 | 34,504 | 2,968 | 993 | 11,4[illegible] | 1,923 |
| Pitt | 8,053 | 390 | 423 | 1,580 | 3,970 | 312 | 6,656 | 30 | 37,356 | 26 |
| Polk | 1,917 | 37 | 82 | 34 | 703 | 56 | 970 | - | 4,441 | 1 |
| Randolph | 11,786 | 83 | 627 | 64 | 3,543 | 31 | 9,203 | 377 | 27,791 | - |
| Richmond | 2,983 | 21 | 405 | 38 | 2,663 | 8 | 4,786 | - | 17,374 | 80 |
| Robeson | 9,120 | 452 | 621 | 6,434 | 5,365 | 2,634 | 8,985 | 631 | 41,534 | 154 |
| Rockingham | 10,052 | 34,193 | 586 | 7,270 | 4,726 | 3,390 | 8,993 | 251 | 37,948 | 199 |
| Rowan | 7,990 | 3,541 | 698 | 10,791 | 5,126 | 4,909 | 9,062 | 139 | 37,959 | 272 |
| Rutherford | 6,778 | 2,994 | 331 | 37,872 | 2,930 | 14,013 | 4,912 | 382 | 21,356 | 787 |
| Sampson | 5,908 | 101 | 345 | 705 | 3,321 | 136 | 4,839 | 99 | 23,036 | 11 |
| Scotland | 1,780 | 272 | 171 | 585 | 1,663 | 191 | 3,385 | 2,458 | 12,463 | 22 |
| Stanly | 3,915 | 1,288 | 321 | 2,307 | 2,745 | 395 | 3,764 | 130 | 17,420 | 11,43[illegible] |
| Stokes | 4,908 | 38,172 | 186 | 146,468 | 1,627 | 63,072 | 2,138 | 1,052 | 10,278 | 3,504 |
| Surry | 8,047 | 1,285 | 521 | 1,413 | 3,908 | 445 | 6,333 | 194 | 23,729 | 66 |
| Swain | 988 | 182 | 53 | - | 532 | - | 838 | - | 3,290 | - |
| Transylvania | 2,181 | 31 | 116 | 807 | 935 | 201 | 1,968 | 3 | 6,691 | 12 |
| Tyrrell | 674 | 3 | 70 | - | 627 | - | 1,139 | - | 4,732 | - |
| Union | 6,003 | 896 | 534 | 182 | 4,126 | 72 | 6,294 | 384 | 25,997 | 3 |
| Vance | 2,452 | 267 | 280 | 66 | 2,193 | 33 | 3,913 | 30 | 16,660 | 1 |
| Wake | 25,540 | 214 | 1,839 | 265 | 16,875 | 119 | 26,854 | 891 | 144,690 | 699 |
| Warren | 2,761 | - | 108 | - | 1,183 | - | 1,584 | - | 8,294 | - |
| Washington | 1,494 | 930 | 622 | 26 | 1,387 | 173 | 2,501 | 36 | 7,468 | 39 |
| Watauga | 4,143 | 47 | 176 | 585 | 1,509 | 140 | 2,268 | 33 | 11,054 | 9 |
| Wayne | 6,682 | 29,890 | 564 | 21,769 | 5,475 | 6,828 | 9,922 | 144 | 37,706 | 1,619 |
| Wilkes | 9,785 | 1,081 | 415 | 1,074 | 3,589 | 327 | 3,732 | 189 | 17,403 | 41 |
| Wilson | 4,374 | 202 | 539 | 86 | 4,449 | 18 | 8,416 | 16 | 30,285 | 1 |
| Yadkin | 3,292 | 10 | 189 | 18 | 1,718 | 4 | 2,171 | - | 11,255 | 1 |
| Yancey | 1,831 | 13 | 95 | 102 | 771 | 19 | 1,023 | - | 5,3[illegible] | 2 |

SOURCE: North Carolina Department of Natural Resources and Community Development, Division of Environmental Management.

Ref 15

25 February 1987

TO: File

FROM: Stan Atwood SA

RE: Tri-County Community College
NC D038551263

I called Dr. Leon Tatham, Dean on Instruction, at the above institution. They have 1316 students and faculty this quarter. There are four primary buildings on campus with a fifth under construction. In addition, there are three "support" buildings.

SA/tb/0181b

Ref 16

25 February 1987

TO: File

FROM: Stan Atwood SA

RE: Emerson Electric Co. and Tri-County Community College

I spoke with Bob Wood, Cherokee County Health Director, by telephone to report results from samples taken on 11 February 1987 and to ask him for some additional information as follows:

1. The Health Department has sampled the well at Peachtree Elementary School and the results were negative. Mr. Wood reported 250 students, faculty, and staff at this school.

2. Emerson Electric employs between 300 and 500 people. Two of their drinking supply wells are located near the water tower on the northeast side of the property. A third well, located on the northeast side of the property has been shut down due to contamination.

3. Clifton Precision employs 476 people.

4. The Murphy Medical Center, across the street from Emerson, has 50 beds in the hospital, and about 60 beds in the nursing home.

5. Tri-County Community College has been using bottled water for drinking since the contamination was detected. The wells still supply all other water needs.

SA/tb/0181b

# IARC MONOGRAPHS
ON THE
# EVALUATION OF THE CARCINOGENIC RISK OF CHEMICALS TO HUMANS

## Some Halogenated Hydrocarbons

VOLUME 20

This publication represents the views and expert opinions
of an IARC Working Group on the
Evaluation of the Carcinogenic Risk of Chemicals to Humans
which met in Lyon,
6-13 June 1978

October 1979

INTERNATIONAL AGENCY FOR RESEARCH ON CANCER

Ref 17



# TRICHLOROETHYLENE

This compound was considered by a previous Working Group, in February 1976 (IARC, 1976a). Since that time new data have become available and these have been incorporated into the monograph and taken into account in the present evaluation.

Two reviews on trichloroethylene are available (Lyman, 1978; Mercier, 1977).

## 1. Chemical and Physical Data

### 1.1 Synonyms and trade names

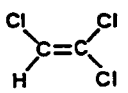
Chem. Abstr. Services Reg. No.: 79-01-6

Chem. Abstr. Name: Trichloroethene

Synonyms: Acetylene trichloride; 1-chloro-2,2-dichloroethylene; 1,1-dichloro-2-chloroethylene; ethinyl trichloride; ethylene trichloride; TCE; Tri; trichlorethylene; 1,1,2-trichloroethylene

Trade names: Algylen; Anamenth; Benzinol; Blacosolv; Blancosolv; Cecolene; Chlorilen; Chlorylea; Chlorylen; Chorylen; Circosolv; Crawhaspol; Densinfluat; Dow-Tri; Dukeron; Fleck-Flip; Flock Flip; Fluate; Gemalgene; Germalgene; Lanadin; Lethurin; Narcogen; Narkogen; Narkosoid; Nialk; Perma-A-Chlor; Perm-A-Clor; Petzinol; Philex; Threthylen; Threthylene; Trethylene; Triad; Trial; Triasol; Trichloran; Trichloren; Triclene; Tri-Clene; Trielene; Trielin; Triklone; Trilen; Trilene; Triline; Trimar; Triol; TRI-plus; TRI-plus M; Vestrol; Vitran; Westrosol

### 1.2 Structural and molecular formulae and molecular weight




$C_2HCl_3$ Mol. wt: 131.4

Ref 17



1.3 Chemical and physical properties of the pure substance

From Weast (1976), unless otherwise specified

(a) Description: Colourless liquid (Irish, 1963)

(b) Boiling-point: 87°C

(c) Melting-point: -73°C

(d) Freezing-point: -86.8°C (Irish, 1963)

(e) Density: $d_4^{20}$ 1.4642

(f) Refractive index: $n_D^{20}$ 1.4773

(g) Spectroscopy data: $\lambda_{vap} < 200$ nm; infra-red, Raman, nuclear magnetic resonance and mass spectral data have been tabulated (Grasselli & Ritchey, 1975).

(h) Solubility: Miscible with water (0.1% w/v at 20°C) (Irish, 1963); miscible with acetone, ethanol, diethyl ether, chloroform and oils (Lloyd *et al.*, 1975)

(i) Volatility: Vapour pressure is 77 mm at 25°C (Irish, 1963).

(j) Vapour density: 4.54 (air = 1) (Irish, 1963)

(k) Stability: Nonflammable; when pure and containing a stabilizer, it is stable in presence of air, moisture, light and in contact with metals up to 130°C. When heated with ozone, it decomposes rapidly into products such as hydrogen chloride, phosgene, carbon monoxide and chlorine peroxide. At 700°C and above, the vapour decomposes to give a mixture of dichloroethylene, tetrachloroethylene, carbon tetrachloride, chloroform and methyl chloride (Hardie, 1964). Upon contact with certain metals, high temperatures, open flame or ultraviolet light, it decomposes almost instantly to phosgene and/or hydrogen chloride, chlorine and dichloroacetyl chloride. In the presence of alkali, trichloroethylene decomposes to highly toxic dichloroacetylene (US Occupational Safety & Health Administration, 1975).

Ref 17



(l) Reactivity: The most important reaction of trichloroethylene is its oxidative breakdown of atmospheric oxygen, greatly accelerated by elevation of temperature and exposure to light, especially ultra-violet; not hydrolysed by water under normal conditions; reacts with alkali under pressure at 150°C to produce glycolic acid and with sulphuric acid to give monochloroacetic acid (Hardie, 1964)

(m) Conversion factor: 1 ppm in air is equivalent to 5.37 mg/m$^3$.

### 1.4 Technical products and impurities

Trichloroethylene is available in the US in high-purity, electronic USP, technical, metal degreasing and extraction grades (Hawley, 1971). Typical analysis of a commercial grade is: boiling-range at 760 mm, 86.6-87.8°C; density, $d_4^{15}$ 1.467-1.471; acidity (as HCl), 0.0005% max; alkalinity (as NaOH), 0.001% max; no free halogen; residue on evaporation, 0.005 max; moisture content, not cloudy at -12°C.

Antioxidants, such as amines (0.001-0.01% or more) (Copelin, 1957) or combinations of epoxides such as epichlorohydrin (see also IARC, 1976b) and esters (0.2-2% total) (Starks, 1956), are added to trichloroethylene.

Specifications for trichloroethylene produced in Japan are: specific gravity (15°C/40°C), 1.4680; boiling-range, 86.5-88.2°C; nonvolatile matter, 0.005% max; acid content (as HCl), 0.0002% max.

## 2. Production, Use, Occurrence and Analysis

### 2.1 Production and use

#### (a) Production

Trichloroethylene was prepared by Fischer in 1864 during experiments on the reduction of hexachloroethane with hydrogen (Hardie, 1964). The first commercial method for its preparation was the dehydrochlorination of acetylene-derived 1,1,2,2-tetrachloroethane (see monograph, p. 477) by reaction with calcium hydroxide or by gas-phase pyrolysis. Although this method is still used today, over 90% of the trichloroethylene produced in the US is prepared by the chlorination and dehydrochlorination of 1,2-dichloroethane (see monograph, p. 429). The same process is used in Japan.

Ref 17



Trichloroethylene has been produced commercially in Austria and the UK since 1908, in Germany since 1910, in the US since 1925 (Hardie, 1964) and in Japan since 1935. Production of trichloroethylene in the US in 1977 was 132 million kg (US International Trade Commission, 1977); output has been decreasing since 1970, when a reported 277 million kg were produced by 7 companies (US Tariff Commission, 1972), due primarily to legislation restricting the use and emissions of trichloroethylene and to the closing of 3 acetylene-based and 1 ethylene-based plants.

US exports of trichloroethylene in 1976 were 16 million kg, mostly to the Federal Republic of Germany (3.8 million kg), France (3.4 million kg), Mexico (2.1 million kg) and Brazil (2 million kg) (US Department of Commerce, 1977a). US imports during that year totalled 7 million kg (US Department of Commerce, 1977b).

At least 9 companies in western Europe produce trichloroethylene, with a total production in excess of 200 million kg/year. In at least 3 countries (the Federal Republic of Germany, France and the UK) annual production is estimated to exceed 50 million kg/year. These countries and Italy import and export 10-50 million kg/year trichloroethylene. Annual production of trichloroethylene in eastern Europe is estimated to be more than 100 million kg.

In Japan, 4 companies produced 80 million kg trichloroethylene in 1976, compared with 106 million kg in 1972; in 1976, 11 million kg trichloroethylene were exported.

(b) Use

Of the trichloroethylene produced in the US in 1977, 82% was used for vapour degreasing of fabricated metal parts, 15% was exported and the remainder (3%) was used in a variety of miscellaneous applications.

Trichloroethylene is widely used in vapour degreasing, since all of its physical and chemical properties fall within the limits required in such processes. One disadvantage of trichloroethylene in this use is its high photochemical reactivity, which causes smog and led to restrictions on its use. Since trichloroethylene decomposes rapidly upon exposure to high temperatures, open flame or ultra-violet light [see section 1.3 (k)], a proposed standard was issued by the US Occupational Safety and Health Administration on 20 October, 1975, which requires that operations involving high temperatures, open flames or ultra-violet light take place outside areas in which trichloroethylene vapours are present, unless such operations are appropriately shielded and ventilated (US Occupational Safety & Health Administration, 1975).

Miscellaneous applications of trichloroethylene include its use as a solvent in the textile industry; as a solvent for adhesives and lubricants; and as a low-temperature heat transfer fluid. It has also

been use
cleaning

A p
anaesthe
analgesi
as a dis
instrume
volatile

The
use in t
of spice
tion (FD.
proposed
additive
prohibit
the isol
and in v
or detec
when the
proposed
will be
under th
be banne
deleteri
to be de
regulati
animal a
for the
also pro
animal d
skin dis
1977).

No
ethylene
uses (23

It
accepted
issuance
registra
p. 31) c

The
standard
exposure
of 535 r

Ref 17



been used as a component in several consumer products (e.g., spot removers, cleaning fluids for rugs) (Lloyd *et al.*, 1975).

A pharmaceutical grade of trichloroethylene is used as a general anaesthetic in surgical, dental and obstetrical procedures and as an analgesic in the treatment of trigeminal neuralgia. It has been used as a disinfectant and detergent for skin, minor wounds and surgical instruments. It has also been used on a variety of animals as a volatile anaesthetic.

The use of trichloroethylene as an extraction solvent (e.g., for use in the manufacture of decaffeinated coffee and for the extraction of spice oleoresins) was approved by the US Food and Drug Administration (FDA) for many years. However, on 27 September 1977, the FDA proposed regulations prohibiting the use of trichloroethylene as a food additive, directly or indirectly. Specific examples of practices to be prohibited include use in hop extraction, decaffeination of coffee, the isolation of spice oleoresins, adhesive coatings and components, and in vinyl chloride-hexene-1 copolymers. Food containing any added or detectable level of trichloroethylene will be deemed to be adulterated when the final order has been issued. On the same date, the FDA also proposed a regulation that any human drug containing trichloroethylene will be considered a new drug and will be deemed to be misbranded; under this regulation anaesthetics containing trichloroethylene would be banned. It was also proposed to declare trichloroethylene a deleterious substance, thereby causing any cosmetic product containing it to be deemed adulterated under existing law. The FDA also proposed a regulation prohibiting the use of trichloroethylene as an additive in animal and pet food; such practices as the use of trichloroethylene for the extraction of oil-seed products would be prohibited. The FDA also proposed an order prohibiting the use of trichloroethylene in animal drug products, such as its use as an inhalation anaesthetic, skin disinfectant and in detergents (US Food & Drug Administration, 1977).

No data on its use in Europe were available. In 1977, trichloroethylene was used in Japan in metal cleaning (63%), solvent and other uses (23%) and exports (14%).

It was reported in May 1978 that trichloroethylene has been accepted by the US Environmental Protection Agency as a candidate for issuance of a notice of a rebuttable presumption against renewal of registration (RPAR) (see General Remarks on Substances Considered, p. 31) on the basis of its possible carcinogenicity (Anon., 1978).

The US Occupational Safety and Health Administration's health standards for exposure to air contaminants require that an employee's exposure to trichloroethylene not exceed an 8-hr time-weighted average of 535 mg/m$^3$ (100 ppm) in the working atmosphere in any 8-hr work shift

Ref 17



of a 40-hr work week (US Occupational Safety & Health Administration, 1975). The corresponding standard in the Federal Republic of Germany is 260 mg/m$^3$, that in the German Democratic Republic and Czechoslovakia, 250 mg/m$^3$ and that in Sweden, 160 mg/m$^3$ (Winell, 1975).

It was proposed on 20 October 1975 that the maximum allowable concentration in the US be reduced from 1070 mg/m$^3$ (200 ppm) to 805 mg/m$^3$ (150 ppm) (US Occupational Safety & Health Administration, 1975). The maximum acceptable ceiling concentration in the USSR is 10 mg/m$^3$ (1.86 ppm) (Winell, 1975).

The US National Institute for Occupational Safety and Health has recently recommended that occupational exposure to halogenated anaesthetic agents, including trichloroethylene, be controlled so that no worker is exposed to concentrations greater than 10.7 mg/m$^3$ (2 ppm) (National Institute for Occupational Safety & Health, 1977b).

## 2.2 Occurrence

Trichloroethylene is not known to occur as a natural product. Its occurrence in air, water, soil and sediments, food, marine organisms and humans has been reviewed (Battelle Columbus Laboratories, 1977).

### (a) Air

The US Environmental Protection Agency has estimated that approximately 60% of the total annual world production of trichloroethylene is released to the environment, with annual emissions of about 540 million kg to the atmosphere and 9.1 million kg to the ocean (Fuller, 1976). The dispersive uses of trichloroethylene (metal cleaning and solvent applications) have been estimated to result in annual emissions of 192 million kg in the US (Fuller, 1976) and 100 million kg in Japan (Ohta *et al.*, 1976).

The background ambient air concentration of trichloroethylene has been reported for several locations: (1) western Eire, levels of 80 ng/m$^3$ (15 ppt[1]); (2) over the North Atlantic, < 27 ng/m$^3$ (5 ppt) (Lovelock, 1974); (3) in a rural area, < 27 ng/m$^3$ (5 ppt) (Grimsrud & Rasmussen, 1975); (4) in the northern hemisphere, about 80 ng/m$^3$ (15 ppt); and (5) in the southern hemisphere, about 8 ng/m$^3$ (1.5 ppt) (Cox *et al.*, 1976).

Trichloroethylene has also been detected in ambient air: (1) in north-eastern US, at typical levels of 1 µg/m$^3$ (0.19 ppb[2]) in urban areas and < 0.1 µg/m$^3$ (0.02 ppb) in rural areas (Lillian *et al.*, 1975); (2) in Michigan, at levels of 150-500 ng/m$^3$ (30-90 ppt) (Russell & Shadoff,

[1] 1 ppt in air is equivalent to 5.37 ng/m$^3$.
[2] 1 ppb in air is equivalent to 5.37 µg/m$^3$.

Ref 17



1977); (3) at 4 sites in California, at levels of 83-1670 ng/m$^3$ (15.6-310.8 ppt) (Singh, 1976); (4) at 5 US land stations, at levels ranging from 2-28 ng/m$^3$ (0.4-5.2 ppt); (5) at 11 sea stations, at levels ranging from 1-22 ng/m$^3$ (0.2-4 ppt) (Murray & Riley, 1973); (6) in Tokyo, at 26 sites, at average levels of 6.4 µg/m$^3$ (1.2 ppb) (Ohta *et al.*, 1976); and (7) in Manchester, UK, at levels of 5.35-343 µg/m$^3$ (1-64 ppb) (Pearson & McConnell, 1975).

(b) Water

Trichloroethylene has been found in 2 raw-water samples, 1 lake-water sample, 10 finished drinking-water samples, 1 raw sewage sample, 5 rivers and samples of effluent from 4 chemical plants and 4 sewage treatment plants in the US (Shackelford & Keith, 1976). It was detected in samples of surface-water from 88/204 sites near heavily industrialized areas, at levels > 1 µg/l (Ewing *et al.*, 1977).

Trichloroethylene has been detected in: (1) tap-water (Dowty *et al.*, 1975); (2) tap, lake, spring, and subterranean water, at levels of 105, 38, 5 and 80 ng/l, respectively (Grob & Grob, 1974); and (3) effluent water from a chemical production plant, at a level of 0.2 mg/l (Eurocop-Cost, 1976).

It has also been detected in: (1) a river, at a level of 25 µg/l (Rook *et al.*, 1975); (2) ground-water near waste deposits, at a level of 100 µg/l (Keeping *et al.*, 1975); (3) the drinking-water of 5 cities, at levels of 0-0.5 µg/l (Coleman *et al.*, 1976); and (4) influent and effluent water from a sewage treatment plant, at levels of 8.6-40.4 µg/l (Bellar *et al.*, 1974).

(c) Soil and sediments

Concentrations of trichloroethylene in soil and sediment near production and user sites in the US ranged from 0- > 100 µg/kg (Battelle Columbus Laboratories, 1977).

(d) Food and drink

Trichloroethylene has been detected in the following foodstuffs in the UK: dairy products (0.3-10 µg/kg), meat (12-22), oils and fats (0-19), beverages (0-60) and fruits and vegetables (McConnell *et al.*, 1975). Traces of trichloroethylene have also been found in edible oils after extraction (Gracián & Martel, 1972).

(e) Marine organisms

Trichloroethylene has been detected in 3 species of mollusc at levels of 0-250 ng/g, and in 5 species of fish at levels of 0-479 ng/g (dry weight) (Dickson & Riley, 1976).

Ref 17



(f) Humans

Trichloroethylene has been detected in post-mortem human tissue samples, at levels of < 1-32 µg/kg (wet tissue) (McConnell *et al.*, 1975) and in human expired air, at levels of 0-3.9 µg/hr/subject (Conkle *et al.*, 1975).

It has been estimated that about 60,000 people are exposed annually to trichloroethylene as an anaesthetic (Fuller, 1976).

(g) Occupational exposure

Occupational exposure to trichloroethylene has been reviewed (National Institute for Occupational Safety & Health, 1973).

Trichloroethylene has been detected in the atmosphere of dry-cleaning plants (Babenko, 1974). Levels of 1076-43,000 mg/m$^3$ (200-8000 ppm) were found in a small factory (Kleinfeld & Tabershaw, 1954).

Concentrations of trichloroethylene vapour in a dial assembly workshop ranged from < 135 -> 538 mg/m$^3$ (25-100 ppm); those in the degreasing room were 800-1350 mg/m$^3$ (150-250 ppm) (Takamatsu, 1962).

The concentration to which surgeons and nurses were exposed in operating-rooms varied from 1.6-554 mg/m$^3$ (0.3-103 ppm) (Corbett, 1973). About 5000 medical, dental and hospital personnel are routinely exposed to trichloroethylene.

A 1974 National Occupational Hazard Survey indicated that workers primarily exposed to trichloroethylene are those in hospitals, in the aircraft manufacturing industry, in blast furnaces and in steel mills (National Institute for Occupational Safety & Health, 1977a).

(h) Other

Trichloroethylene has been detected as a trace impurity in helium (Schehl, 1973).

## 2.3 Analysis

A review of methods for the analysis of trichloroethylene in waste-treatment plant sludge was made by Camisa (1975). Analytical methods to determine trichloroethylene in air, oleoresins, blood and urine have also been reviewed (Kouer, 1975; Walter *et al.*, 1976).

Methods used for the analysis of trichloroethylene in environmental samples are listed in Table 1.

TABLE 1. METHODS FOR THE ANALYSIS OF TRICHLOROETHYLENE

TABLE 1. METHODS FOR THE ANALYSIS OF TRICHLOROETHYLENE

| ANALYTICAL METHOD | | | | |
|---|---|---|---|---|
| SAMPLE TYPE | EXTRACTION/CLEAN-UP | DETECTION | LIMIT OF DETECTION | REFERENCE |
| **Formulations** | | | | |
| Cough syrups and encapsulated liquids | Transfer to ethanol, dilute as appropriate, transfer to separator containing 10% sucrose solution and carbon disulphide | IR | | Horwitz (1975) |
| **Air** | | | | |
| Workplace | Trap on charcoal, extract (carbon disulphide) | GC/FID | Useful range, 519-2176 mg/m$^3$ | National Institute for Occupational Safety & Health (1977c) |
| Ambient | Trap in Drechsel flask fitted with rubber septum, sample with gas syringe | GC/ECD | 1 µg/m$^3$ | Bureau International Technique des Solvants Chlorés (1976) |
| Ambient | Analyse directly | GC/ECD | 10 mg/m$^3$ | Krynska *et al.* (1976) |
| Rural | Trap on porous polymer, desorb by heating, retrap in line on GC column | GC/ECD; GC/MS | 160 ng/m$^3$ (30 ppt) | Russell & Shadoff (1977) |
| Atmosphere | Analyse directly | GC/MS | 27 ng/m$^3$ (5 ppt) | Grimsrud & Rasmussen (1975) |
| Ambient | Analyse directly | Carbon dioxide laser | 1.8 µg/m$^3$ (0.7 ppb) | Kreuzer *et al.* (1972) |
| Ambient | Analyse directly | Carbon dioxide laser | 23 µg/m$^3$ (4.7 ppb) | Schnell & Fischer (1975) |
| **Water** | | | | |
| Sea- and fresh-water | Extract (pentane), dry | GC/ECD | 50 ng/l | Bureau International Technique des Solvants Chlorés (1976) |
| Waste-water | Extract (freon) | GC/FID | 0.7 ng | Austern *et al.* (1975) |
| River water | Headspace analysis | GC/MS | | Rook *et al.* (1975) |

Pg 17

TABLE 1. METHODS FOR THE ANALYSIS OF TRICHLOROETHYLENE (continued)

| ANALYTICAL METHOD | | | | |
|---|---|---|---|---|
| SAMPLE TYPE | EXTRACTION/CLEAN-UP | DETECTION | LIMIT OF DETECTION | REFERENCE |
| Drinking-water | Inject directly | GC/ECD | 2 µg/l | Nicholson *et al.* (1977) |
| Tap-water | Inject directly | GC/MS | 0.2 µg/l | Fujii (1977) |
| Food | | | | |
| Spice oleoresins | Dilute with ethanol, add internal standard | GC/microcoulometry | | Horwitz (1975) |
| Biological | | | | |
| Blood | Analyse directly, using precolumn on GC and internal standard | GC/FID | | Cole *et al.* (1975a,b) |
| Miscellaneous | | | | |
| Oils and liquid paraffin | Headspace analysis | GC/FID | 0.2 µg | Drexler & Osterkamp (1977) |

Abbreviations: IR - infra-red spectrometry; GC/FID - gas chromatography/flame-ionization detection; ECD - electron capture detection; MS - mass spectrometry

Ref 17

Use
trichloro
8 Europea
mg/kg (Pa
has also

A sy
Ellison &

3.1 Carc

Oral

Mous
olc, were
1,2-epoxy
by gavage
2000-2400
males and
All surv
Time-wei
females
Groups o
controls.
Hepatoce
females,
high-dos
cell tum
male.
ted with
Lung tum
mas) in
dose gro
adenomas
ethylene

[1]Th
carcinog
oral adr
mice car
(Toxicol
inhalati
of the N

Ref 17



Use of gas chromatography with electron capture detection to detect trichloroethylene residues in grain has been studied collaboratively by 8 European laboratories. The limit of detection ranged from 0.005-0.2 mg/kg (Panel on Fumigant Residues in Grain, 1974). Gas chromatography has also been used by Kuchinskii (1977) and Lillian *et al.* (1975).

A system to determine trichloroethylene in water is described by Ellison & Wallbank (1974).

## 3. Biological Data Relevant to the Evaluation of Carcinogenic Risk to Humans

### 3.1 Carcinogenicity studies in animals[1]

#### Oral administration

Mouse: Groups of 50 male and 50 female B6C3F1 hybrid mice, 5 weeks old, were administered 99% pure trichloroethylene, containing 0.19% 1,2-epoxybutane and 0.09% epichlorohydrin (see IARC, 1976b) in corn oil by gavage on 5 days a week for 78 weeks. High-dose males received 2000-2400 mg/kg bw/day, and females 1400-1800 mg/kg bw/day; low-dose males and females received 1000-1200 mg/kg bw/day and 700-900 mg/kg bw. All surviving animals were observed until they were 95 weeks of age. Time-weighted average doses were 1169 and 869 in low-dose males and females and 2339 and 1739 mg/kg bw/day in high-dose males and females. Groups of 20 male and 20 female mice served as vehicle-treated matched controls. Survival was reduced in high-dose males and control males. Hepatocellular carcinomas occurred in 1/20 control males and 0/20 control females, in 26/50 low-dose males and 4/50 low-dose females, and in 31/48 high-dose males and 11/47 high-dose females. Metastases of the liver-cell tumours to the lung were found in 7/98 treated males and in 1 control male. The first hepatocellular carcinoma was observed in a mouse treated with the high dose of trichloroethylene which died during week 27. Lung tumours occurred in treated animals of both sexes: 5/50 (5 adenomas) in males and 4/50 (2 adenomas, 2 carcinomas) in females in the low-dose group, and 2/48 (1 adenoma, 1 carcinoma) in males and 7/47 (5 adenomas, 2 carcinomas) in females treated with the high dose of trichloroethylene. Among controls, only one lung adenoma was reported in a

[1]The Working Group was aware of studies in progress to assess the carcinogenicity of trichloroethylene in mice by skin, subcutaneous and oral administration (IARC, 1978a) and of an inhalation study in rats and mice carried out under contract to the Manufacturing Chemist's Association (Toxicology Information Program, 1976). Preliminary results of the inhalation study (Page & Arthur, 1978) indicate findings similar to those of the National Cancer Institute (1976).

Ref 17



female (National Cancer Institute, 1976) [The Working Group noted that the low-dose males and females also received 1 and 0.7 mg/kg bw/day epichlorohydrin, and the high-dose males and females received 2.1 and 1.56 mg/kg bw/day epichlorohydrin].

Rat: Groups of 50 male and 50 female Osborne-Mendel rats, 7 weeks of age, received 99% pure trichloroethylene, containing 0.19% 1,2-epoxybutane and 0.09% epichlorohydrin (see IARC, 1976b) in corn oil by gavage on 5 days a week for 78 weeks. High-dose animals received varying dose schedules of 1000-1500 mg/kg bw/day, and low-dose animals received 500-750 mg/kg bw/day. All surviving animals were killed 110 weeks after the start of treatment. The time-weighted average doses were 549 and 1097 mg/kg bw/day. A group of 20 male and 20 female vehicle-treated rats served as controls. Of the males, 17/20 controls, 42/50 low-dose and 47/50 high-dose animals died before the end of the study; of the females, 12/20 controls, 35/48 low-dose animals and 37/50 high-dose animals died. Median survival times were approximately 60 weeks for high-dose males, 85 weeks for low-dose males and 70 weeks for high- and low-dose females. Of the males, 5/20 controls, 7/50 low-dose and 5/50 high-dose rats developed tumours; of the females, 7/20 controls, 12/48 low- and 12/50 high-dose rats developed tumours. No liver-cell tumours occurred; tumours that occurred in various other organs in treated and vehicle control animals were mainly reticulum-cell sarcomas, lymphosarcomas or malignant lymphomas, fibroadenomas of the mammary gland, haemangiosarcomas at various sites, follicular adenocarcinomas of the thyroid, chromophobe adenomas of the pituitary and renal hamartomas. Toxic nephropathy was observed in rats of both sexes treated with high and low doses of trichloroethylene (National Cancer Institute, 1976) [The Working Group noted the poor survival of treated rats and that the low- and high-dose animals also received 0.5 and 1 mg/kg bw/day epichlorohydrin].

In a preliminary report of a study in progress, groups of 30 male and 30 female Sprague Dawley rats, 13 weeks of age, were given 50 or 250 mg/kg bw trichloroethylene (purity unspecified) in olive oil by gavage 4-5 times per week for 52 weeks, followed by observation for life. A group of 30 male and 30 female controls received olive oil alone. Results were reported 76 weeks after the start of treatment, at which time 46 controls, 39 low-dose and 34 high-dose males and females combined of each group were still alive. Among high-dose rats that died, 1 lymphoid leukaemia and 1 plasmocytoma were observed (minimum latent period, 38 weeks); 2 plasmocytomas occurred in low-dose animals that died (minimum latent period, 70 weeks). No such tumours were found in controls (Maltoni & Maioli, 1977).

Ref 17



## 3.2 Other relevant biological data

### (a) Experimental systems

#### Toxic effects

Wide variations in impurities and manufacturing processes of trichloroethylene produce inconsistencies in experimental toxicity tests (Defalque, 1961); in addition, pure trichloroethylene decomposes readily into highly toxic products. The extensive literature on the toxicity of trichloroethylene has been reviewed by Aviado *et al.* (1976), Browning (1965), Defalque (1961), the US Occupational Safety & Health Administration (1975), Lloyd *et al.* (1975), Von Oettingen (1964), Smith (1966) and Walter *et al.* (1976).

The oral $LD_{50}$ in rats is 7.2 g/kg bw (Smyth *et al.*, 1969) and in mice, 2.85 g/kg bw (Aviado *et al.*, 1976). The i.p. $LD_{50}$ in mice is 3.2 g/kg bw (Klaassen & Plaa, 1966) or 1.83 g/kg bw (Schumacher & Grandjean, 1960); that in dogs is 2.8 g/kg bw (Klaassen & Plaa, 1967). The lowest lethal i.v. dose for dogs is 150 mg/kg bw; in rabbits, the s.c. lethal dose is 1.8 g/kg bw (Barsoum & Saad, 1934).

The maximum concentrations of vapour that produced no toxic effects after exposure for 7 hrs daily on 5 days a week for 6 months were: rats and rabbits, 1076 mg/m$^3$ (200 ppm); guinea-pigs, 538 mg/m$^3$ (100 ppm); and monkeys, 2150 mg/m$^3$ (400 ppm) (Adams *et al.*, 1951). Thirty exposures for 8 hrs daily on 5 days/week to 3825 mg/m$^3$ (700 ppm), or continuous exposure to 189 mg/m$^3$ (35 ppm) for 90 days caused no visible sign of toxicity in rats, dogs, monkeys, guinea-pigs or rabbits (Prendergast *et al.*, 1967).

In 8 cats exposed to concentrations of 108 mg/m$^3$ of air (20 ppm) for 1-1.5 hrs per day for 4-6 months, centrilobular hepatitis, nephritis, hypertrophy of lymphoid glands and splenomegaly were observed (Mosinger & Fiorentini, 1955). In mice, trichloroethylene caused less damage to the kidneys and liver than did carbon tetrachloride or chloroform (Klaassen & Plaa, 1966).

In a chronic toxicity study, the maximal tolerated oral dose of industrial-grade trichloroethylene in Osborne-Mendel rats was 1100 mg/kg bw for animals of both sexes; that in B6C3F1 hybrid mice was 2340 mg/kg (males) and 1740 mg/kg (females) (National Cancer Institute, 1976).

#### Embryotoxicity and teratogenicity

Groups of rats and mice were exposed by inhalation for 7 hrs daily on days 6-15 of gestation to 1600 mg/m$^3$ in air (300 ppm) trichloroethylene; no effects were observed on the average number of implantation sites per litter, litter size, incidence of foetal resorptions, foetal sex ratios or

Ref 17



foetal body measurements. No treatment-related increased incidence in skeletal or visceral malformations was observed (Schwetz *et al.*, 1975).

Absorption, distribution, excretion and metabolism

A review is available (Piotrowski, 1977).

Following inhalation of trichloroethylene, none was detected in the blood or organs of rats (Kimmerle & Eben, 1973a).

Dogs exposed to trichloroethylene excreted trichloroacetic acid and the glucuronide of trichloroethanol in the urine (Barrett & Johnston, 1939; Butler, 1949). When $^{36}$Cl-trichloroethylene was given by gavage to rats, 10-20% of the dose was excreted in the urine as 1-5% trichloroacetic acid and 10-15% trichloroethanol; 0-0.5% was excreted as trichloroethylene in the faeces and 72-85% as trichloroethylene in the expired air (Daniel, 1963).

The demonstration of the enzymic conversion of trichloroethylene to chloral by liver microsomes from rabbits, rats and dogs supports the suggestion of Powell (1945) that the trichloroethylene oxide intermediate rearranges into chloral hydrate (Byington & Leibman, 1965; Leibman, 1965). Chloral was also isolated *in vitro* as an intramolecular rearrangement product of trichloroethylene oxide; chloral is then in part reduced to trichloroethanol or oxidized to trichloroacetic acid (Bonse & Henschler, 1976; Bonse *et al.*, 1975). Spectral evidence for the formation of trichloroethylene oxide (2,2,3-trichloro-oxirane) during incubation of trichloroethylene with metabolizing hepatic microsomes was reported by Uehleke *et al.* (1977).

$^{14}$C-Trichloroethylene is bound irreversibly to liver endoplasmic protein *in vivo* and *in vitro* (Allemand *et al.*, 1978; Bolt *et al.*, 1977; Uehleke & Poplawski-Tabarelli, 1977; Van Duuren & Banerjee, 1976); it is bound to exogenous DNA *in vitro* (Banerjee & Van Duuren, 1978). Binding is correlated with the activity of hepatic mixed-function oxidases (Uehleke & Poplawski-Tabarelli, 1977); thus, treatment of animals with inducers of hepatic mixed-function oxidases, such as phenobarbital, methylcholanthrene, Aroclor 1254 or hexachlorobenzene, increases the hepatotoxicity of trichloroethylene (Carlson, 1974; Moslen *et al.*, 1977a) and depletes hepatic glutathione (Moslen *et al.*, 1977b).

Mutagenicity and other related short-term tests

Trichloroethylene was mutagenic in *Escherichia coli* K12 and in *Salmonella typhimurium* TA100 (Greim *et al.*, 1975; Simon *et al.*, 1977) in the presence of a microsomal activation system. In another assay with *Salmonella typhimurium* TA100, the pure compound was not mutagenic either in the presence or absence of rat liver microsomes; it was shown additionally that two of the impurities in a technical-grade

Ref 17



sample of trichloroethylene, epichlorohydrin and 1,2-epoxybutane, were mutagenic in the absence of rat liver microsomes (Henschler *et al.*, 1977).

In *Saccharomyces cerevisiae* strain XV185-14C, trichloroethylene induced reverse mutations in the presence of mouse liver microsomes; the mutation frequencies were concentration-dependent. The authors concluded that trichloroethylene induced base-pair as well as frameshift type mutations (Shahin & Von Borstel, 1977). Positive results have been reported in the same species for the induction of gene mutations and mitotic gene conversion (strain D7) in the presence of mammalian microsomes and for the host(mouse)-mediated assay (strain D4) (Bronzetti *et al.*, 1978).

Mice given single i.p. injections of half-$LD_{50}$ doses of trichloroethylene in dimethylsulphoxide, or five repeated injections of one-sixth the $LD_{50}$ at one-day intervals, showed no increase in the frequency of chromosome aberrations in their bone-marrow cells (Černá & Kypěnová, 1977).

In spot tests for somatic mutations, i.p. treatment of pregnant mice with 1 mM trichloroethylene induced coat colour mutations in exposed embryos (Fahrig, 1977).

[To what extent the positive mutagenic results reported with trichloroethylene are due to impurities in the test samples could not be determined by the Working Group].

(b) Humans

Numerous fatalities resulting from anaesthesia with trichloroethylene and from industrial intoxications have been compiled. Sudden death, probably due to ventricular fibrillation, has been reported on exertion shortly after intense exposure (Defalque, 1961).

Chronic inhalation of trichloroethylene affects the central nervous system (Grandjean *et al.*, 1955). Accidental ingestions produced inebriety, vomiting, diarrhoea, collapse and coma, followed either by death (pulmonary oedema and liver and kidney necrosis at autopsy) or recovery with transient neurological sequelae (amnesia, headache, numbness, weakness of extremities, psychosis or hemiparesis) (Defalque, 1961). Toxic effects on the liver (Schüttmann, 1970) and cutaneous reactions (Bauer & Rabens, 1974; Schirren, 1971; Stewart *et al.*, 1974) have been reported.

Psychophysiological function was depressed in volunteers exposed to 592 mg/m$^3$ (110 ppm) trichloroethylene for two 4-hr periods (Salvini *et al.*, 1971). Experimental exposure of 10 volunteers to 1070 mg/m$^3$ (200 ppm) trichloroethylene vapour for periods of 7 hrs over 5 days

Ref 17



produced fatigue and sleepiness (Stewart *et al.*, 1970). Impairment of neurological and psychological functions after acute and longer exposure was also reported by Gamberale *et al.* (1976) and Triebig *et al.* (1977). It has been suggested that the toxic action in humans was due mainly to contaminants (Browning, 1965; Defalque, 1961).

There is an indication that the hepatotoxic effect of trichloroethylene is enhanced by concomitant exposure to ethanol or isopropyl alcohol (Traiger & Plaa, 1974).

About 60% of inspired trichloroethylene is taken up by the body; the arterial blood concentration increased linearly with the concentration in the alveolar air (Åstrand & Övrum, 1976).

Humans exposed to trichloroethylene excrete trichloracetic acid and trichloroethanol in the urine (Kimmerle & Eben, 1973b; Nomiyama & Nomiyama, 1971; Powell, 1945), and the concentration of trichloracetic acid in the urine is an indication of trichloroethylene exposure (Axelson *et al.*, 1978; Smith, 1978). Kinetic studies of the formation and excretion of trichloroacetic acid and trichloroethanol have been reported (Fernandez *et al.*, 1977; Monster *et al.*, 1976; Müller *et al.* 1974). Chloral hydrate was also identified as a trichloroethylene metabolite in the blood (Cole *et al.*, 1975a; Scansetti *et al.*, 1959).

### 3.3 Case reports and epidemiological studies[1]

An epidemiological study of cancer mortality among 518 males exposed occupationally to relatively low levels of trichloroethylene has been reported. Levels of exposure were estimated by concentrations of trichloroacetic acid in the urine: exposure categories with averages below and above 100 mg/l trichloroacetic acid in the urine were used; 100 mg/l corresponds roughly to an 8-hr time-weighted average exposure of 160 mg/m$^3$ (30 ppm) trichloroethylene in air. When compared with the national population rates, 49 deaths from all causes were observed *versus* 62 expected. With no consideration given to latency or intensity of exposure, 11 deaths due to cancer at all sites were observed *versus* 14.5 expected. When analyses were restricted to those with 10 or more years since onset of exposure, no significant excess of cancer was demonstrated, either for those exposed to high or lower levels of trichloroethylene. It was concluded, however, that this study could not rule out a cancer risk to humans, particularly for rare types of malignancies such as liver cancer (Axelson *et al.*, 1978) [The small size of the study group and the relatively short latent period (mainly less than 20 years) underline this conclusion].

[1]The Working Group was aware of 2 studies in progress: a cancer mortality study of workers occupationally exposed to trichloroethylene and a follow-up study of workers exposed to organochloride and alkylchloride compounds, vinyl chloride, trichloroethylene and unsaturated compounds (IARC, 1978b).

Ref 17



## 4. Summary of Data Reported and Evaluation

### 4.1 Experimental data

Trichloroethylene was tested in one experiment in mice and in one in rats by oral administration. In mice, it produced hepatocellular carcinomas and lung tumours in both males and females. The experiment in rats was considered to be inadequate. Preliminary results of a study in progress by oral administration to rats could not be evaluated.

Trichloroethylene is mutagenic in bacteria and yeast and in spot tests for somatic mutations in mice.

### 4.2 Human data[1]

No case reports were available to the Working Group. The only epidemiological study available reported no statistically significant excess of cancer associated with exposure to trichloroethylene. However, because of the small size of the group and the relatively short time since onset of exposure, no assessment of carcinogenicity could be made.

The extensive production of trichloroethylene for over 50 years, together with its use as an industrial solvent and metal cleaning agent, as an inhalational anaesthetic and as an additive in drugs, food and consumer products, indicate that widespread human exposure occurs. This is confirmed by many reports of its occurrence in air, water and foods and in human tissues and expired air.

### 4.3 Evaluation

There is *limited evidence* that trichloroethylene is carcinogenic in mice.

---

[1]Subsequent to the meeting of the Working Group, the Secretariat became aware of a study of 330 deceased laundry and dry-cleaning workers who had been exposed to carbon tetrachloride, trichloroethylene and tetrachloroethylene. An excess of lung, cervical and skin cancers and a slight excess of leukaemias and liver cancers were observed (Blair *et al.*, 1979).

Ref 17



## 5. References


Adams, E.M., Spencer, H.C., Rowe, V.K., McCollister, D.D. & Irish, D.D. (1951) Vapor toxicity of trichloroethylene determined by experiments on laboratory animals. AMA Arch. ind. Hyg. occup. Med., 4, 469-481

Allemand, H., Pessayre, D., Descatoire, V., Degott, C., Feldmann, G. & Benhamou, J.-P. (1978) Metabolic activation of trichloroethylene into a chemically reactive metabolite toxic to the liver. J. Pharmacol. exp. Ther., 204, 714-723

Anon. (1978) Trichloroethylene. Pestic. Tox. Chem. News, 10 May, p.2

Åstrand, I. & Övrum, P. (1976) Exposure to trichloroethylene. I. Uptake and distribution in man. Scand. J. Work Environ. Health, 4, 199-211

Austern, B.M., Dobbs, R.A. & Cohen, J.M. (1975) Gas chromatographic determination of selected organic compounds added to wastewater. Environ. Sci. Technol., 9, 588-590

Aviado, D.M., Zakhari, S., Simaan, J. & Ulsamer, A.G. (1976) Methyl Chloroform and Trichloroethylene in the Environment, Cleveland, OH, Chemical Rubber Co., pp. 47-89

Axelson, O., Andersson, K., Hogstedt, C., Holmberg, B., Molina, G. & de Verdier, A., (1978) A cohort study on trichloroethylene exposure and cancer mortality. J. occup. Med., 20, 194-196

Babenko, K.V. (1974) Sanitary hygienic assessment of the working conditions for operators involved in the chemical cleaning of clothes (Russ.). Gig. Sanit., 11, 77-79

Banerjee, S. & Van Duuren, B.L. (1978) Covalent binding of the carcinogen trichloroethylene to hepatic microsomal proteins and to exogenous DNA *in vitro*. Cancer Res., 38, 776-780

Barrett, H.M. & Johnson, J.H. (1939) The fate of trichloroethylene in the organism. J. biol. Chem., 127, 765-770

Barsoum, G.S. & Saad, K. (1934) Relative toxicity of certain chloride derivatives of the aliphatic series. Q. J. Pharm. Pharmacol., 7, 205-214

Battelle Columbus Laboratories (1977) Multimedia Levels. Trichloroethylene, EPA 560/6-77-029, Washington DC, US Environmental Protection Agency. Available from Springfield, VA, National Technical Information Service, Report No. PB-276535

Ref 17



Bauer, M. & Rabens, S.F. (1974) Cutaneous manifestations of trichloroethylene toxicity. Arch. Dermatol., 110, 886-890

Bellar, T.A., Litchenberg, J.J. & Kroner, R.C. (1974) The occurrence of organohalides in chlorinated drinking waters. J. Am. Water Works Assoc., 66, 703-706

Blair, A., Decoufle, P. & Grauman, D. (1979) Causes of death among laundry and dry cleaning workers. Am. J. publ. Health, 69, 508-511

Bolt, H.M., Buchter, A., Wolowski, L., Gil, D.L. & Bolt, W. (1977) Incubation of $^{14}$C-trichloroethylene vapor with rat liver microsomes: uptake of radioactivity and covalent protein binding of metabolites. Int. Arch. occup. environ. Health, 39, 103-111

Bonse, G. & Henschler, D. (1976) Chemical reactivity, biotransformation, and toxicity of polychlorinated aliphatic compounds. CRC Crit. Rev. Toxicol., 4, 395-409

Bonse, G., Urban, T., Reichert, D. & Henschler, D. (1975) Chemical reactivity, metabolic oxirane formation and biological reactivity of chlorinated ethylenes in the isolated perfused rat liver preparation. Biochem. Pharmacol., 24, 1829-1834

Bronzetti, G., Zeiger, E. & Frezza, D. (1978) Genetic activity of tricholoroethylene in yeast. J. environ. Pathol. Toxicol., 1, 411-418

Browning, E. (1965) Toxicity and Metabolism of Industrial Solvents, Amsterdam, Elsevier, pp. 189-212

Bureau International Technique des Solvants Chlorés (1976) Standardization of methods for the determination of traces of some volatile chlorinated aliphatic hydrocarbons in air and water by gas chromatography. Anal. chim. acta, 82, 1-17

Butler, T.C. (1949) Metabolic transformations of trichloroethylene. J. Pharmacol. exp. Ther., 97, 84-92

Byington, K.H. & Leibman, K.C. (1965) Metabolism of trichloroethylene by liver microsomes. II. Identification of the reaction product as chloral hydrate. Mol. Pharmacol., 1, 247-254

Camisa, A.G. (1975) Analysis and characteristics of trichloroethylene wastes. J. Water Pollut. Control Fed., 47, 1021-1031

Carlson, G.P. (1974) Enhancement of the hepatotoxicity of trichloroethylene by inducers of drug metabolism. Res. Comm. Chem. Pathol. Pharmacol., 7, 637-640

# DOCUMENTATION OF THE THRESHOLD LIMIT VALUES

## FOURTH EDITION

## 1980

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS INC.

CINCINNATI, OHIO

Ref 18

limits for the dichlorobenzenes. For the present, this limit is retained.

Other recommendations for trichlorobenzene: Bulgaria, Poland, U.S.S.R., Yugoslavia, 1.4 ppm.


References:

1. Treon, J.: Unpublished report from the Kettering Laboratory, University of Cincinnati, OH (1950).
2. Brown, V.K.H., Muir, C., Thorpe, J.: *Ann. Occup. Hyg. 12*:209 (1969).
3. Gage, J.C.: *Brit. J. Ind. Med. 27*:1 (1970).
4. Cameron, G.R., Thomas, J.C., Ashmore, A.S., Buchan, J.L., Warren, E.H. Hughes, A.W.N.: *J. Path. Bact.*, Vol. 281 (1937).
5. Powers, M.B., Coate, W.B., Lewis, T.R.: *Arch. Env. Health 30*:1 965 (1975).
6. Rowe, V.K.: Private communication (1975).
7. Coate, W.B., Schoenfisch, W.H., Busey, W.M., Lewis, T.R.: *Chronic Inhalation Exposure of Rats, Rabbits and Monkeys to 1,2,4-Trichlorobenzene.*


## 1,1,1-TRICHLOROETHANE

**Methyl chloroform, METHYL CHLOROFORM**

## 1,1,2-TRICHLOROETHANE

**Vinyl trichloride**

$H_2ClCHCl_2$

**TLV, 10 ppm ( ≈ 45 mg/m³)**

**STEL, 20 ppm ( ≈ 90 mg/m³)**

*A colorless, non-flammable liquid with a sweet odor, 1,1,2-trichloroethane has a molecular weight of 133.42 and a specific gravity of 1.4416 at 20° C. It boils at 113.7° C, freezes at -36.4° C and has a vapor pressure of 19 mm Hg at 20° C. Insoluble in water, it is miscible with alcohol, ether and other organic solvents.*

It is used as a solvent for fats, resins, etc., and in organic synthesis.

1,1,2-trichloroethane depresses the central nervous system, causing narcosis, in which respect it is considerably more potent than chloroform.[1,2] By inhalation its acute toxicity is somewhat greater for certain laboratory animals (rats) than that of chloroform. Narcotic concentrations of 1,1,2-trichloroethane result in irritation to the eyes and nose and injection of the conjunctiva. Death occurs from respiratory arrest. Concentrations producing deep narcosis and death are of the order of 13,600 ppm for a two-hour exposure. The corresponding concentration for chloroform is 30,000 to 40,000 ppm. 1,1,2-trichloroethane is lethal by oral and subcutaneous administration; 0.75 g/kg was lethal to dogs by mouth, compared with 2.25 g/kg for chloroform.[3] Fatty degeneration of the liver was observed in dogs dying two or more days following administration of trichloroethane, which is also absorbed through the intact skin.[4]

More recent data include the following[5]: oral $LD_{50}$, rat – 1140 mg/kg; intraperitoneal $LD_{50}$, mouse – 994, dog – 450 mg/kg; subcutaneous $LD_{50}$, mouse – 227 mg/kg. Exposure at 500 ppm for 8 hours was fatal to rats.

The current TLV of 10 ppm was based on the toxicological resemblance to symmetric tetrachloroethane, and by analogy with the TLV for chloroform, which at that time was 50 ppm. In view of the above comparisons of the toxicity of 1,1,2-trichloroethane with that of chloroform, a limit somewhat lower than 10 ppm, the TLV for the latter compound, might be in order for 1,1,2-trichloroethane. For the present, the TLV of 10 ppm and STEL of 20 ppm are retained.

Other recommendations: Several western European nations and Japan had adopted the 10 ppm TLV, as of 1977; Poland, with 22 ppm, was the only exception. West Germany (1979) considers it a potential carcinogen.


References:

1. Lazarew, N.W.: *Arch. Exptl. Path. Pharmakol. 141*:19 (1929).
2. Von Oettingen, W.F.: The Halogenated Hydrocarbons, Their Toxicity & Potential Dangers, *USPHS Pub. No. 414*, pp. 155-156, US Gov. Printing Office, Washington, DC (1955).
3. Barsoum, G.S., Saad, K.: *Q. J. Pharm. & Pharmacol. 7*:205 (1934).
4. Burgi, E.: *Bruxelles Med. 16*:1481 (1936).
5. NIOSH: *Registry of the Toxic Effects of Chemical Substances* (1977).


## TRICHLOROETHYLENE

$Cl_2=CHCl$

**TLV, 50 ppm ( ≈ 270 mg/m³)**

**STEL, 150 ppm ( ≈ 805 mg/m³)**

*Trichloroethylene is a nonflammable, colorless liquid of sweetish odor. It has a molecular weight of 131.4 and a specific gravity of 1.4649. The boiling point is 87° C and it solidifies at -84.8° C. The vapor pressure at 20° C equals 58 mm Hg. It is practically insoluble in water, but highly soluble in lipids. (Partition coefficient at 37° C: blood-air 9, oil-air 943). In the presence of oxygen and short ultraviolet wavelength, trichloroethylene is decomposed to phosgene and hydrochloric acid.*

Trichloroethylene is used for degreasing, dry cleaning, and as a solvent. In the past, trichloroethylene was used as an extractant in food-processing (FDA had approved residue below 25 ppm in decaffeinated ground coffee and 10 ppm for instant coffee). This was discontinued in 1975, when NCI issued an alert, warning that trichloroethylene may be a carcinogen. Its use as an anesthetic was aban-

Ref 18

doned because of its decomposition in the soda-lime circuit into toxic and flammable dichloroacetylene, phosgene and carbon monoxide.

*The sites of biological effects of trichloroethylene:* 1) CNS (euphoria, analgesia, anesthesia); 2) Liver (necrosis, hepatomas); 3) Kidney (necrosis); 4) Lung (tachypnea); 5) Heart (arrhythmias); 6) Skin (irritation, vesication; paralysis of the fingers immersed in liquid trichloroethylene); 7) Bone marrow (myelotoxic anemia).

The knowledge of acute toxicity of trichloroethylene comes mainly from its use as an anesthetic.[1] Tachypnea and ventricular arrhythmias are equated with overdosage (inhaled concentrations greater an 15000 ppm).

Vernon and Ferguson[2] found that a two-hour exposure of a volunteer to 1000 ppm of trichloroethylene resulted in adverse effects on visual perception and motor skill; but two-hour exposures at 300 ppm and 100 ppm produced no significant effect. In a later report, the same authors[3] noted that low levels of alcohol in the blood (20-30 mg/100 mL) markedly augmented the effect of the two-hour exposures to trichloroethylene at concentrations of 300 and 1000 ppm.

Hepatic injury was observed in rats[4] exposed for 2 hours to a trichloroethylene concentration of 10,000 ppm, when the rats were pre-treated with phenobarbital, Aroclor 1254, hexachlorobenzene, 3-methyl cholanthrene or pregnenolone-16-α-carbonitrile. Liver injuries are associated with extensive metabolism of trichloroethylene in the body.

Death in laboratory animals from acute exposure to trichloroethylene vapor also results from respiratory failure or cardiac arrest.[5,6] Trichloroethylene is reported to have direct action on the bone marrow of rabbits, causing myelotoxic anemia.[7] It caused residual brain damage in dehydrated rats[8] exposed to 3000 ppm of trichloroethylene. Eight-hour exposure to any concentration higher than 3000 ppm might be fatal.[9]

Adams and associates[9] found no adverse effects when monkeys were exposed repeatedly at 400 ppm, rats and rabbits at 200 ppm, and guinea pigs at 100 ppm. Adams *et al* concluded from their animal studies that exposure to 100 ppm is probably safe for humans.

Stopps and McLaughlin[10] exposed volunteers to 100 ppm of trichloroethylene and found no changes in various performance tests, but did note some changes at higher concentrations. Steward and associates[11] reported that volunteers exposed to 200 ppm of trichloroethylene for seven hours a day showed mild responses such as slight fatigue and sleepiness on the fifth day of exposure. There were no measurable objective responses. Also, Triebig *et al*[12] exposed seven healthy volunteers to 100 ppm of trichloroethylene for five days observing no impairments of the examined person's mental or psychological capacities. On the other hand, Ertle *et al*,[13] in a similar study, observed fatigue, lassitude and headache in his volunteers.

Several European authorities, reported symptoms in workers exposed to concentrations generally below 100 ppm. Ahlmark and Forssman[14] estimated exposure to trichloroethylene by measuring the urinary excretion of trichloroacetic acid. They found the chief symptoms to be abnormal fatigue, irritability, headache, gastric disturbances and intolerance to alcohol. Ahlmark and Friberg[15] tentatively suggested 30 ppm as a desirable limit for the time-weighted average occupational exposure.

Haas[16] and Grandjean *et al*[17] found a variety of nervous disturbances in a group of 50 workers exposed to trichloroethylene vapor at concentrations ranging from 1 to 335 ppm. These disturbances increased with the length of exposure (up to five years or more), and were distinctly more frequent when trichloroethylene concentrations exceeded 40 ppm.

Bardodej and Vyskocil[18] also recommended a limit of about 40 ppm, finding signs and symptoms of chronic trichloroethylene poisoning including intolerance to alcohol, tremors, giddiness and anxiety at an exposure above 40 ppm.

Lilis and co-workers[19] reported that workers exposed at concentrations averaging about 10 ppm (12% of the tests showed values about 40 ppm) complained of headache, dizziness and sleepiness.

Smyth and associates reported an oral $LD_{50}$ to be 4.92 mg/kg and, after four hours exposure, a lethal concentration to be 8000 ppm.[20] Rats were used in both instances.

Trichloroethylene was found neither embryotoxic nor teratogenic in Sprague-Dawley rats and Swiss Webster mice inhaling trichloroethylene for seven hours at a concentration of 300 ppm on days 6-15 of gestation.[21]

Trichloroethylene was found to be weakly mutagenic in the metabolizing E. coli mutagenic systems.[22]

Recently trichloroethylene came under investigation as a possible carcinogen. The concern was initiated by a report from the National Cancer Institute[23] that hepatocellular carcinomas resulted from oral administration of trichloroethylene to mice. In this bioassay, male and female rats (Osborne-Mendel) and mice (B6C3F1) were exposed to trichloroethylene for 18 months with an observation period of 3-6 months following exposure. Rats were given doses at either 1000 mg/kg or 500 mg/kg, 5 times/week. Male mice were given 2400 or 1200 mg/kg and female mice 1800 mg/kg or 900 mg/kg doses 5 times/week. Hepatocellular carcinomas were not seen in the rats; 30 of the 98 (30.6%) mice given the low dose, and 41 of the 95 (43.2%) mice given the high dose developed hepatocellular carcinomas. Only 1 (2.5%) of the 40 control mice developed a carcinoma.

A cohort study on trichloroethylene exposure and cancer in man, conducted recently in Scandinavian countries[24] in 7,688 workers exposed to relatively small concentrations of trichloroethylene, did not reveal any excess cancer mortality. Half of the population under study was exposed to trichloroethylene for more than 10 years: 548 persons were exposed to trichloroethylene concentrations greater than 30 ppm, 3,095 persons to concentrations smaller than 30 ppm. The exposure was evaluated from urinary excretion of trichloroacetic acid, 100 mg/L being associated with an eight-hour exposure of 30 ppm of trichloroethylene, a time-weighted exposure.

A TLV of 50 ppm and 150 ppm as a STEL are recommended for trichloroethylene to provide workers with adequate protection against the toxic effect.

Other recommendations: ANSI (1967) 100 ppm; NIOSH (1978) 25 ppm; Czechoslovakia (1969) 45 ppm, for brief exposures 225 ppm; Germany (1970) 50 ppm; Sweden 30 ppm; USSR (1967) 2 ppm.

Ref 18

# TRICHLOROETHYLENE

*CAS 79-01-6*

$CCl_2 = CHCl$

**RECOMMENDED BEI**

| Indices | Time | | BEI | Current Experience |
|---|---|---|---|---|
| * Trichloroacetic acid in urine | End of workweek | G | 100 mg/L or below | Satisfactory |
| * Trichloroacetic acid and trichloroethanol in urine | End of shift and<br>End of workweek | G<br>G | 300 mg/L or below<br>320 mg/g creatinine | Satisfactory<br>Satisfactory |
| * Free trichloroethanol in blood | End of shift and End of workweek | | 4 mg/L or below | Satisfactory |
| ** Trichloroethylene in end-exhaled air (confirmatory test) | Prior to shift and end of workweek | | 0.5 ppm or below | Fair |

## Physical Proterties

Solubility: highly soluble in fat, poorly soluble in water. Partition coefficients at 37°C: blood/gas = 9.5; lean tissues/gas = 20; fat/gas = 600[1] At room temperature trichloroethylene is present in ambient air as vapor; saturated vapor pressure is 58 torr at 20°C.

## Absorption

Under most conditions occuring at the workplace trichloroethylene is absorbed by inhalation. At steady state, about 60% of inhaled trichloroethylene is absorbed in systemic circulation.[2] Liquid trichloroethylene penetrates the intact skin.[3] Trichloroethylene crosses the placenta.[4]

## Possible Nonoccupational Exposure

Trichloroethylene is used as a solvent in some household products such as spot removers and adhesives. In the USA, its use was restricted when NCI issued an alert that trichloroethylene may be a carcinogen.[5] Sniffing of trichloroethylene was also reported.[6]

## Elimination

Metabolism is the main elimination pathway of trichloroethylene. The large interindividual variation in urinary excretion of the two major metabolites, trichloroacetic acid and trichloroethanol, is frequently reported. Some of this variation can be explained by differences in experimental setting,[7] by alcohol ingestion,[7,8] and by exposure to other chemicals.[9,10] Elimination of trichloroacetic acid is very slow because of protein binding.[11] Unchanged trichloroethylene is exhaled. Following an 8-hour exposure, the amount of exhaled trichloroethylene accounts for 9% of pulmonary uptake. The desaturation curve shows 3 exponential decays with half-times of 20 min, 3 hr, and 30 hr.[12] Trichloroethylene accumulates in the body mainly in fat.[7] About 8% of the metabolites are excreted in feces and sweat.[2]

## Metabolic Pathways

The metabolic pathways of trichloroethylene are shown in Figure 5. The percentages shown in the diagram represent a fraction of pulmonary uptake exhaled or excreted as a metabolite after an 8-hour exposure.[12] Metabolites other than those indicated in the diagram are monochloroacetic acid and chloroform.[13] Ikeda et al[14] suggested that the correlation between trichloroethylene concentration and trichloroacetic acid excretion is linear only if the exposure concentration is below 50 ppm. Correlation between trichloroethylene concentrations and trichloroethanol excretion remains linear at least up to an exposure to 1000 ppm. Sex differences in metabolic pathways in man were suggested.[15,16]

## TLV-TWA

The recommended TLV-TWA of 50 ppm (≈ 270 mg/m³) is based on CNS effects and is protective against excessive discomfort induced by alcoholic beverages (1980, suppl. 1982).

## Summary

Urinary excretion of trichloroacetic acid (TCAA) and trichloroethanol (TCOH) are used as indicators of trichloroethylene exposure. Both metabolites accumulate in the body and are indicators of total exposure; they do not reflect variation of exposure concentration. Sampling at the end of the work week is recommended. The interindividual and intraindividual variation in excretion is so large that excretion of metabolites is recommended only as a screening test applicable to group or to periodic examination of an individual. Blood level of trichloroethanol is suggested as an individual test, since the interindividual variation is smaller. Since

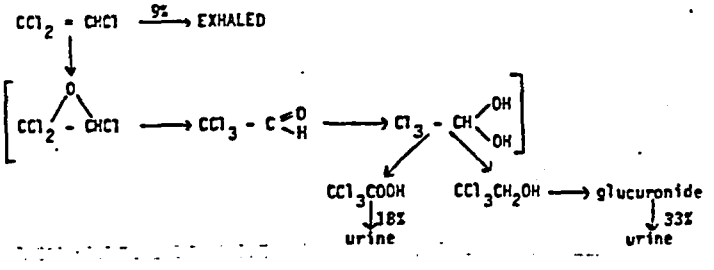



Figure 5 — Metabolic pathways of trichloroethylene.

Ref 18

TCAA and TCOH are metabolites of other solvents, determination of trichloroethylene in end-exhaled air is recommended as a confirmatory test.

## TRICHLOROACETIC ACID (TCAA) IN URINE INDEX

### Methods

Colorimetric methods based on Fujiwara reaction are nonspecific but easy to use.[17,18] Gas chromatographic methods[19-21] are specific.

### Sampling and Storage

Urine specimens should be collected in glass containers at the end of the workweek (fourth or fifth days are the most suitable). Timing is not critical. Exposure to chlorinated ethanes and ethylenes should be avoided a couple of days immediately preceding sampling. Alcohol intake and disulfiram treatment should he recorded and considered in the interpretation. Urine specimens should be kept refrigerated.

### Levels Without Occupational Exposure

Specific methods are available. TCAA is not present in urine of unexposed subjects. It is, however, a metabolite of other chlorinated industrial solvents such as $CCl_3-CH_2Cl$, $CCl_2 = CCl_2$, $CHCl_2-CHCl_2$, $CCl_3-CH_3$, and $CCl_3 \bullet CHO$,[22] which can be found in some household products. Nonoccupational exposure to trichloroethylene is possible (household products, drinking water, sniffing).

### Kinetics

The concentration of TCAA in urine rises slowly during and following trichloroethylene exposure, and peaks on the third to fifth day after exposure; then it slowly declines with a half-time of 50-100 hours.[2,11,23,24] TCAA accumulates in the body during the workweek. Ikeda suggested that the correlation between trichloroethylene concentrations and TCAA excretion is linear only if the exposure concentration is smaller than 50 ppm.[14] Protein binding of TCAA is extensive.[11]

### Factors Affecting Interpretation of BEI

TCAA is a metabolite of some other chlorinated hydrocarbons: $CCl_3 \bullet CH_2Cl$, $CHCl_2 \bullet CHCl_2$, $CCl_2 = CCl_2$, $CCl_3-CH_3$, $CCl_3 \bullet CHO$. Exposure to these chlorinated hydrocarbons and nonoccupational exposure to trichloroethylene would be manifested by increases of TCAA excretion. Ethanol intake and disulfiram treatment partly inhibit production of TCAA.[2,8] Intake of other xenobiotics including inhalation coexposure to other solvents, inhibits metabolism of trichloroethylene and reduces excretion of TCAA.[9,10]

### Justification

TCAA is an indicator of integrated exposure; it does not reflect the fluctuation of exposure. Analysis of kinetic data[14,15,23-27] has produced a general agreement that a concentration of 100-200 mg/L of TCAA in urine is the bioequivalent to the current TLV (50 ppm). The investigators agree that the interindividual variation is large, but some of this variation can be explained by differences in experimental setting. Based on the epidemiological studies and clinical observations, smaller concentrations of TCAA in urine were suggested as no-effect levels: Ahlmark and Forssman, < 40 mg/L;[28] Frant and Westerndorp, 50 mg/L;[29] Suchanova, 75 mg/L;[30] Teisinger, 100 mg/L;[31] and Bardodej, 100 mg/L.[32] Because of large interindividual variation, some investigators consider the determination of TCAA in urine as a very poor indicator of trichloroethylene exposure.[33] Attempts to reduce the variation by relating TCAA to creatinine, density, and excretory rate did not bring any significant improvement. The advantage of the test is that TCAA concentrations in urine are little affected by timing of exposure and sampling.

### Current Information Available

Sufficient information is available to support the following BEI as a screening test.

### Recommendation

The Committee recommends 100 mg/L of TCAA in urine voided at the end of the workweek as a BEI for trichloroethylene. This BEI can be applied to the mean of a group or as a screening test for individuals. If the TCAA concentration in urine collected periodically from the same workers is below the BEI, then the TWA is most likely not exceeded.

## CHLORINATED METABOLITES IN URINE INDEX

Chlorinated metabolites represent the sum of trichloroacetic acid (TCAA) and free and conjugated trichloroethanol (TCOH) in urine, expressed as TCAA.

### Method

Colorimetric method based on Fujiwara reaction in oxidized urine specimens[17,18] is the most convenient.

### Sampling and Storage

Urine specimens should be collected in glass containers at the end of the shift. The last two shifts of the workweek are suitable for collection. Exposure to other chlorinated ethanes and ethylenes, and alcohol intake and disulfiram treatment should be recorded and considered in the interpretation. Urine specimens should be kept refrigerated.

### Levels Without Occupational Exposure

TCAA and TCOH in urine of unexposed subjects are not measurable. TCAA and TCOH are, however, metabolites of other industrial chlorinated solvents such as $CCl_3-CH_2Cl$, $CCl_2 = CCl_2$, $CHCl_2-CHCl_2$, and $CCl_3-CH_3$,[22] which can be found in some household products. Nonoccupational exposure to trichloroethylene is possible (household products, drinking water, sniffing).

### Kinetics

The elimination of the two metabolites, TCAA and TCOH, have different patterns. Concentration of TCAA in urine peaks on the third to fifth day after exposure and declines slowly with a half-time of 50-100 hours.[2,11,23,24] TCOH-concentration peaks during the first 3 hours after the exposure and then declines with the half-time 12-26 hours.[2,24,25] Therefore, the concentration ratio of TCOH/TCAA in urine changes depending on the timing of the exposure and sampling schedules.[7,16,25,34] For example, at the end of the first exposure, the concentration of TCOH is approximately 10 times larger than the concentration of TCAA, but on the third post-exposure day the TCOH concentration drops below the TCAA level.[16,25,34] It was shown in volunteers undergoing 5 consecutive exposures that, at the end of the work week, the TCOH/TCAA ratio varies between 1 and 2.[11,16] In urines collected from workers on the morning

Ref 18

prior to the fifth work shift Nomiyama found the ratio equal to 1.[34] Nomiyama[15] derived an equation for correlation of exposure concentration (ppm) with concentration of chlorinated metabolites in urine specimens collected on the t-day after the last 8-hour exposure:

$$ppm = (1/6)C_t\,10^{kt} \qquad (1)$$

where:

$C_t$ = the concentration of chlorinated metabolites in urine specimens mg/L collected from the workers on t-day after the exposure.

k = the elimination rate constant, which for males equals 0.23 and for females 0.20.

The equation is valid for urines collected from subjects exposed 8 hrs/day, 5 days/week to the same time-weighted exposure concentration. Surprisingly, the linear correlation between exposure concentration and chlorinated metabolites in urine is valid for a wide range of exposure concentrations.[14]

### Factors Affecting Interpretation of BEI

TCAA and TCOH are metabolites of some other chlorinated hydrocarbons: $CCl_3 \bullet CH_2Cl$, $CHCl_2 \bullet CHCl_2$, $CCl_2 = CCl_2$, $CCl_3 - CH_3$.[22] Exposure to these chemicals and nonoccupational exposure to products containing trichloroethylene would be manifested by increased excretion of both metabolites. Ethanol intake or disulfiram treatment inhibits metabolism of trichloroethylene.[2,8] Intake of other xenobiotics, including coexposure to other solvents, can also inhibit metabolism of trichloroethylene and reduce excretion of metabolites.[9,10]

### Justification

Urinary excretion of TCAA and TCOH is another indicator of integrated exposure which is little affected by fluctuation of the exposure concentration. Concentrations of chlorinated metabolites in urine during occupational exposure to 50 ppm can be calculated from equation 1. According to this equation, the concentration of metabolites in urine collected at the end of the workweek is 300 mg/L. Based on observations in workers occupationally exposed to trichloroethylene, Ikeda *et al*[14] suggest a similar value, 275 mg/g of creatinine or 257 mg/L. After two days without occupational exposure, the concentrations of metabolites decline to one third (approximately 100 mg/L). Large interindividual and intraindividual variation of metabolite excretion was observed in controlled[2,16,23,35,38] and field[14,29] studies.

### Current Information Available

Sufficient data are available from studies in volunteers to propose a BEI that is bioequivalent to the TLV-TWA on a pharmacokinetic basis.

### Recommendation

The Committee recommens 300 mg/L (320 mg/g of creatinine) of chlorinated metabolites of trichloroethylene (expressed as TCAA) in urine voided at the end of the shift preceded by at least three regularwork shifts as a BEI for integrated exposure to trichloroethylene. This BEI can be applied to the mean of a group test or as a screening test for individuals. If the TCAA concentration in urine specimens collected periodically from the same workers is below the BEI, then the TLV-TWA is most likely not exceeded.

## FREE TRICHLOROETHANOL (TCOH) IN BLOOD INDEX

### Method

A gas chromatograph equipped with an electron capture detector is used for determination of TCOH in blood. The methods utilize either the head space technique[20] or hexane extraction.[36,37]

### Sampling and Storage

Blood should be collected at the end of the shift. Either of the last two shifts of the workweek are suitable for collection. Blood can be collected from the cubital vein and stored refrigerated in sealed vacutainers containing heparin. Hemolyzed capillary blood obtained from the finger or ear lobe can be stored refrigerated in sealed glass containers for up to 14 days.[36] Exposure to chlorinated ethanes and ethylenes, alcohol intake, and disulfiram treatment should be recorded and considered in the interpretation.

### Levels Without Occupational Exposure

Specific analytical methods are available. TCOH is not present in blood of unexposed subjects. TCOH is, however, a metabolite of industrial chlorinated solvents such as $CCl_3 \bullet CH_2Cl$, $CCl_2 = CCl_2$, or $CH_3 \bullet CCl_3$,[22] which can be found in some household products. Nonoccupational exposure to trichloroethylene is possible (household products, drinking water, glue sniffing).

### Kinetics

About 50% of TCOH in blood is conjugated with glucuronic acid.[20] TCOH in blood rises rapidly during the exposure and starts to decline shortly after the end of the exposure with a half-time of 12 hours.[11,25] During occupational exposure, TCOH accumulates in the blood significantly for the first three days.[11,16,25] No protein binding of TCOH was reported.

### Factors Affecting Interpretation of BEI

TCOH is a metabolite of some other chlorinated hydrocarbons: $CCl_3 \bullet CH_2Cl$, $CCl_2 = CCl_2$, or $CH_3 \bullet CCl_3$. Exposure to such chemicals and nonoccupational exposure to trichloroethylene would be manifested by increased TCOH concentrations in blood. Ethanol intake, disulfiram treatment, and most likely intake of other xenobiotics including coexposure to some other solvents reduce TCOH concentrations in blood.[2,8-10]

### Justification

Based on pharmacokinetic studies performed in volunteers exposed repetitively to trichloroethylene,[11,16,23,25,38] the following bioequivalent to the current TLV-TWA of 50 ppm of trichloroethylene can be extrapolated:

- Free TCOH in blood at the end of the last shift of the workweek — 3.8 mg/L
- Free TCOH in blood prior to the last shift of the workweek — 1.5 mg/L
- Free TCOH in blood at the end of the first shift of the workweek — 2.7 mg/L
- Free TCOH in blood prior to the first shift of the workweek — 0.2 mg/L

Concentrations of total TCOH are approximately double that of the concentrations of free TCOH.[20] TCOH in blood is preferred by some investigators as a biological indicator of the exposure, since the neurological symptoms induced by trichloroethylene exposure are associated with metabolism to trichloroethanol,[39] and since

Ref 18

interindividual and intraindividual variation are much smaller than the variation of metabolite excretion. TCOH concentrations seem to correlate mainly with the integrated exposure to trichloroethylene. However a significant excursion from the TLV-TWA would affect the blood concentration of TCOH. In West Germany, free TCOH in blood of 5 mg/L (ceiling value) is recommended as BAT.[40]

### Current Information Available

Sufficient amount of information is available to propose a BEI. However, further corroboration of BEI in field studies is needed.

### Recommendation

The Committee recommends a concentration of 4 mg/L of free TCOH in blood collected at the end of the fourth or fifth shift of the workweek as a BEI for trichloroethylene. Since interindividual variation is smaller than urinary excretion of metabolites it can be applied to individuals.

## TRICHLOROETHYLENE IN END-EXHALED AIR INDEX

### Method

Gas chromatographic methods are specific and highly sensitive electron capture detector is used.[25,41]

### Sampling and Storage

End-exhaled air should be collected 16 hours after trichloroethylene exposure (prior to the shift). Because timing of sampling is critical, an adjustment must be made if the sample is collected at another time (see equation below). Samples must be collected in uncontaminated atmosphere since exposure to traces of trichloroethylene prior or during sampling would profoundly affect the measurement. The samples should be stored in sealed glass containers and analyzed shortly after collection.[41] Contact of samples with rubber and plastic must be prevented because of the high absorption of trichloroethylene by these materials.

### Levels Without Occupational Exposure

Specific methods are available. Trichloroethylene is not present in exhaled air of unexposed persons. Nonoccupational exposure is possible (household products, drinking water, glue sniffing).

### Kinetics

Concentration of trichloroethylene in mixed-exhaled air rises sharply at the beginning of the exposure and levels off at 40% of the inhaled concentration. After the end of the exposure, trichloroethylene concentration in exhaled air declines, the elimination curve being described by 3 exponential decays with half-times of approximately 20 min, 3 hrs, and 30 hrs.[12] Because of the long half-time of the last exponential decays, the concentrations of trichloroethylene in exhaled air increases slightly during the workweek. The declining concentration of alveolar air, $c_{alv}$ in ppm, after a single 8-hour exposure to 50 ppm can be described by the equation:

$$c_{alv} = 2.6e^{-2.1t} + 1.6e^{-0.23t} + 0.25e^{-0.024t}$$

where:

t = hours after the end of the exposure

e = the base of natural logarithm

This equation is derived from data by Fernandez et al[12] and was corroborated by a simulation model.[42] The coefficients describing the desaturation curve after repetitious exposures, are larger because of accumulation of trichloroethylene in the body.

### Factors Affecting Interpretation of BEI

Determination of trichloroethylene in exhaled air is a specific exposure test. Precautions must be taken to avoid nonoccupational exposure to products containing trichloroethylene and contact with traces of trichloroethylene prior and during sampling.

### Justification

Concentrations of trichloroethylene in end-exhaled air collected prior to the shift can be used as an indicator of integrated exposure. BEI calculated from the above equation should be 0.21 ppm. The above equation relates to a single 8-hour exposure. However, because of the accumulation of trichloroethylene in the body, the concentration increases during the working week. Based on experimental data obtained in volunteers by Stewart et al,[43] the concentration in the end-exhaled air prior to the fifth expousre should be 0.45 ppm. Determination of trichloroethylene in end-exhaled air is recommended as a confirmatory test, since TCOH and TCAA are metabolites of other chemicals.

### Current Information Available

A sufficient amount of information in exposed volunteers is available for recommending BEI. No suitable data from the field are available to corroborate the recommendation.

### Recommendation

The Committee recommends 0.4 ppm of trichloroethylene in end-exhaled air collected prior to the last shift of the week as a BEI to be used mainly as a confirmatory test for trichloroethylene exposure. This value is related to repetitious 8-hour exposures to 50 ppm, and is not affected by short excursions.

### Other BEI

Determination of trichloroacetic acid in blood was also suggested as an indicator of trichloroethylene exposure.[23] Urinary excretion of trichloroethanol,[35] TCOH/TCAA ratio in urine,[35] and trichloroethylene in blood[27] are other options. The committee took under consideration these options but decided not to recommend them at this time.

### References:


1. Fiserova-Bergerova, V: Gases and Their Solubility: Review of Fundamentals. *Modeling of Inhalation Exposure to Vapors: Uptake, Distribution, and Elimination*, Vol. 1, Chap. 1, 3-28. CRC Press, Boca Raton, FL (1983).
2. Bartonicek, V: Metabolism and Excretion of Trichloroethylene After Inhalation by Human Subjects. *Brit. J. Ind. Med. 19*:134-141 (1962).
3. Stewart, R.D. and A.B. Dodd: Absorption of Carbon Tetrachloride, Trichloroethylene, Tetrachloroethylene, Methylene Chloride, and 1,1,1-Trichloroethane Through the Human Skin. *Ind. Hyg. J. 25*:439-446 (1964).
4. Laham, S.: Studies on Placental Transfer Trichloroethylene. *Ind. Med. 39*:46-49 (1970).
5. National Cancer Institute: *Carcinogenesis Bioassay of Trichloroethylene CAS No. 79-02-6.* National Cancer Inst. Tech. Rep. Series No. 2. DHEW Pub. No. (NIH) 76-802. Washington, DC (1976).
6. Litt, I.F. and M.I. Cohen; Danger-Vapor Harmful: Spot-Remover Sniffing. *New Eng. J. Med. 281*:543-544 (1969).

# Appendix D

## Site Inspection Form

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 1 - SITE LOCATION AND INSPECTION INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| NC | D038551263 |

**II. SITE NAME AND LOCATION**

| 01 SITE NAME (Legal, common, or descriptive name of site) | 02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER |
|---|---|
| Tri-County Community College | Route 1, P.O. Box 40 |

| 03 CITY | 04 STATE | 05 ZIP CODE | 06 COUNTY | 07 COUNTY CODE | 08 CONG DIST |
|---|---|---|---|---|---|
| Murphy | NC | 28906 | Cherokee | 20 | 11 |

09 COORDINATES — LATITUDE 35° 03' 58.1" — LONGITUDE 83° 57' 59.1"

10 TYPE OF OWNERSHIP (Check one): ☐ A. PRIVATE ☐ B. FEDERAL ☒ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL ☐ F. OTHER ☐ G. UNKNOWN

**III. INSPECTION INFORMATION**

01 DATE OF INSPECTION: 02 / 11 / 87 (MONTH DAY YEAR)

02 SITE STATUS: ☐ ACTIVE ☒ INACTIVE

03 YEARS OF OPERATION: 1967 (BEGINNING YEAR) | Present (ENDING YEAR) — UNKNOWN

04 AGENCY PERFORMING INSPECTION (Check all that apply): ☐ A. EPA ☐ B. EPA CONTRACTOR (Name of firm) ☐ C. MUNICIPAL ☐ D. MUNICIPAL CONTRACTOR (Name of firm) ☒ E. STATE ☐ F. STATE CONTRACTOR (Name of firm) ☐ G. OTHER (Specify)

| 05 CHIEF INSPECTOR | 06 TITLE | 07 ORGANIZATION | 08 TELEPHONE NO. |
|---|---|---|---|
| Stan Atwood | Toxicologist | NC DHR/DHS | (919) 733-2801 |

| 09 OTHER INSPECTORS | 10 TITLE | 11 ORGANIZATION | 12 TELEPHONE NO. |
|---|---|---|---|
| Jack Butler | Env. Engineer | NC DHR/DHS | (919) 733-2801 |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |

| 13 SITE REPRESENTATIVES INTERVIEWED | 14 TITLE | 15 ADDRESS | 16 TELEPHONE NO |
|---|---|---|---|
| Leon Tatham | Dean of Instruction | Tri-County Community College Murphy, NC | (704) 837-6810 |
| Lyle Carringer | Business Mgr. | " | (704) 837-6810 |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |
| | | | |

| 17 ACCESS GAINED BY (Check one) | 18 TIME OF INSPECTION | 19 WEATHER CONDITIONS |
|---|---|---|
| ☒ PERMISSION ☐ WARRANT | 0800-1300 | clear, 20's - 50's |

**IV. INFORMATION AVAILABLE FROM**

| 01 CONTACT | 02 OF (Agency/Organization) | 03 TELEPHONE NO. |
|---|---|---|
| Leon Tatham | Tri-County Community College | (704) 837-6810 |

| 04 PERSON RESPONSIBLE FOR SITE INSPECTION FORM | 05 AGENCY | 06 ORGANIZATION | 07 TELEPHONE NO. | 08 DATE |
|---|---|---|---|---|
| Stan Atwood | NC DHR/DHS | SHW Mgmt. Br. | (919) 733-2801 | 03 / 02 / 87 (MONTH DAY YEAR) |

EPA FORM 2070-13 (7-81)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 2 - WASTE INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| NC | D038551263 |

**II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS**

01 PHYSICAL STATES (Check all that apply)

- ☐ A. SOLID
- ☐ B. POWDER, FINES
- ☐ C. SLUDGE
- ☐ D. OTHER _____ (Specify)
- ☐ E. SLURRY
- ☒ F. LIQUID
- ☐ G. GAS

02 WASTE QUANTITY AT SITE (Measures of waste quantities must be independent)

TONS _____
CUBIC YARDS Unknown
NO. OF DRUMS _____

03 WASTE CHARACTERISTICS (Check all that apply)

- ☒ A. TOXIC
- ☐ B. CORROSIVE
- ☐ C. RADIOACTIVE
- ☒ D. PERSISTENT
- ☐ E. SOLUBLE
- ☐ F. INFECTIOUS
- ☐ G. FLAMMABLE
- ☐ H. IGNITABLE
- ☒ I. HIGHLY VOLATILE
- ☐ J. EXPLOSIVE
- ☐ K. REACTIVE
- ☐ L. INCOMPATIBLE
- ☐ M. NOT APPLICABLE

**III. WASTE TYPE**

| CATEGORY | SUBSTANCE NAME | 01 GROSS AMOUNT | 02 UNIT OF MEASURE | 03 COMMENTS |
|---|---|---|---|---|
| SLU | SLUDGE | | | |
| OLW | OILY WASTE | | | |
| SOL | SOLVENTS | Unknown | | Chlorinated solvents in well |
| PSD | PESTICIDES | | | |
| OCC | OTHER ORGANIC CHEMICALS | | | |
| IOC | INORGANIC CHEMICALS | | | |
| ACD | ACIDS | | | |
| BAS | BASES | | | |
| MES | HEAVY METALS | | | |

**IV. HAZARDOUS SUBSTANCES** (See Appendix for most frequently cited CAS Numbers)

| 01 CATEGORY | 02 SUBSTANCE NAME | 03 CAS NUMBER | 04 STORAGE/DISPOSAL METHOD | 05 CONCENTRATION | 06 MEASURE OF CONCENTRATION |
|---|---|---|---|---|---|
| SOL | Trichloroethene | 79-01-6 | Unknown | 300-542 | ppb |
| SOL | Tetrachloroethene | 127-18-4 | Unknown | 0.06 | ppb |

**V. FEEDSTOCKS** (See Appendix for CAS Numbers)

| CATEGORY | 01 FEEDSTOCK NAME | 02 CAS NUMBER | CATEGORY | 01 FEEDSTOCK NAME | 02 CAS NUMBER |
|---|---|---|---|---|---|
| FDS | | | FDS | | |
| FDS | | | FDS | | |
| FDS | | | FDS | | |
| FDS | | | FDS | | |

**VI. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

1. Sample analyses data sheet, NC NRCD/DEM, January 20, 1987.
2. Summary Trip Report, Tri-County Community College and Emerson Electric, February 12, 1987.
3. USGS Topographic Map, Peachtree Quadrangle, 1973.
4. Sample analyses data sheets, NC DHR/DHS, February 23, 1987.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

**II. HAZARDOUS CONDITIONS AND INCIDENTS**

01 [X] A. GROUNDWATER CONTAMINATION — 02 [X] OBSERVED (DATE: Jan. 1987) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

Trichloroethene detected in well sample.

01 [X] B. SURFACE WATER CONTAMINATION — 02 [X] OBSERVED (DATE: 2-11-87) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

McComb Branch contained 64 ppb trichloroethene.

01 ☐ C. CONTAMINATION OF AIR — 02 ☐ OBSERVED (DATE: _____) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

01 ☐ D. FIRE/EXPLOSIVE CONDITIONS — 02 ☐ OBSERVED (DATE: _____) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

01 ☐ E. DIRECT CONTACT — 02 ☐ OBSERVED (DATE: _____) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

01 [X] F. CONTAMINATION OF SOIL — 02 ☐ OBSERVED (DATE: _____) — [X] POTENTIAL — ☐ ALLEGED
03 AREA POTENTIALLY AFFECTED: _____ (Acres) — 04 NARRATIVE DESCRIPTION

Contaminated water discharged through septic tank with a sand filter bed.

01 [X] G. DRINKING WATER CONTAMINATION — 02 ☐ OBSERVED (DATE: _____) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ~1300 — 04 NARRATIVE DESCRIPTION

See "A" above.

01 ☐ H. WORKER EXPOSURE/INJURY — 02 ☐ OBSERVED (DATE: _____) — ☐ POTENTIAL — ☐ ALLEGED
03 WORKERS POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

01 ☐ I. POPULATION EXPOSURE/INJURY — 02 ☐ OBSERVED (DATE: _____) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

**II. HAZARDOUS CONDITIONS AND INCIDENTS** *(Continued)*

01 ☐ J. DAMAGE TO FLORA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ K. DAMAGE TO FAUNA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION *(Include name(s) of species)*

01 ☐ L. CONTAMINATION OF FOOD CHAIN — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ M. UNSTABLE CONTAINMENT OF WASTES *(Spills, Runoff, Standing liquids, Leaking drums)* — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ N. DAMAGE TO OFFSITE PROPERTY — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS

**III. TOTAL POPULATION POTENTIALLY AFFECTED:** _____

**IV. COMMENTS**

Site has switched to bottled drinking water.

**V. SOURCES OF INFORMATION** *(Cite specific references, e.g., state files, sample analysis, reports)*

As previously cited.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION
### PART 4 - PERMIT AND DESCRIPTIVE INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| NC | D038551263 |

**II. PERMIT INFORMATION**

| 01 TYPE OF PERMIT ISSUED (Check all that apply) | 02 PERMIT NUMBER | 03 DATE ISSUED | 04 EXPIRATION DATE | 05 COMMENTS |
|---|---|---|---|---|
| ☒ A. NPDES | NC 0035394 | | 3-31-87 | up for renewal |
| ☐ B. UIC | | | | |
| ☐ C. AIR | | | | |
| ☐ D. RCRA | | | | |
| ☐ E. RCRA INTERIM STATUS | | | | |
| ☐ F. SPCC PLAN | | | | |
| ☐ G. STATE (Specify) | | | | |
| ☐ H. LOCAL (Specify) | | | | |
| ☐ I. OTHER (Specify) | | | | |
| ☐ J. NONE | | | | |

**III. SITE DESCRIPTION**

| 01 STORAGE/DISPOSAL (Check all that apply) | 02 AMOUNT | 03 UNIT OF MEASURE |
|---|---|---|
| ☐ A. SURFACE IMPOUNDMENT | | |
| ☐ B. PILES | | |
| ☐ C. DRUMS, ABOVE GROUND | | |
| ☐ D. TANK, ABOVE GROUND | | |
| ☐ E. TANK, BELOW GROUND | | |
| ☐ F. LANDFILL | | |
| ☐ G. LANDFARM | | |
| ☐ H. OPEN DUMP | | |
| ☐ I. OTHER (Specify) | | |

04 TREATMENT (Check all that apply)

- ☐ A. INCENERATION
- ☐ B. UNDERGROUND INJECTION
- ☐ C. CHEMICAL/PHYSICAL
- ☐ D. BIOLOGICAL
- ☐ E. WASTE OIL PROCESSING
- ☐ F. SOLVENT RECOVERY
- ☐ G. OTHER RECYCLING/RECOVERY
- ☐ H. OTHER (Specify)

05 OTHER

- ☒ A. BUILDINGS ON SITE

06 AREA OF SITE

77 (Acres)

07 COMMENTS

NPDES permit is for discharge from a septic tank sand filter bed to McComb Branch.

**IV. CONTAINMENT**

01 CONTAINMENT OF WASTES (Check one)

☐ A. ADEQUATE, SECURE ☐ B. MODERATE ☐ C. INADEQUATE, POOR ☐ D. INSECURE, UNSOUND, DANGEROUS

02 DESCRIPTION OF DRUMS, DIKING, LINERS, BARRIERS, ETC.

**V. ACCESSIBILITY**

01 WASTE EASILY ACCESSIBLE: ☐ YES ☒ NO

02 COMMENTS

A specific source for the groundwater contamination has not been identified.

**VI. SOURCES OF INFORMATION** (Cite specific references, e.g. state files, sample analysis, reports)

1. Permanent files, NC NRCD/Water Quality Section, Raleigh, NC.
2. As previously cited.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| NC | D038551263 |

## II. DRINKING WATER SUPPLY

**01 TYPE OF DRINKING SUPPLY** (Check as applicable)

| | SURFACE | WELL |
|---|---|---|
| COMMUNITY | A. ☐ | B. ☒ |
| NON-COMMUNITY | C. ☐ | D. ☒ |

**02 STATUS**

| ENDANGERED | AFFECTED | MONITORED |
|---|---|---|
| A. ☐ | B. ☐ | C. ☒ |
| D. ☐ | E. ☒ | F. ☒ |

**03 DISTANCE TO SITE**

A. 0.5 (mi)
B. 0.1 (mi)

## III. GROUNDWATER

**01 GROUNDWATER USE IN VICINITY** (Check one)

☒ A. ONLY SOURCE FOR DRINKING
☐ B. DRINKING (Other sources available) COMMERCIAL, INDUSTRIAL, IRRIGATION (No other water sources available)
☐ C. COMMERCIAL, INDUSTRIAL, IRRIGATION (Limited other sources available)
☐ D. NOT USED, UNUSEABLE

**02 POPULATION SERVED BY GROUND WATER** ~5800

**03 DISTANCE TO NEAREST DRINKING WATER WELL** on site (mi)

| 04 DEPTH TO GROUNDWATER | 05 DIRECTION OF GROUNDWATER FLOW | 06 DEPTH TO AQUIFER OF CONCERN | 07 POTENTIAL YIELD OF AQUIFER | 08 SOLE SOURCE AQUIFER |
|---|---|---|---|---|
| 20 (ft) | West | 20 (ft) | (gpd) | ☒ YES ☐ NO |

**09 DESCRIPTION OF WELLS** (Including useage, depth, and location relative to population and buildings)

On site well reported to be more than 400 ft. deep. Water level and yield unknown.

| 10 RECHARGE AREA | | 11 DISCHARGE AREA | |
|---|---|---|---|
| ☒ YES ☐ NO | COMMENTS | ☐ YES ☐ NO | COMMENTS |

## IV. SURFACE WATER

**01 SURFACE WATER USE** (Check one)

☒ A. RESERVOIR, RECREATION DRINKING WATER SOURCE
☐ B. IRRIGATION, ECONOMICALLY IMPORTANT RESOURCES
☐ C. COMMERCIAL, INDUSTRIAL
☐ D. NOT CURRENTLY USED

**02 AFFECTED/POTENTIALLY AFFECTED BODIES OF WATER**

| NAME: | AFFECTED | DISTANCE TO SITE |
|---|---|---|
| McComb Branch | ☐ | on site (mi) |
| Hiwassee River | ☐ | 0.3 (mi) |
| | ☐ | (mi) |

## V. DEMOGRAPHIC AND PROPERTY INFORMATION

**01 TOTAL POPULATION WITHIN**

| ONE (1) MILE OF SITE | TWO (2) MILES OF SITE | THREE (3) MILES OF SITE |
|---|---|---|
| A. 2000 NO. OF PERSONS | B. NO. OF PERSONS | C. 5810 NO. OF PERSONS |

**02 DISTANCE TO NEAREST POPULATION** 0.1 (mi)

**03 NUMBER OF BUILDINGS WITHIN TWO (2) MILES OF SITE** 100's

**04 DISTANCE TO NEAREST OFF-SITE BUILDING** 0.1 (mi)

**05 POPULATION WITHIN VICINITY OF SITE** (Provide narrative description of nature of population within vicinity of site, e.g., rural, village, densely populated urban area)

Site is located in a rural community.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

## VI. ENVIRONMENTAL INFORMATION

01 PERMEABILITY OF UNSATURATED ZONE (Check one)

☐ A. $10^{-6} - 10^{-8}$ cm/sec ☒ B. $10^{-4} - 10^{-6}$ cm/sec ☐ C. $10^{-4} - 10^{-3}$ cm/sec ☐ D. GREATER THAN $10^{-3}$ cm/sec

02 PERMEABILITY OF BEDROCK (Check one)

☐ A. IMPERMEABLE (Less than $10^{-6}$ cm/sec) ☐ B. RELATIVELY IMPERMEABLE ($10^{-4} - 10^{-6}$ cm/sec) ☒ C. RELATIVELY PERMEABLE ($10^{-2} - 10^{-4}$ cm/sec) ☐ D. VERY PERMEABLE (Greater than $10^{-2}$ cm/sec)

| 03 DEPTH TO BEDROCK | 04 DEPTH OF CONTAMINATED SOIL ZONE | 05 SOIL pH |
|---|---|---|
| Unknown (ft) | (ft) | |

| 06 NET PRECIPITATION | 07 ONE YEAR 24 HOUR RAINFALL | 08 SLOPE SITE SLOPE | DIRECTION OF SITE SLOPE | TERRAIN AVERAGE SLOPE |
|---|---|---|---|---|
| 21 (in) | 3-3.5 (in) | 6 % | West | 5-8 % |

09 FLOOD POTENTIAL

SITE IS IN _____ YEAR FLOODPLAIN

10 ☐ SITE IS ON BARRIER ISLAND, COASTAL HIGH HAZARD AREA, RIVERINE FLOODWAY

11 DISTANCE TO WETLANDS (5 acre minimum)

ESTUARINE: A. _____ (mi)

OTHER: B. _____ (mi)

12 DISTANCE TO CRITICAL HABITAT (of endangered species)

_____ (mi)

ENDANGERED SPECIES: None identified

13 LAND USE IN VICINITY

DISTANCE TO:

| COMMERCIAL/INDUSTRIAL | RESIDENTIAL AREAS; NATIONAL/STATE PARKS, FORESTS, OR WILDLIFE RESERVES | AGRICULTURAL LANDS PRIME AG LAND | AGRICULTURAL LANDS AG LAND |
|---|---|---|---|
| A. 0.2 (mi) | B. 0.1 (mi) | C. _____ (mi) | D. 0.2 (mi) |

14 DESCRIPTION OF SITE IN RELATION TO SURROUNDING TOPOGRAPHY

Site is at the edge of a draw about 60 ft. above the river elevation.

## VII. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)


1. As previously cited.
2. Clay et al. 1975. North Carolina Atlas: Portrait of a Changing Southern State.
3. USGS Open file report 80-44. Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 6 - SAMPLE AND FIELD INFORMATION

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

## II. SAMPLES TAKEN

| SAMPLE TYPE | 01 NUMBER OF SAMPLES TAKEN | 02 SAMPLES SENT TO | 03 ESTIMATED DATE RESULTS AVAILABLE |
|---|---|---|---|
| GROUNDWATER | 1 | NC Laboratory of Public Health | 2/87 |
| SURFACE WATER | 6 | " | " |
| WASTE | 1 | " | " |
| AIR | | | |
| RUNOFF | | | |
| SPILL | | | |
| SOIL | | | |
| VEGETATION | | | |
| OTHER | | | |

## III. FIELD MEASUREMENTS TAKEN

| 01 TYPE | 02 COMMENTS |
|---|---|
| | |
| | |
| | |
| | |
| | |

## IV. PHOTOGRAPHS AND MAPS

01 TYPE ☒ GROUND ☐ AERIAL

02 IN CUSTODY OF NC CERCLA Unit and included with report
(Name of organization or individual)

03 MAPS ☒ YES ☐ NO

04 LOCATION OF MAPS Included with report

## V. OTHER FIELD DATA COLLECTED (Provide narrative description)

Windshield house count in the site vicinity.

## VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

1. Summary Trip Report, letter to Denise Smith, 2-12-87.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 7 - OWNER INFORMATION

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

## II. CURRENT OWNER(S)

| 01 NAME | 02 D+B NUMBER | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|---|
| State of North Carolina | | | | Raleigh | NC | |
| | | | | | | |
| | | | | | | |

## PARENT COMPANY (If applicable)

| 08 NAME | 09 D+B NUMBER | 10 STREET ADDRESS (P.O. Box, RFD #, etc.) | 11 SIC CODE | 12 CITY | 13 STATE | 14 ZIP CODE |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

## III. PREVIOUS OWNER(S) (List most recent first)

| 01 NAME | 02 D+B NUMBER | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

## IV. REALTY OWNER(S) (If applicable; list most recent first)

| 01 NAME | 02 D+B NUMBER | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

## V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

EPA FORM 2070-13 (7-81)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 8 - OPERATOR INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| NC | D038551263 |

**II. CURRENT OPERATOR** (Provide if different from owner) / **OPERATOR'S PARENT COMPANY** (If applicable)

| | |
|---|---|
| 01 NAME: Tri-County Community College | 10 NAME: |
| 02 D+B NUMBER: | 11 D+B NUMBER: |
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.): P.O. Box 40 | 12 STREET ADDRESS (P.O. Box, RFD #, etc.): |
| 04 SIC CODE: | 13 SIC CODE: |
| 05 CITY: Murphy | 14 CITY: |
| 06 STATE: NC | 15 STATE: |
| 07 ZIP CODE: 28906 | 16 ZIP CODE: |
| 08 YEARS OF OPERATION: | |
| 09 NAME OF OWNER: State of North Carolina | |

**III. PREVIOUS OPERATOR(S)** (List most recent first; provide only if different from owner) / **PREVIOUS OPERATORS' PARENT COMPANIES** (If applicable)

| | |
|---|---|
| 01 NAME: Clifton Precision Products | 10 NAME: Litton Industries |
| 02 D+B NUMBER: | 11 D+B NUMBER: |
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.): P.O. Box 160 | 12 STREET ADDRESS (P.O. Box, RFD #, etc.): 360 N. Cresent Drive |
| 04 SIC CODE: | 13 SIC CODE: |
| 05 CITY: Murphy | 14 CITY: Beverly Hills |
| 06 STATE: NC | 15 STATE: CA |
| 07 ZIP CODE: 28906 | 16 ZIP CODE: 90210 |
| 08 YEARS OF OPERATION: 1 | |
| 09 NAME OF OWNER DURING THIS PERIOD: State of North Carolina | |
| 01 NAME: N.C. Dept. of Transportation | 10 NAME: |
| 02 D+B NUMBER: | 11 D+B NUMBER: |
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.): 1 South Wilmington Street | 12 STREET ADDRESS (P.O. Box, RFD #, etc.): |
| 04 SIC CODE: | 13 SIC CODE: |
| 05 CITY: Raleigh | 14 CITY: |
| 06 STATE: NC | 15 STATE: |
| 07 ZIP CODE: | 16 ZIP CODE: |
| 08 YEARS OF OPERATION: | |
| 09 NAME OF OWNER DURING THIS PERIOD: State of North Carolina | |
| 01 NAME: N.C. Dept. of Corrections | 10 NAME: |
| 02 D+B NUMBER: | 11 D+B NUMBER: |
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.): 840 West Morgan Street | 12 STREET ADDRESS (P.O. Box, RFD #, etc.): |
| 04 SIC CODE: | 13 SIC CODE: |
| 05 CITY: Raleigh | 14 CITY: |
| 06 STATE: NC | 15 STATE: |
| 07 ZIP CODE: | 16 ZIP CODE: |
| 08 YEARS OF OPERATION: 25± | |
| 09 NAME OF OWNER DURING THIS PERIOD: State of North Carolina | |

**IV. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

1. Permanent files, NC Solid and Hazardous Waste Mgmt. Branch, Raleigh, NC.
2. Bob Wood, Cherokee County Health Director, telephone conversation, 2-4-87.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 9 - GENERATOR/TRANSPORTER INFORMATION

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

## II. ON-SITE GENERATOR

| 01 NAME | 02 D+B NUMBER | |
|---|---|---|
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | |
| 05 CITY | 06 STATE | 07 ZIP CODE |

## III. OFF-SITE GENERATOR(S)

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE | 05 CITY | 06 STATE / 07 ZIP CODE |
| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE | 05 CITY | 06 STATE / 07 ZIP CODE |

## IV. TRANSPORTER(S)

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE | 05 CITY | 06 STATE / 07 ZIP CODE |
| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE | 05 CITY | 06 STATE / 07 ZIP CODE |

## V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 10 - PAST RESPONSE ACTIVITIES

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

**II. PAST RESPONSE ACTIVITIES**

01 [X] A. WATER SUPPLY CLOSED — 02 DATE Jan. 1987 — 03 AGENCY NC DHR/DHS
04 DESCRIPTION
Well water no longer used for drinking.

01 [X] B. TEMPORARY WATER SUPPLY PROVIDED — 02 DATE Jan. 1987 — 03 AGENCY
04 DESCRIPTION
Bottled water.

01 [ ] C. PERMANENT WATER SUPPLY PROVIDED — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] D. SPILLED MATERIAL REMOVED — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] E. CONTAMINATED SOIL REMOVED — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] F. WASTE REPACKAGED — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] G. WASTE DISPOSED ELSEWHERE — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] H. ON SITE BURIAL — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] I. IN SITU CHEMICAL TREATMENT — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] J. IN SITU BIOLOGICAL TREATMENT — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] K. IN SITU PHYSICAL TREATMENT — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] L. ENCAPSULATION — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] M. EMERGENCY WASTE TREATMENT — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] N. CUTOFF WALLS — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] O. EMERGENCY DIKING/SURFACE WATER DIVERSION — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] P. CUTOFF TRENCHES/SUMP — 02 DATE — 03 AGENCY
04 DESCRIPTION

01 [ ] Q. SUBSURFACE CUTOFF WALL — 02 DATE — 03 AGENCY
04 DESCRIPTION

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 10 - PAST RESPONSE ACTIVITIES

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

**II PAST RESPONSE ACTIVITIES** *(Continued)*

01 ☐ R. BARRIER WALLS CONSTRUCTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ S. CAPPING/COVERING — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ T. BULK TANKAGE REPAIRED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ U. GROUT CURTAIN CONSTRUCTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ V. BOTTOM SEALED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ W. GAS CONTROL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ X. FIRE CONTROL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ Y. LEACHATE TREATMENT — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ Z. AREA EVACUATED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 1. ACCESS TO SITE RESTRICTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 2. POPULATION RELOCATED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 3. OTHER REMEDIAL ACTIVITIES — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

**III. SOURCES OF INFORMATION** *(Cite specific references, e.g., state files, sample analysis, reports)*

1. Leon Tatham, Tri-County Community College, personal communication, 2-11-87.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 11 - ENFORCEMENT INFORMATION

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| NC | D038551263 |

## II. ENFORCEMENT INFORMATION

01 PAST REGULATORY/ENFORCEMENT ACTION ☐ YES ☒ NO

02 DESCRIPTION OF FEDERAL, STATE, LOCAL REGULATORY/ENFORCEMENT ACTION

## III. SOURCES OF INFORMATION *(Cite specific references, e.g., state files, sample analysis, reports)*

# Appendix E

## Site Safety Plan

SITE SAFETY PLAN

A. GENERAL INFORMATION

Site Name Tri-County Community College Site Number NC D038551263
Location US 64 East of Murphy Date 2/9/87

Purpose of Visit ____ PA X SI ____ Other

Proposed Date of Inspection 2/9/87

Date of Briefing 2/9/87

Priority Ranking ____ Low X Medium ____ High

Site Investigation Team

| Personnel | Responsibilities |
|---|---|
| Stan Atwood | sampling |
| Jack Butler | sampling |
| | |
| | |

PLAN PREPARATION:
Prepared By Mary Dignere

Approved By Lee Crosby

B. SITE/WASTE CHARACTERISTICS

Waste Type(s) X Liquid ____ Solid ____ Sludge ____ Gas

Characteristics ____ Corrosive ____ Ignitable ____ Radioactive
X Volatile X Toxic ____ Reactive ____ Other

List Known or Suspected Hazards (physical,chemical biological or radioactive) on Site and their toxicological effects. Also, if known, list chemical amounts

| HAZARD | EFFECT(S) |
|---|---|
| halogenated solvents | see attached sheet |
| | |
| | |
| | |
| | |

Facility Description: Size 10-20 acres Buildings 4-6 buildings

Disposal Methods Being Investigated surface water contamination

Unusual Features on Site (dike integrity, power lines, terrain etc.):

History of the Site: The Dept. of Correction had a prison on site from the late 30s-1965. Dept. of Transportation maintained a maintenance shed at or near the site prior to 1976. Clifton Precision occupied the site from March 1966-January 1967. Tri-County Community College has been on-site since 1967. The college has a body shop ~ 2 gallons of trichloroethylene/5 years.

## C. HAZARD EVALUATION

Sampling is to consist of surface water and sediment. This is the only sampling scheduled. This sampling can be done in Level D. These samples need to be preserved by putting them on ice. Acid does not need to be used in preserving the samples.

## D. WORK PLAN INSTRUCTION

Map or Sketch Attached? No
Perimeter Identified? No
Command Post Identified? No
Zones of Contamination Identified? No

Personal Protective Equipment

Level of Protection ____ A ____ B ____ C ____ X D

Modifications

Surveillance Equipment:

| | | | |
|---|---|---|---|
| _____ | H Nu | _____ | Detector Tubes and Pumps |
| _____ | Explosimeter | _____ | O2 Meter |
| _____ | TLD | _____ | (Radiation Monitor) |

Decontamination Procedures

_____ Level A Segregated equipment drop, boot cover and glove wash, boot cover and glove rinse, tape removal, suit and hard hat removal, SCBA backpack removal, inner glove wash, inner glove removal, inner clothing removal, field wash, redress

_____ Level B Segregated equipment drop, boot cover and glove wash,boot cover and glove rinse, tape removal. boot cover removal outer glove removal, suit/safety removal, SCBA backpack removal, inner glove wash, inner glove rinse, facepiece removal, inner glove removal, inner clothing removal, field wash, redress.

_____ Level C Segregated equipment drop, boot cover and glove wash, boot cover and glove rinse, tape removal, boot cover removal, outer glove removal,suit/safety boot wash, suit/safety boot rinse (Canister or Mask Change), safety boot removal, splash suit removal, inner glove wash, inner glove rinse, facepiece removal, inner glove removal, inner clothing removal. field wash redress.

__X__ Level D Segregated equipment drop. boot and glove wash, boot and glove rinse.

Modifications _____

Work Schedule/ Limitations stream water and sediment samples are the only samples to be taken.

EMERGENCY PRECAUTIONS

| Acute Exposure Symptoms | First Aid |
|---|---|
| eyes | irrigate eyes |
| skin | soap and water wash |
| inhalation | fresh air |
| ingestion | medical attention |
| | |

Hospital (Address and Phone Number)

Murphy Medical Center

US 64, Murphy, NC

Emergency Transportation Systems (Phone Numbers)

Fire use 911

Ambulance use 911

Rescue Squad use 911

Emergency Route to Hospital hospital adjoining site

PREVAILING WEATHER CONDITIONS AND FORECAST sunny with highs in the 40's.

EQUIPMENT CHECKLIST

| | | | |
|---|---|---|---|
| | Air purifying respirator | X | First Aid Kit |
| | Cartridges for respirator | X | 3 gal. Distilled H2O |
| | 3M 8710 Respirator | X | Personal Protective Clothing |
| | 02 Indicator | | |
| | Detector Tube & Pump | X | Boots or Boot Covers |
| | Eye Wash Unit | X | Coveralls (tyvek) |
| | H Nu | X | Eye Protection |
| | pH Meter | | Hard Hat |
| | Explosimeter | X | Decontamination Materials. |
| | Radioactive Monitor | | |

Poison Control Center - State Coordinator

Duke University Medical Center
Telephone: 1-800-672-1697
Box 3024
Durham, NC 27710

| | | | |
|---|---|---|---|
| ASHEVILLE<br>704-255-4490 | Western NC Poison Control Center<br>Memorial Mission Hosp.<br>509 Biltmore Ave. 28801 | HENDERSONVILLE<br>704-693-6522<br>Ext. 555, 556 | Margaret R. Pardee Memorial Hospital<br>Fleming St., 28739 |
| CHARLOTTE<br>704-379-5827 | Mercy Hospital<br>2001 Vail Ave, 28207 | HICKORY<br>704-322-6649 | Catawba Mem. Hosp.<br>Fairgrove Chur. Rd 28601 |
| DURHAM<br>1-800-672-1697 | Duke Univ Medical Center<br>Box 3007, 27710 | JACKSONVILLE<br>919-577-2555 | Onslow Mem. Hospital<br>Western Blvd. 28540 |
| GREENSBORO<br>919-379-4105 | Moses Cone Hospital<br>1200 N. Elm St, 27420 | WILMINGTON<br>919-343-7046 | New Hanover Mem. Hospital<br>2131 S. 17th St, 28401 |

1-800-722-2222

# HAZARDOUS SUBSTANCE INFORMATION FORM

Chemical Name: Halogenated solvents

## I. PHYSICAL/CHEMICAL PROPERTIES

| | Reference |
|---|---|
| Chemical Formula _____ | _____ |
| Natural Physical State at 25°C liquid | 1 |
| Vapor Pressure 14 - 91 mm Hg at 20°C | 1 |
| Melting Point _____ °F/°C Boiling Point 170 - 250 °F/°C | 1 |
| Flash Point (open or closed cup) none °C/°F | 1 |
| Solubility - $H_2O$ insoluble | 1 |
| Other _____ | _____ |

Physical Features: (odor, color, etc.) colorless liquids at room temp. sweet odor. I.P. CHCl2 - 11.42, CCl2CCl2 - 9.32, CHCLCCl2 - 9.47 eV CH2Cl2 - 11.35

## II. TOXICOLOGICAL DATA

Standards: 5 - 350 TLV 10 - 350 PEL 300 - 1000 IDLH _____

Routes of Exposure: Inhalation, skin

Acute/Chronic Symptoms: Acute: headache, dizziness, irritation to nose & eyes narcotic feeling. Chronic: liver damage.

First Aid: Eye: irrigate immediately. Skin: soap wash immediately. Inhalation: fresh air & artificial resp. Ingestion: medical attention.

emical Name: Halogenated solvents

I. HAZARDOUS CHARACTERISTICS — Reference

A. Combustibility Yes ____ No X ____ ____

Toxic by-products ____ ____

____ ____

B. Flammability LEL ____ UEL ____ ____

C. Reactivity Hazard Chemically active metals (K, Na, etc.) ____

rong caustics & oxidizers.

D. Corrosivity Hazard yes/no pH: ____ ____

Neutralizing agent: ____ ____

E. Radioactive Hazard — Exposure Rate

| | | | |
|---|---|---|---|
| Background | yes/no | ____ | ____ |
| Alpha particles | yes/no | ____ | ____ |
| Beta particles | yes/no | ____ | ____ |
| Gamma radiation | yes/no | ____ | ____ |

. REFERENCES

NIOSH Pocket Guide to Chemical Hazards, 1985.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
TENNESSEE VALLEY AUTHORITY
MAPS AND SURVEYS BRANCH

MURPHY QUADRANGLE
NORTH CAROLINA-CHEROKEE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC) 141-SE


Mapped and edited by Tennessee Valley Authority
Published by the Geological Survey

Control by USC&GS, USGS, and TVA

Topography by TVA in 1955 by photogrammetric methods using aerial photography taken 1952.
Map field checked by TVA, 1957

Polyconic projection. 1927 North American datum
10,000 foot grid based on North Carolina rectangular coordinate system
1000 metre Universal Transverse Mercator Grid ticks, Zone 16, shown in blue

Fine red dashed lines indicate selected fence and field lines visible on aerial photographs. This information is unchecked

Revisions shown in purple and recompilation of woodland areas compiled by the Tennessee Valley Authority from aerial photographs taken 1973. This information not field checked

UTM GRID AND 1973 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C. 20242,
AND BY U.S. TENNESSEE VALLEY AUTHORITY, CHATTANOOGA, TENN. 37401 OR KNOXVILLE, TENN. 37902
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

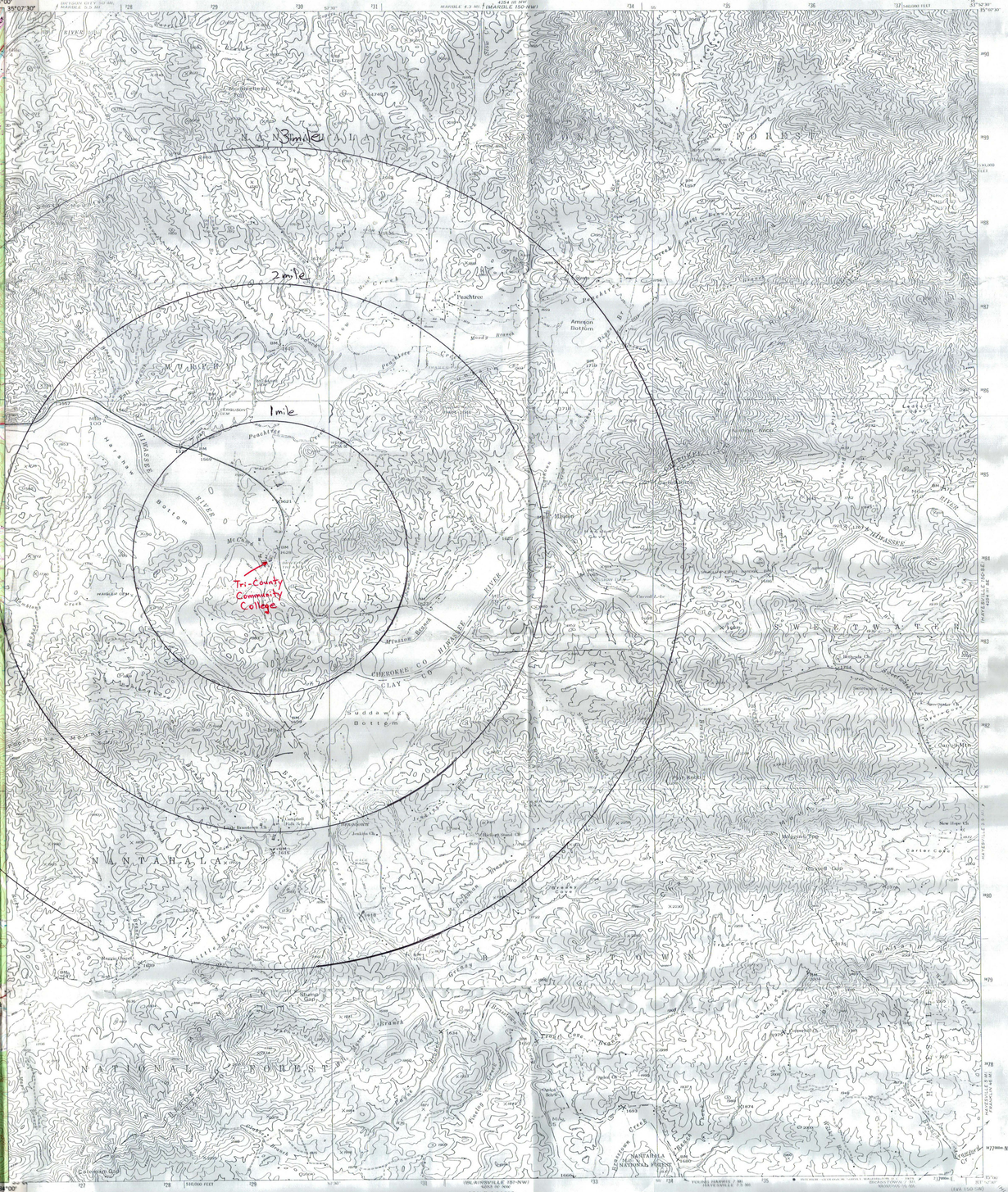
ROAD CLASSIFICATION
Heavy-duty — Poor motor road
Medium-duty — Wagon and jeep track
Light-duty — Foot trail
U. S. Route — State Route
In developed areas, only through roads are classified

MURPHY, N.C.
N3500—W8400/7.5
1957
PHOTOREVISED 1973
AMS 4154 II SE-SERIES V842

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
TENNESSEE VALLEY AUTHORITY
MAPS AND SURVEYS BRANCH

PEACHTREE QUADRANGLE
NORTH CAROLINA
7.5 MINUTE SERIES (TOPOGRAPHIC) 150-SW




Mapped and edited by Tennessee Valley Authority
Published by the Geological Survey

Control by USC&GS, USGS, and TVA

Topography by USGS in 1937 by photogrammetric methods using aerial photographs taken 1937.
Map field checked by TVA

Polyconic projection. 1927 North American datum
10,000 foot grid based on North Carolina rectangular coordinate system
1000 metre Universal Transverse Mercator Grid ticks, Zone 17, shown in blue

Fine red dashed lines indicate selected fence and field lines visible on aerial photographs. This information is unchecked

Revisions shown in purple and recompilation of woodland areas compiled by the Tennessee Valley Authority from aerial photographs taken 1973. This information is not field checked

UTM GRID AND 1973 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

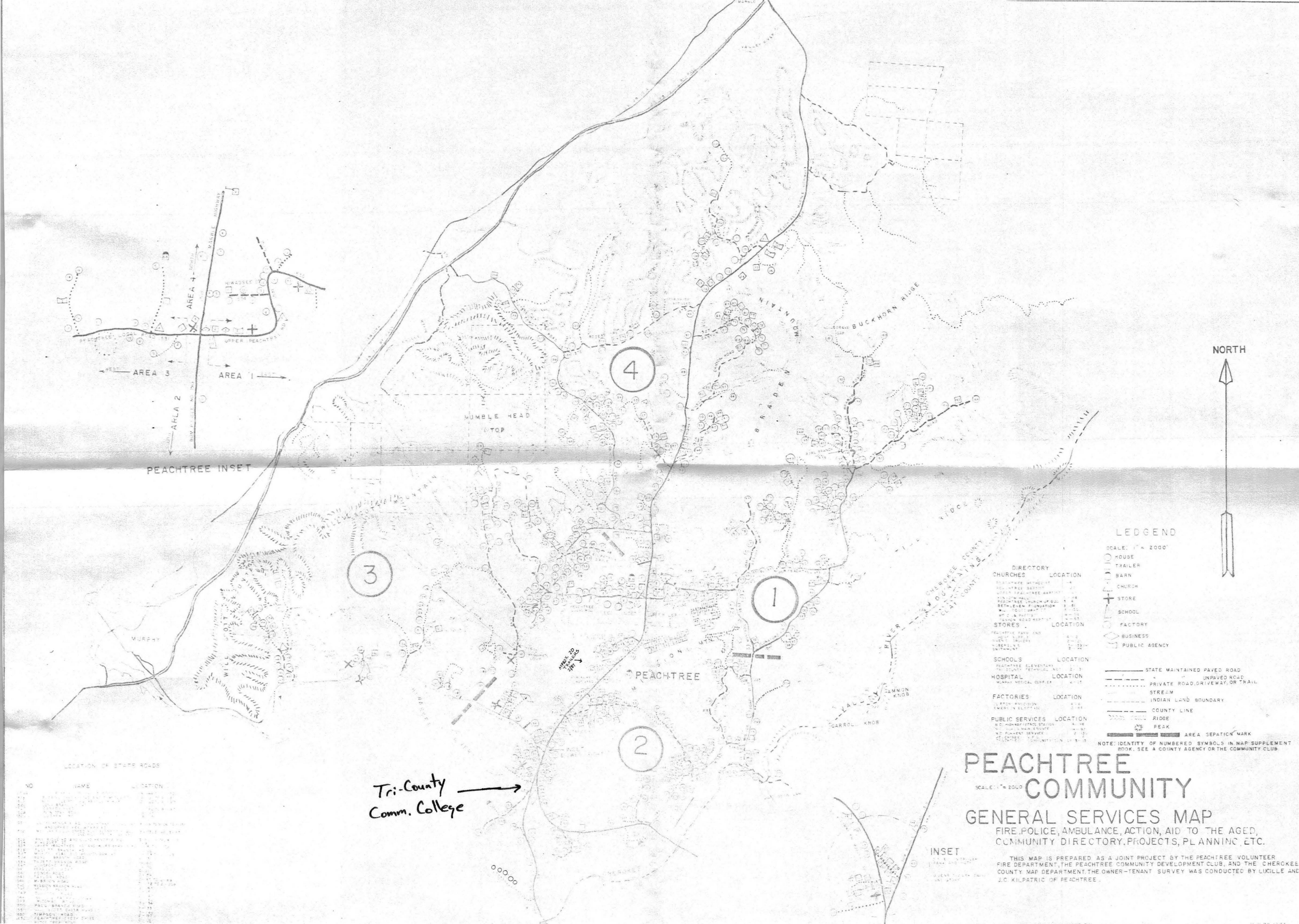
CONTOUR INTERVAL 50 FEET
DASHED LINES REPRESENT HALF-INTERVAL CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C. 20242,
AND BY U.S. TENNESSEE VALLEY AUTHORITY, CHATTANOOGA, TENN. 37401 OR KNOXVILLE, TENN. 37902
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION
Heavy-duty — Poor motor road
Medium-duty — Wagon and jeep track
Light-duty — Foot trail
U. S. Route — State Route

PEACHTREE, N.C.
N3500—W8152.5/7.5
1937
PHOTOREVISED 1973
AMS 4154 II SW-SERIES V842


PEACHTREE INSET
AREA 1
AREA 2
AREA 3
AREA 4
NORTH
4
3
1
2
MUMBLE HEAD
TOP
BUCKHORN RIDGE
PEACHTREE
MURPHY
Tri-County
Comm. College
INSET
LEGEND
SCALE: 1" = 2000'
HOUSE
TRAILER
BARN
CHURCH
STORE
SCHOOL
FACTORY
BUSINESS
PUBLIC AGENCY
DIRECTORY
CHURCHES LOCATION
STORES LOCATION
SCHOOLS LOCATION
HOSPITAL LOCATION
FACTORIES LOCATION
PUBLIC SERVICES LOCATION
STATE MAINTAINED PAVED ROAD
UNPAVED ROAD
PRIVATE ROAD, DRIVEWAY, OR TRAIL
STREAM
INDIAN LAND BOUNDARY
COUNTY LINE
RIDGE
PEAK
AREA SEPATION MARK
NOTE: IDENTITY OF NUMBERED SYMBOLS IN MAP SUPPLEMENT BOOK. SEE A COUNTY AGENCY OR THE COMMUNITY CLUB
PEACHTREE COMMUNITY
SCALE: 1" = 2000'
GENERAL SERVICES MAP
FIRE, POLICE, AMBULANCE, ACTION, AID TO THE AGED, COMMUNITY DIRECTORY, PROJECTS, PLANNING, ETC.
THIS MAP IS PREPARED AS A JOINT PROJECT BY THE PEACHTREE VOLUNTEER FIRE DEPARTMENT, THE PEACHTREE COMMUNITY DEVELOPMENT CLUB, AND THE CHEROKEE COUNTY MAP DEPARTMENT. THE OWNER-TENANT SURVEY WAS CONDUCTED BY LUCILLE AND J.C. KILPATRIC OF PEACHTREE.
LOCATION OF STATE ROADS
NO NAME LOCATION

Tri-Cnty Community College

Septic Tank + Sand Filter

2/11/87

Sample 6

McComb Branch below Tri-County C.C. discharge

2/11/87

Tri-Cnty Comm. College

Discharge from sand filter bed
to McComb Br.

2/11/87

Tri-County Community College

Sand Filter Bed

2/11/87

Sample 4

Hiwassee River (upstream)

2/11/87

Tri-Cnty Comm. College Sample 5

Well house + water tower

2/11/87

#4 Hiwassee River
Upstream

#5 Tap - Tri-County C.C.

#6 McComb Branch

Tri-County Comm. College
Septic Tank + Filter Bed

Tri-County Sand Filter Bed