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375SERBSF10,624

Site Name (Subject):	SQUIBB E R & SONS
Site ID (Document ID):	NCD991278730
Document Name (DocType):	Pre-CERCLIS Screening (PSA)
Report Segment:	
Description:	Phase II Screening Site Investigation: References
Date of Document:	6/11/1992
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Access Level:	PUBLIC
Division:	WASTE MANAGEMENT
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STATE OF NORTH CAROLINA

Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
Superfund Section

E.R. Squibb & Sons
NCD 991278730

Phase II
Screening Site Inspection
References

June 1991

By:

Greenhorne & O'Mara, Inc.

CERCLA

RECEIVED
JAN 28 1992
SUPERFUND SECTION

LIST OF REFERENCES FOR THE E.R. SQUIBB AND SONS SITE
EPA ID NUMBER - NCD 991278730

1. Williams, Alvin L. (NUS). 1990. Letter to Mr. A.R Hanke regarding Screening Site Inspection, Phase I, for E.R. Squibb & Sons. September 17.

2. Potential Hazardous Waste Site Preliminary Assessment (EPA Form 2070-12) and attachments for E.R. Squibb & Sons. Filed by Durway/Crosby, North Carolina Department of Human Resources. December 3, 1985.

3. Pharr, B.H. (E.R. Squibb & Sons). 1982. Letter and attachments to Mr. William Paige regarding closure plan for 4,000-gallon underground storage tank. March 30.

4. Interim Status Inspection for E.R. Squibb & Sons, performed by Larry D. Perry, North Carolina Solid and Hazardous Waste Management Branch. January 28, 1982.

5. RCRA Inspection and Evaluation Report for E.R. Squibb & Sons, performed by Michael E. Willford, North Carolina Department of Human Resources Solid and Hazardous Waste Management Branch. January 23, 1990.

6. Greenhorne & O'Mara, Inc. 1991. Field Notes. Site visit to the E.R. Squibb & Sons Site. April 30, 1991.

7. USGS 7.5' Quadrangle Maps: Lucama, NC (1978); Kenly East, NC (1978); Kenly West, NC (1978); and, Stancils Chapel, NC (1978).

8. NUS Corporation. 1990. Field notes. Site reconnaissance for E.R. Squibb & Sons site. March 13.

9. Durway, D. Mark (NCDHR). 1985. Letter to Denise Bland (EPA) regarding Preliminary Assessment Report for E.R. Squibb & Sons. December 19.

10. U.S. Department of Commerce, National Climatic Data Center, Climatic Atlas of the United States, Asheville, NC.

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13. Soil Conservation Service. 1990. Soil Survey for Johnston County, North Carolina, United States Department of Agriculture.

14. NUS Corporation. 1990. Field Notes. Site reconnaissance for Union Camp Smithfield Site. March 13.

15. NUS Corporation. 1990. Water Use Survey for E.R. Squibb & Sons. TDD No. F4-9002-44. March 13.

16. Spangenberg, Rachel M. (Greenhorne & O'Mara, Inc.). 1991. Population calculations for E.R. Squibb & Sons. October 22.

17. DeRosa, Pat (NCDEHNR). 1991. Letter to technical staff, RE: U.S. Census Bureau 1990 Population Data. September 16.

18. Williams, Alvin L. (NUS). 1990. Telecon with Mr. Don Baker (Wildlife Resources Commission), RE: Recreational activity along the Neuse River, Little River, and Middle Creek. March 27.

19. U.S. Fish and Wildlife Service, Endangered and Threatened Species of the Southeastern United States. Atlanta, Georgia, 1988.

20. U.S. Environmental Protection Agency, Region IV, Environmental Services Division. Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia. February 1, 1991.

REFERENCE 1

NUS CORPORATION
1927 LAKESIDE PARKWAY
SUITE 614
TUCKER, GEORGIA 30084
404-938-7710

C-586-9-0-119

September 17, 1990

Mr. A.R. Hanke
Waste Programs Branch
Waste Management Division
Environmental Protection Agency
345 Courtland Street, N. E.
Atlanta, Georgia 30365

Date: _____
Site Disposition: _____
EPA Project Manager: _____

Subject: Screening Site Inspection, Phase I
E.R. Squibb and Sons
Kenly, Jonnston County, North Carolina
EPA ID No. NCD991278730
TDD No. F4-9002-44

Dear Mr. Hanke:

FIT 4 conducted a Phase I Screening Site Inspection at E.R. Squibb and Sons in Kenly, Johnston County, North Carolina. This assessment included a review of EPA and state file material, completion of a target survey, and an offsite reconnaissance of the facility and surrounding area.

E.R. Squibb and Sons is located along Flowers Road off Interstate 95 about 0.5 mile southwest of Kenly, North Carolina. The facility is located in a sparsely-populated area outside the city limits of Kenly. There are few commercial businesses with one located 0.25 mile south of the property line. Accessibility to the facility is restricted by an 8-foot wire fence and a guarded entrance (Refs. 1, 2).

E.R. Squibb and Sons began operations as a new facility in 1978. Prior to 1978, the property was used for farming. The Squibb facility is a 97-acre property which receives bulk shipments of unfinished penicillin, which it processes to such finished forms as tablets, capsules, and powders. Squibb generates halogenated and nonhalogenated solvent wastes at a rate of 125,000 lbs./yr. The waste materials identified as hazardous result from two separate process operations. The first process involves the recovery of solvents, which are collected as a mixture of spent methyl alcohol and spent methylene chloride, from tablet coating. The second process involves the recovery of solvents from the drying of penicillin cake which contains n-butyl alcohol (Refs. 3, 4).

Beginning in 1978, Squibb and Sons stored halogenated and nonhalogenated waste solvents in tanks and drums on site. These wastes are transported off site every 90 days by Seaboard Chemical Company (Ref. 3). Until January 18, 1982, Squibb stored butyl alcohol in an underground storage tank; however, file materials indicate that fuel oil is the only substance presently stored in underground tanks at the facility (Ref. 3). There is no documentation that addresses spills of any hazardous substance(s) on site.

E.R. Squibb and Sons filed a Resource Conservation and Recovery Act (RCRA) Part A application on November 13, 1980, for storage of hazardous waste (Ref. 1). The company withdrew its application, thereby requiring waste removal within the 90-day storage period. The North Carolina Department of Human Resources, Solid and Hazardous Waste Management Branch, inspected Squibb and Sons on January 23, 1990. The purpose of this inspection was to ensure the facility was in compliance with applicable 40 CFR, Parts 262, 265, and 268. Only minor violations were noted (Ref. 6). As of March 1990, the Squibb facility is classified as a large-quantity generator of hazardous waste (Refs. 5, 7). Prior to RCRA, Squibb and Sons was issued an air quality permit by the North Carolina Division of Environmental Management (Ref. 5).

The E.R. Squibb and Sons facility is located in the fall zone of North Carolina near the city of Kenly. The fall zone is an area of transition between the folded and faulted metamorphic and igneous rocks of the Piedmont Physiographic Province to the north and the sedimentary assemblage of the Atlantic Coastal Plain to the south (Ref. 8, p. 5). The topography of the area represents a fairly flat plain with 50 to 70 feet of fluvial incision along the streams (Ref. 9). The mean annual rainfall is 48 inches, with a mean net precipitation of 7 inches (Ref. 10, pp. 43, 63).

A thin blanket of surficial sands covers most of the area and ranges in thickness from 0 to 30 feet. The coarse-grained sands and gravels of the Cretaceous Tuscaloosa Formation outcrop in the fall zone and may occur as a thin layer between the surficial sands and the crystalline basement rocks (Ref. 8, p. 23).

In Kenly, the crystalline basement rocks are primarily slate. Groundwater in the study area is derived from the unconfined water-table aquifer. The groundwater resides in the surficial and Tuscaloosa sands, if present, and in the secondary faults and fractures in the slate basement rocks (Ref. 8, pp. 23, 25). Municipal wells in Kenly are cased to the slate which occurs at a depth of 40 feet below land surface (bls) (Ref. 8, p. 25).

The water-table surface generally conforms to the topographic gradient, although it is somewhat flatter (Ref. 11, p. 9). In the facility area, groundwater flow should be northwesterly (Ref. 11, p. 9). Depth to the surficial water table is approximately 10 to 15 feet bls based on mean pool elevations of proximal surface water bodies (Ref. 9). Hydraulic conductivity for the surficial sands should be on the order of 10^{-1} cm/sec (Ref. 12, p. 29).

The Squibb facility receives water from the city of Kenly. The city of Kenly purchases drinking water from the Smithfield Public Utility Authority. Smithfield Public Utilities has a surface water intake along the Neuse River. This is the only surface water intake in Johnston County (Ref. 13). The city of Kenly system connects with the Smithfield system at the intersection of Highways 2144 and 301 (Refs. 2, 9). Residents not served by a municipal water system obtain water from private wells (Ref. 2). The nearest resident and private drinking water well are located about 2,800 feet north of the facility; the well is completed at a depth of 45 feet (Ref. 14).

A house count from USGS topographic maps identifies 430 homes within a 3-mile radius using private wells. An additional 462 homes located between 3 and 4 miles from the facility also use private wells. A school and some churches are located within 1 mile of the facility, but they are on the municipal water system (Refs. 2, 9). Population is 1,372 within 1 mile of the facility and 4,960 within 4 miles (Ref. 15). Kenly maintains their own water system that has approximately 1,000 customers.

Surface water drainage from the facility appears to travel overland southwest for about 1,200 feet. The runoff continues east along Interstate 95 for about 6,500 feet before entering Little River. The Little River continues south for the remainder of the 15-mile migration pathway. Smithfield Public Utilities is not affected by surface water drainage from this facility (Refs. 9, 14). There are few wetlands located along the Little River south of the facility (Ref. 9). There are no surface water intakes located along the 15-mile migration pathway (Ref. 16). Recreational fishing does occur along the Little River (Ref. 17).

There are no critical habitats within the vicinity of the study area (Ref. 18). However, several threatened or endangered species are recognized by the state throughout Johnston County (Ref. 19)

Because of the permeability of the confining layer within the study area and the number of groundwater targets, it is recommended that Phase II of the Screening Site Inspection be conducted at E.R. Squibb and Sons on a high-priority basis. If you have any comments or questions about this assessment, please contact me at NUS Corporation.

Very truly yours,

Alvin L. Williams
Project Manager

Approved:

ALW/gwn

Enclosures

cc: Robert Morris

REFERENCES

1. Potential Hazardous Waste Site Preliminary Assessment (EPA Form 2070-12) and attachments for E.R. Squibb and Sons. Filed by Durway/Crosby, North Carolina Department of Human Resources, December 3, 1985.

2. NUS Corporation Field Logbook No. F4-2089 for E.R. Squibb and Sons, TDD No. F4-9002-44. Documentation of facility reconnaissance, March 13, 1990.

3. D. Mark Durway, Geologist, North Carolina Department of Human Resources, letter to Denise Bland, EPA North Carolina CERCLA Project Officer, December 19, 1985. Subject: Preliminary Assessment Report for E.R. Squibb and Sons.

4. B.H. Pharr, Plant Engineer, E.R. Squibb and Sons, letter to William Paige, North Carolina Division of Health Services, March 30, 1982. Subject: Closure plan.

5. Interim Status Inspection Report for E.R. Squibb and Sons, Kenly, North Carolina; filed by Larry D. Perry, North Carolina Solid and Hazardous Waste Management Branch, January 28, 1982.

6. North Carolina Department of Human Resources, Solid and Hazardous Waste Management Branch, RCRA Inspection Report on E.R. Squibb and Sons, January 13, 1990.

7. North Carolina Department of Human Resources, Solid and Hazardous Waste Management, Alphabetic List of Hazardous Waste Facilities, March 18, 1989.

8. Richard D. Pusey, Geology and Ground Water in the Goldsboro Area, North Carolina Department of Water Resources, Ground Water Bulletin No. 2 (Raleigh: U S. Geological Survey, 1960).

9. U.S. Geological Survey, 7.5 minute series Topographic Quadrangle Maps of North Carolina: Lucama 1978, Kenly East 1978, Kenly West 1978, Stancils Chapel 1978, scale 1:24,000.

10. U.S. Department of Commerce, Climatic Atlas of the United States (Washington: GPO, 1978), (Washington, D.C.: GPO, June 1968) Reprint: 1983, National Oceanic and Atmospheric Administration.

11. Harry E. LeGrand, Ground Water of the Piedmont and Blue Ridge Provinces in the Southeastern States, U.S. Geological Survey Circular 138, Washington, 1967, pp. 9, 10.

12. R. Allan Freeze and John A. Cherry, Groundwater, (Englewood Cliffs, N.J.: Prentice-Hall, Inc. 1979).

13. NUS Corporation Field Logbook No. F4-2088 for Union Camp Smithfield Saw, TDD No. F4-9002-43. Documentation of facility reconnaissance, March 13, 1990.

14. NUS Corporation Water Use Survey for E.R. Squibb and Sons, TDD No. F4-9002-44, March 13, 1990.

15. U.S. Environmental Protection Agency, Graphical Exposure Modeling System (GEMS) Data Base, compiled from U.S. Bureau of the Census data (1980).

16. Department of Natural Resources Environmental Health Section, Water Supply Branch, Alphabetical within county listing of active community PWS, November 19, 1987, Johnston County (County Code 03).

17. Don Baker, Habitat Conservation Manager, Wildlife Resources Commission, telephone conversation with Alvin L. Williams, NUS Corporation, March 27, 1990. Subject: Recreational activity along the Neuse River, Little River, and Middle Creek.

18. U.S. Fish and Wildlife Service, Endangered and Threatened Species of the Southeastern United States (Atlanta, Georgia, 1988).

19. North Carolina Natural Heritage Program Element List for Johnston County, June 21, 1989, p 1

REFERENCE 2

Refrence 2

EPA

POTENTIAL HAZARDOUS WASTE SITE PRELIMINARY ASSESSMENT
PART 1 - SITE INFORMATION AND ASSESSMENT

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D991278730

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER
E.R. Squibb and Sons	Flowers Road

03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE	08 CONG DIST
Kenly	NC	27542	Johnston	51	2

09 COORDINATES LATITUDE	LONGITUDE
35° 35' 09"	78° 08' 27"

10 DIRECTIONS TO SITE (Starting from nearest public road)

The Squibb facility is situated on a 97 acre property on Flowers Road immediately off I-95. This location is approximately 0.5 miles SW of Kenly.

III. RESPONSIBLE PARTIES

01 OWNER (If known)	02 STREET (Business, mailing, residential)
E.R. Squibb and Sons	P.O. Box 4000

03 CITY	04 STATE	05 ZIP CODE	06 TELEPHONE NUMBER
Princeton	NJ	08540	(609) 921-4000

07 OPERATOR (If known and different from owner)	08 STREET (Business, mailing, residential)
E.R. Squibb and Sons	P.O. Box 1000

09 CITY	10 STATE	11 ZIP CODE	12 TELEPHONE NUMBER
Kenly	NC	27542	(919) 284-5131

13 TYPE OF OWNERSHIP (Check one)

☒ A. PRIVATE ☐ B. FEDERAL: _____ (Agency name) ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL

☐ F. OTHER: _____ (Specify) ☐ G. UNKNOWN

14 OWNER/OPERATOR NOTIFICATION ON FILE (Check all that apply)

☒ A. RCRA Part A DATE RECEIVED: 11 13 80 (MONTH DAY YEAR) ☐ B. UNCONTROLLED WASTE SITE (CERCLA 103 c) DATE RECEIVED: / / (MONTH DAY YEAR) ☐ C. NONE

IV. CHARACTERIZATION OF POTENTIAL HAZARD

01 ON SITE INSPECTION

☐ YES DATE / / (MONTH DAY YEAR)
☒ NO

BY (Check all that apply)
☐ A. EPA ☐ B. EPA CONTRACTOR ☐ C. STATE ☐ D. OTHER CONTRACTOR
☐ E. LOCAL HEALTH OFFICIAL ☐ F. OTHER: _____ (Specify)

CONTRACTOR NAME(S): _____

02 SITE STATUS (Check one)

☒ A. ACTIVE ☐ B. INACTIVE ☐ C. UNKNOWN

03 YEARS OF OPERATION

1978 (BEGINNING YEAR) | _____ (ENDING YEAR) ☐ UNKNOWN

04 DESCRIPTION OF SUBSTANCES POSSIBLY PRESENT, KNOWN, OR ALLEGED

Facility receives bulk shipments of unfinished penicillin, which it processes to such finished forms as tablets, capsules, and powders. Squibb is a new plant, situated on a 97 acre property, which prior to 1978, was used for farming. Squibb generates halogenated and non-halogenated solvents at a rate of 125,000 lbs/yr. Waste is stored

05 DESCRIPTION OF POTENTIAL HAZARD TO ENVIRONMENT AND/OR POPULATION

in tanks and drums and manifested off-site every 90 days, as required for large generat Facility had a 4000 gallon underground storage tank for butyl alcohol; this unit remair in place, but was closed 1-18-82. Presently the only substance stored underground is fuel oil. Squibb uses city water, as do local residents, the nearest of which is locat

V. PRIORITY ASSESSMENT

01 PRIORITY FOR INSPECTION (Check one. If high or medium is checked, complete Part 2 - Waste information and Part 3 - Description of Hazardous Conditions and Incidents)

☐ A. HIGH (Inspection required promptly) ☐ B. MEDIUM (Inspection required) ☒ C. LOW (Inspect on time available basis) ☐ D. NONE (No further action needed, complete current disposition form)

VI. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)	03 TELEPHONE NUMBER
Bill Pharr, Plant Eng.	Squibb - Kenly, NC	919 284-5131

04 PERSON RESPONSIBLE FOR ASSESSMENT	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NUMBER	08 DATE
Durway/Crosby	NC DHR/DHS	SHW Mgmt. Br.	(919) 733-2178	12 / 03 / 85 (MONTH DAY YEAR)

EPA FORM 2070-12 (7-81)

about 0.5 miles away. Bill Pharr, plant eng., and records at this office indicate that no releases have occurred which would pose a threat to human health or t environment.

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D991278730

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 _____

NO OF DRUMS Unknown

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			According to RCRA Part A,
OLW	OILY WASTE			facility generates spent halogenate
SOL	SOLVENTS	125,000	lbs/yr	and non-halogenated solvent waste,
PSD	PESTICIDES			which it stores in tanks or drums
OCC	OTHER ORGANIC CHEMICALS			prior to being manifested off-site
IOC	INORGANIC CHEMICALS			for treatment/disposal.
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS			

IV. HAZARDOUS SUBSTANCES (See Appendix for most frequently cited CAS Numbers)

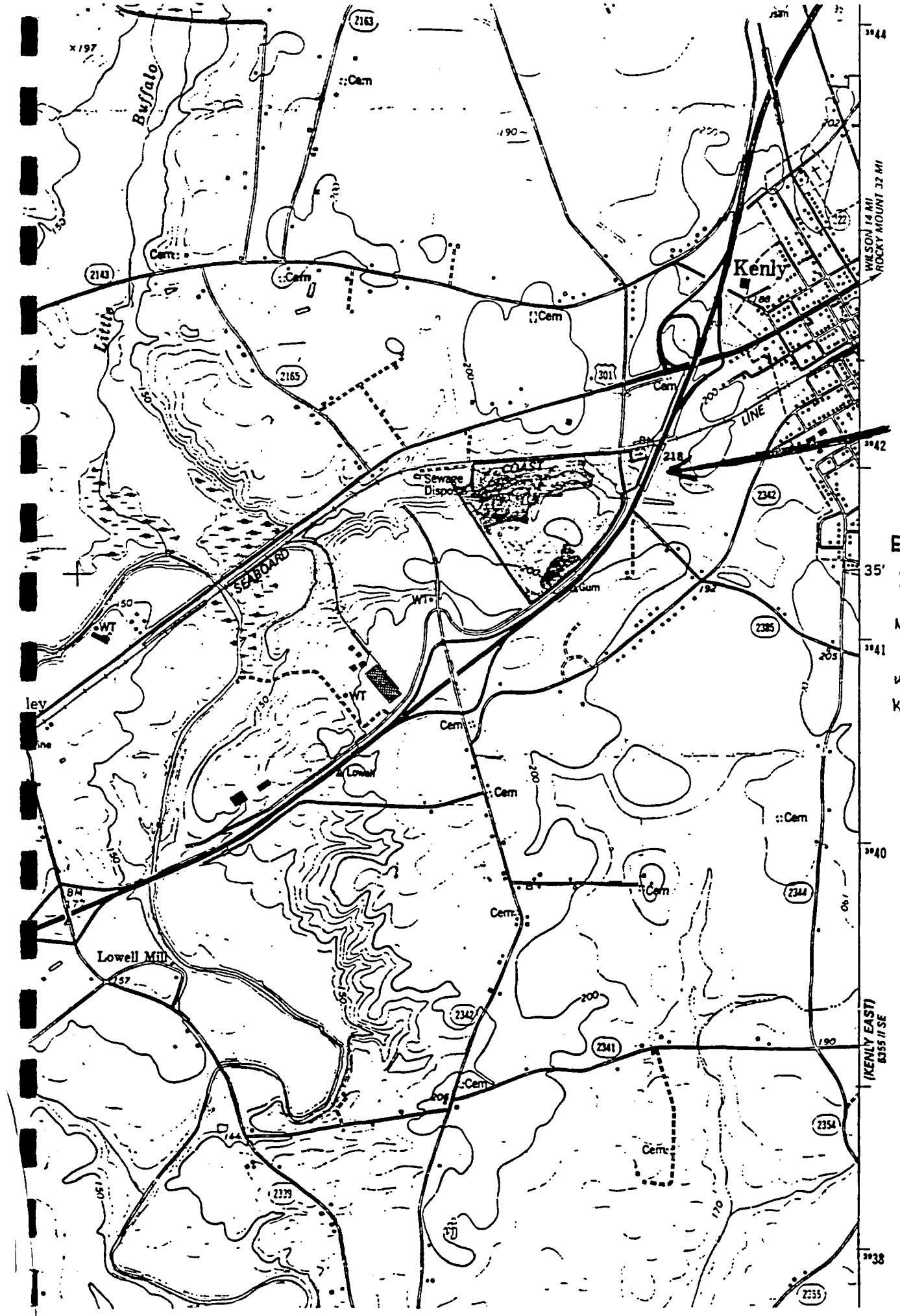
01 CATEGORY	02 SUBSTANCE NAME	03 CAS NUMBER	04 STORAGE/DISPOSAL METHOD	05 CONCENTRATION	06 MEASURE OF CONCENTRATION
F002	spent halog. solvents	----	stored in drums		
F005	spent non-halog. solvents	----	stored in drums		
F003	spent halog. solvents	----	stored in tanks		
	(particular waste types		Facility ships 7-10 drums of		
	include isobutanol		F002 waste to Seaboard Chemical		
	and methylene chloride).		Co. in Jamestown, NC, every 90		
			days. In the past, Squibb has manifested		
			waste to Carochem in Durham, NC.		
			Waste has also been shipped to the Squibb		
			facility in Brunswick, NJ.		

V. FEEDSTOCKS (See Appendix for CAS Numbers)

CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER	CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER
FDS	N/A		FDS		
FDS			FDS		
FDS			FDS		
FDS			FDS		

VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

1. Files at the NC Solid and Hazardous Waste Mgmt. Branch, Raleigh, NC.
2. Bill Pharr, plant eng. at Squibb, in Kenly, NC, personal communication, 12-3-85.

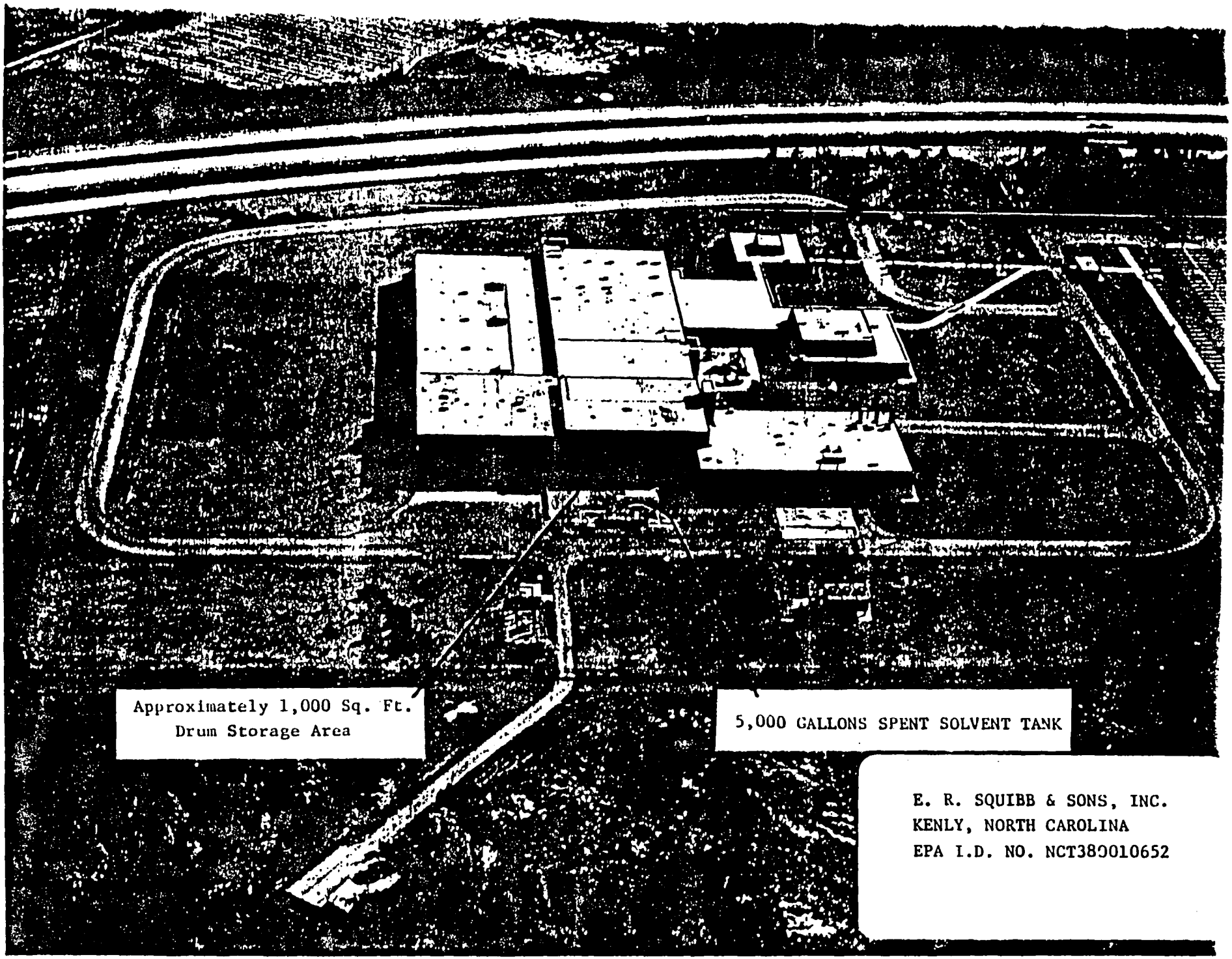


E.R. Squibb +
35° 35' 09" N
78° 08' 27" W

EPA ID No.
NCT3800106

NC D991278730

USGS 7.5'
KENLY WEST, N
(1978)



E. R. SQUIBB & SONS, INC.
KENLY, NORTH CAROLINA
EPA I.D. NO. NCT380010652

REFERENCE 3

Reference 2

SQUIBB

E. R. Squibb & Sons, Inc.

Flowers Road
P.O. Box 1000
Kenly, North Carolina 27542
919-284-5131

RECEIVED
MAR 31 1982
SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH

March 30, 1982

Mr. William Paige
Division of Health Services
Post Office Box 2091
Raleigh, North Carolina 27602

Dear Mr. Paige:

Because of production requirements at the Kenly, North Carolina plant, we are discontinuing the Pencillin drying operation that produces Butyl alcohol (F003). The 4,000 gallon stainless steel underground tank will not be used for storage of Butyl alcohol.

The alcohol in this tank has been pumped into a tanker and transported to our New Brunswick, New Jersey plant for reuse, which is the normal procedure.

Since this alcohol is miscible with water, we propose to dilute the remaining (approximately 1 to 2 gallons) with 200-300 gallons of water, then sewer the dilution. The tank will then be water rinsed and again sewered.

At present we do not have a use for this tank, however, it will be filled approximately half full with water. This will prevent it from floating above ground if the water table rises during heavy rains.

Our Closure Plan is attached for your review.

Sincerely,

BHPharr

B. H. Pharr
Plant Engineer

BHP/ln

Attachment

cc: Mr. O. W. Strickland

RCRA Closure Plan and Cost Estimate
for E. R. Squibb & Sons Facility
Kenly, North Carolina

GENERAL

EPA requires that the Owner/Operator of any site, granted "interim status" to treat, store or dispose of designated hazardous wastes, develop a plan identifying the steps anticipated as necessary to discontinue hazardous waste management activities at any point during, or at the end of the facility's intended life (40 CFR 265.110 - 265.115). The performance standard for these Closure Plans seeks to,

a) minimize the need for further maintenance of the site, once closed, and
b) control or eliminate, to the extent necessary to protect human health and the environment, post closure escape of remaining hazardous wastes and their residues.

The costs of implimenting the Closure Plan are to be estimated and, periodically updated.

The following plan, developed for the E. R. Squibb & Sons, Inc. facility at Kenly, North Carolina, identifies the expected activities and the anticipated costs for closure of this site.

BACKGROUND

E. R. Squibb & Sons, Inc. owns and operates a pharmaceutical manufacturing facility at Kenly, North Carolina. The principal activity at this site involves the processing of unfinished bulk penicillin into such finished product forms as tablets, capsules, and powders for suspension. Some of these activities generate wastes which qualify as hazardous under EPA rules at 40 CFR 261.

In August 1980, in accordance with Section 3010 of the Resource Conservation and Recovery Act (RCRA) Amendments of 1976, Squibb notified EPA that activities at this site generate EPA-designated hazardous wastes. EPA assigned identification number NCT380010652 to the site.

RCRA Closure Plan and Cost Estimate
for E. R. Squibb & Sons Facility
Kenly, North Carolina

In November, 1980, Squibb filed an application with the EPA for the site to continue to STORE hazardous waste in accordance with the Agency's "Interim Status" provisions.

As a hazardous waste management facility at which "storage" is authorized, the site may keep hazardous wastes, in containers (e.g. drums) or in tanks, for periods of time exceeding 90 days. The conditions for closure at a storage facility require that the owner/operator

a) estimate the maximum amount of hazardous wastes on site at any time, and
b) describe the steps needed for closure; in this case, to remove stored wastes and their containers to other active and authorized treatment, storage, or disposal ("TSD") facilities, and to adequately clean contaminated equipment (e.g. tanks, piping, pumps)

SUMMARY OF FACILITY CONDITIONS

At the Kenly site, the waste materials identified as hazardous are liquids. They result from two separate process operations: solvents recovered from tablet coating are collected in drums; solvent recovered from drying wet process intermediate is collected in a single buried tank.

Both materials are sent off site for reclamation/reuse.

MAXIMUM ANTICIPATED INVENTORIES

1) Spent solvents from tablet coating are collected as a mixture of spent methyl alcohol (waste code F003) and spent methylene chloride (waste code F002) in approximately equal amounts. Information on each of these materials is attached. The solvents are collected in 55-gal drums. These drums, when full, are stored until a maximum of twelve are accumulated at which time a solvent reprocessor removes them.

RCRA Closure Plan and Cost Estimate
for E. R. Squibb & Sons Facility
Kenly, North Carolina

2) Spent n-butyl alcohol (waste code F003) is recovered from the drying of penicillin cake, sent to Kenly from Squibb's New Brunswick, New Jersey, facility. It is collected in a single, underground, stainless steel tank, having a maximum capacity of 4,000 gallons. Collected solvent is returned to New Brunswick for reuse.

REMOVAL OF INVENTORIES AT CLOSURE

The cessation of either, or both, spent solvent producing activities at the Kenly site would require the removal of final accumulated inventories. The site understands that the facilities currently receiving and reusing both waste streams can, and will, continue to do so.

DECONTAMINATION OF STORAGE FACILITIES

The removal of contained solvents, in drums, will leave no storage facilities requiring cleaning.

The removal of solvent from tanks to tank trucks by pumping would be expected to result in a quantity remaining in the tank which can not be pumped out. This quantity is estimated to be about five gallons. The removal of this heel is to be accomplished by rinsing the tank and the accompanying pumps and piping with about 200-300 gallons of water and then sewering the rinse; rinsing is to be repeated a second time. No additional treatment of the rinse water is necessary since n-butyl alcohol is readily stabilized by secondary wastewater treatment plant organisms (i.e. the Kenly sewerage facility).

Squibb anticipates that these activities will be accomplished within the 180-day period after generating the last scheduled volume of spent solvent. This facility is an active manufacturing site and, as such, no estimates for when spent solvent generating activities might cease can reasonably be made.

ESTIMATED COSTS FOR CLOSURE

a) Drummed spent solvents are removed by a reprocessor at no cost, normally; a transportation fee of about $200 may be applied if too few drums of spent solvent are present at the time of a scheduled pick-up.

b) The shipment of spent solvent from Kenly to New Brunswick incurs only a transportation fee of approximately $1,300 per load.

c) Manpower and supervision costs not exceeding $1,000 are expected to complete closure, as described.

CERTIFICATION OF CLOSURE

When all designated hazardous wastes have been removed from the site and all contaminated equipment has been cleaned, Squibb will engage the services of an independent registered professional engineer to review the plan, to inspect the decomissioned facilities and, together with a Squibb representative, to certify that closure was completed as planned.

ANNUAL REVIEW/ADJUSTMENT OF CLOSURE PLAN AND COSTS

In accordance with 40 CFR 265.142, the elements and the costs of the existing closure plan are to be reviewed annually and adjusted, as necessary, to keep them current. This review is to commence on, or about, May 1, each year.

REFERENCE 4

INTERIM STATUS INSPECTION

1. Facility Information

E. R. Squibb & Sons, Inc.
P. O. Box 1000
Kenly, NC 27542 (Johnston County)
EPA I.D. #NCD991278730 (old I.D. #NCT380010652)

2. Facility Contact

Billy H. Pharr - Plant Engineer

3. Survey Participant

Larry D. Perry, N.C. Solid & Hazardous Waste Management Branch

4. Date of Inspection

January 28, 1982

5. Applicable Regulations

40 CFR Parts 262 and 265, Fr May 19, 1980 and amendments

6. Purpose of Survey

RCRA compliance inspection was conducted at the above facility by the N. C. Solid and Hazardous Waste Management Branch. The scope of the inspection was comprehensive including a record review and site survey. Regulatory requirements covered those contained in 40 CFR 262 and 265 under generator standards, general facility standards, storage facilities, tanks and containers.

7. Facility Description

The Squibb facility is situated on a 97-acre site located on Flowers Road immediately off I-95 South of Kenly, N.C. The facility receives penicillin in bulk and processes it to such finished product forms as tablets, capsules and powders.

Prior to RCRA, Squibb had only one existing environmental permit, this being an air quality permit issued by the N. C. Division of Environmental Management.

The Part A application filed by Squibb listed the company as a generator of halogenated solvent - butyl alcohol (F003). Some isobutanol (F005) is generated also.

. . .

The butyl alcohol was stored in a 4,000 gallon underground tank on the site until last week (week of January 18, 1982). Prior to that time all butyl alcohol was stored in the tank and periodically shipped to another Squibb facility in New Brunswick, N.J. for reprocessing. As of the January 18, 1982 week, there will be no more butyl alcohol generated at the Kenly site. The tank has been emptied and will be cleaned out and left in the ground. A closure plan for this tank close-out is to be sent to William Paige for approval prior to clean-out. This letter will be submitted immediately or prior to February 12, 1982.

The methylene chloride is stored in 55-gallon steel drums within the Squibb manufacturing building. This material will continue to be generated. The isobutanol that is generated is mixed with the methylene chloride for storage. Periodically the methylene chloride - isobutanol is picked up by Carochem of Durham (NCT380011031) and transported to that facility for reprocessing.

No hazardous waste is released from the plant. All liquid waste leaving the site is treated by aeration on the site prior to release to the Kenly Wastewater Treatment Plant which has an NPDES permit. Squibb disposes of a volume of defective penicillin products (all solid material - no liquids) in the Johnston County Landfill of which they have a letter of consent from our office.

The site was in overall good shape except for a few deficiencies. The manifest system was in good order. Such things as contingency plan was only in need of updating, closure plan was excellent just needed to be made site specific, etc.

8. Documentation of Site Deficiencies/Recommendations

Squibb was deficient in the areas cited below:

1. (265.14(c)) - Danger signs needed at entrance to storage areas.
2. (265.16) - Personnel training needed documentation.
3. (265.5) - Contingency Plan needed - site has a plan but needs organization.
4. (265.110-112) - Closure Plan needs to be made site specific to Kenly.
5. Tank close-out plan needs to be submitted immediately.

9. Compliance Schedule

A compliance date of April 1, 1982 was agreed to by inspector and Squibb management for deficiency corrections. Another inspection will be made on this date or soon after for correction compliance.

A tank closure plan will be submitted prior to February 12, 1982 to William Paige for approval.

REFERENCE 5

Reference 5

RECEIVED
JAN 25 1990
HAZARDOUS WASTE SECTION

NORTH CAROLINA DEPARTMENT OF HUMAN RESOURCES
SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH
P.O. BOX 2091 RALEIGH, NORTH CAROLINA 27602-2091
306 N.WILMINGTON STREET

DOCKET #

INSPECTION AND EVALUATION REPORT

EPA ID: # NCD 991 278 730 FACILITY NAME: E. R. Squibb & Sons

ADDRESS: 1000 Squibb Dr. CITY: Kenly

NEW: ✓ UPDATE: ____ DATE OF INITIAL EVALUATION: 1 23 90 STAFF ID: 22

RESPONSIBLE AGENCY: S S = STATE E = EPA X = OVERSITE O = OTHER

TYPE OF EVALUATION COVERED BY THIS REPORT: ENTER ONE 1

1= COMPLIANCE EVAL. INSP.(CEI)
2= SAMPLING INSPECTION
3= RECORD REVIEW
4= COMP.GWM EVAL.(CME)
5= COMPLIANCE SCHED. (FOLLOW UP)
6= CITIZEN COMPLAINT
7= PART B CALL-IN
8= WITHWRAWAL CAND.
9= CLOSED FACILITY
10= GENERAL
11= CASE DEVELOPMENT
12= O & M INSPECTION
80= INFORMAL MEETING

DATE OF EVALUATION COVERED BY THIS REPORT: 1 23 90

CLASS OF VIOLATION — VIOLATIONS/RELEASES

CLASS	GWM/RLSE	C/CP	FIN	PT.B	CMPL.SCH	MANIFEST	OT	LAND BAN	Wpile M
I						0	0	0	0
II						0	0	0	0
ACCEPTABLE CODES	X S Z O R* B*	X S Z O	X S Z O I*B*	X S Z O	X S Z O C B	X S Z O	X S Z O	X S Z O	

KEY: X = VIOLATIONS O = NO VIOLATION Z = PENDING

SPECIALTIES: B = VIOL. & SPECIALTY; S = SAME VIOL./SPEC. I = NO insurance only; C = CA SCHED. VIOL. R = 3008(h)-like release; * = CLASS I only

ENTERED

ENFORCEMENT ACTIONS: (AREA OF VIOL./RLSE.=GW, CP, FR, PB, CS, MA, OT, LB, or AA

CLASS	AREA OF VIOL.	TYPE CODE	DATE ACTION TAKEN	COMPLIANCE DATES SCHED.	ACTUAL	PENALTY ASSES.	COLL.	RESP. AG.

CODES FOR TYPES OF ENFORCEMENT ACTIONS:

03 =WARNING LETTER/NOV
04 =ADMIN. COMPLAINT
05 =FINAL ADMIN. ORDER
10 =INFORMAL
11 = FILED CIVIL ACTION
12 = FILED CRIMIMAL ACTION
13 = CIVIL REFERRAL TO AG
90 = HEARING

COMMENTS:

6

RCRA INSPECTION REPORT

1) Facility Information
E.R. Squibb + Sons
1000 Squibb Dr.
Kenly, N.C. 27542
NCD 991278730

2) Facility Contact
David Varley

3) Survey Participants
David Varley
Larry Perry
Michael Williford

4) Date of Inspection
1-23-90

6) Purpose of Survey
Ensure compliance with 40 CFR Parts 262, 265, + 268.

7) Facility Description
Facility receives penicillin in bulk and processes it to finished product in forms of tablets, capsules, and powder. Hazardous wastes generated are methylene chloride, alcohol, and methanol. The waste is stored in drums then shipped offsite to disposers such as Thermal Kem Trial Recovery Services.

DH324

8) Waste Minimization

Chemical substitution

9) Site Deficiencies

Facility appears to be in compliance with applicable RCRA Regulations.

10) Recommendations

Need to upgrade container inspection log. Also, facility needs to notify as a marketer of hazardous waste.

11) Signed

Michael E. W. Clifford
Inspector/Reviewer

1/23/90
Date

[illegible signature]
Facility Contact

DH324

REFERENCE 6

E.R.SQUIBB & Son

WHD

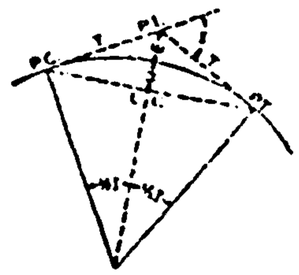
4/30/91

NCD 991278730

Reference 6

CURVE AND REDUCTION TABLES

Published by Eugene Dietzgen Co.



CURVE FORMULAS

1. Radius : $R = \frac{50}{\sin D/2}$
2. Degree of Curve: $D = 100\frac{I}{L}$. Also, $\sin D/2 = \frac{50}{R}$
3. Tangent : $T = R \tan \frac{1}{2} I$. Also, $T = \frac{T \text{ for } 1^\circ \text{ curve}}{D} + C$.
4. Length of Curve: $L = 100\frac{I}{D}$
5. Long Chord : $L.C. = 2R \sin \frac{1}{2} I$.
6. Middle Ordinate: $M = R(1 - \cos \frac{1}{2} I)$
7. External : $E = \frac{R}{\cos \frac{1}{2} I} - R$. Also, $E = T \tan \frac{1}{4} I$.

EXPLANATION AND USE OF TABLES

Given P I Sta. 83+40.7 $I = 45^\circ 20'$ and $D = 6^\circ 30'$ find:

Stations—P.C. = P I − T $T = \frac{T \text{ for } 1^\circ \text{ Curve}}{D} + C$. From Tables V and VI $T = \frac{2392.8}{6.5} + .197 = 368.32 = 3+68.32$. Sta. P. C. = 83+40.7 − (3+68.32) = 79+72.38.

P. T. = P. C. + L. and $L = 100\frac{I}{D} = 100\frac{45.33}{6.5} = 697.38$ Therefore, P. T. = (79+72.38) + (6+97.38) = 86+69.76

Offsets—Tangent offsets vary (approximately) directly with D and with the square of the distance. From Table III Tangent Offset for 100 feet = 5.66 feet. Distance = 80 − Sta. P. C = 27.62 Hence offset = $5.66 \times \left(\frac{27.62}{100}\right)^2 = .432$ ft. Also, square of the distance, divided by twice the radius equals (approximately) the distance from tangent to curve. Thus $(27.62)^2 \div (2 \times 881.95) = .432$ ft.

Deflections—Deflection angle = ½ D for 100 ft., ¼ D for 50 ft., etc. For "X" ft. Deflection Angle (in minutes) = 3 × X × D. For Sta. 80 of above curve Deflection Angle = 3 × 27.62 × 6.5 = 53.86'. Also Deflection Angle = D for 1 ft. from Table III × X = 1.95 × 27.62 = 53.86'. For Sta. 181 Deflection Angle = $53.86' + \frac{6^\circ 30'}{2} = 4^\circ 8.86'$.

Externals—From Table V for 1° curve, with central angle of 45° 20', E = 479.6. Therefore, for 6° 30' curve, $E = \frac{479.6}{6.5}$ + Correction from Table VI = 73.78 + 0.39 = 74.17

4/30/91

Arrived at site @ 7:45 Am

William Dixon
Marie Fisher
Hunt Leffler } & Harvey Allen

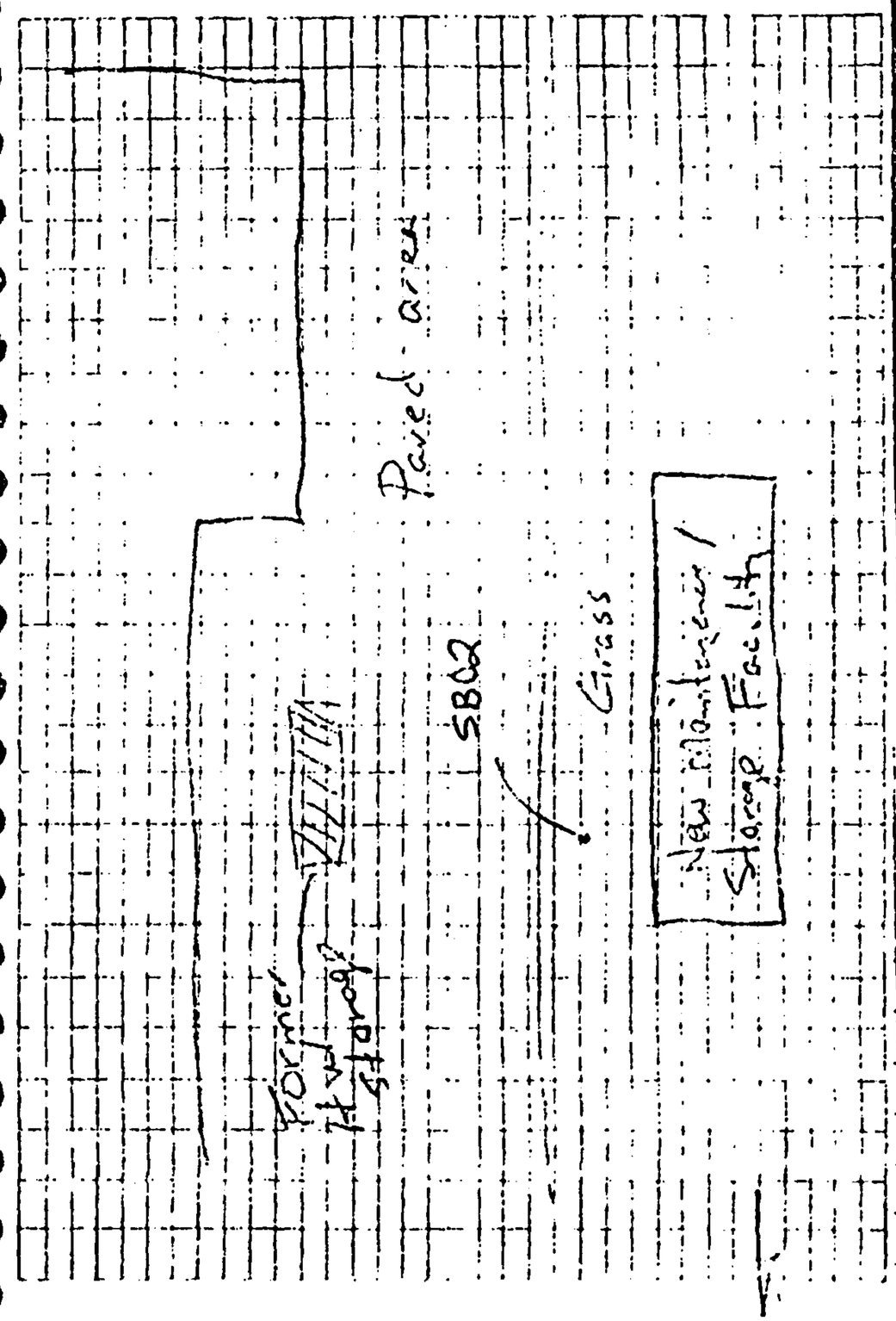
Met with Ken Acuck of Bristol Myers/SQUIBB To Discuss past uses of site

Plant was used to manufacture Penicillin from 1945 thru 1989.

Mr Acuck has been w/ Squibb since plant was operated. He is not aware of any spills or contamination with hazardous waste on the site. He indicated that the plant had always been a small quantity generator & never stored beyond ninety days.

SB02 was

GW02 was attempted approximately 50' west of former Haz waste Storage area. Hole was augered to ~17'; however, groundwater was not encountered. There were no indications based on soil moisture & appearance that groundwater was close. ~~Was~~ I decided we would take a bottom of hole soil boring in lieu of the groundwater sample. Soil reddish & clayey w/ some white clay — layered, stratified & packed.

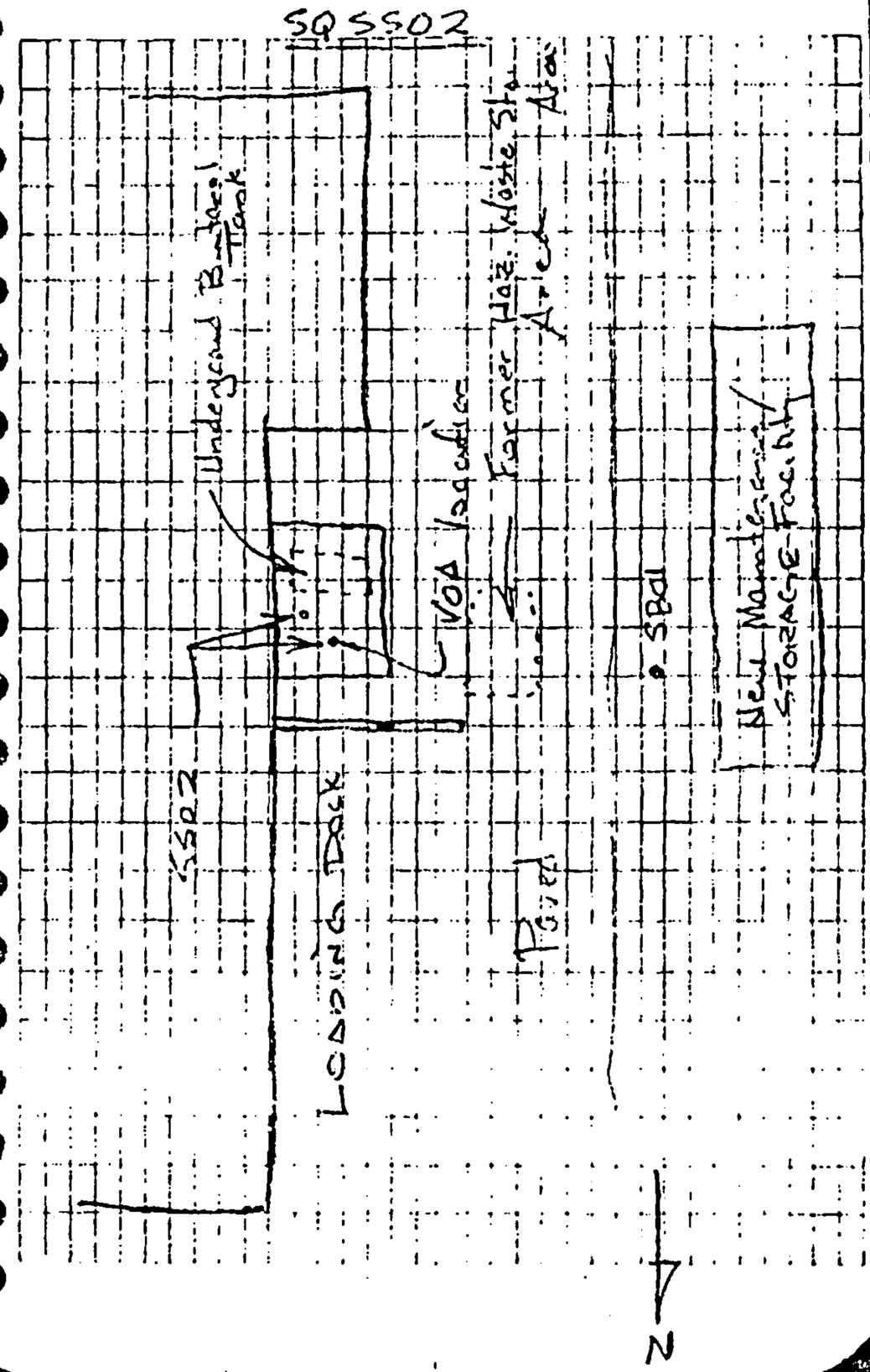


SQSS02 - Time 1015

Sample was composited from two locations north of underground butanol tank.

Sample was taken @ approximately 2' below surface.

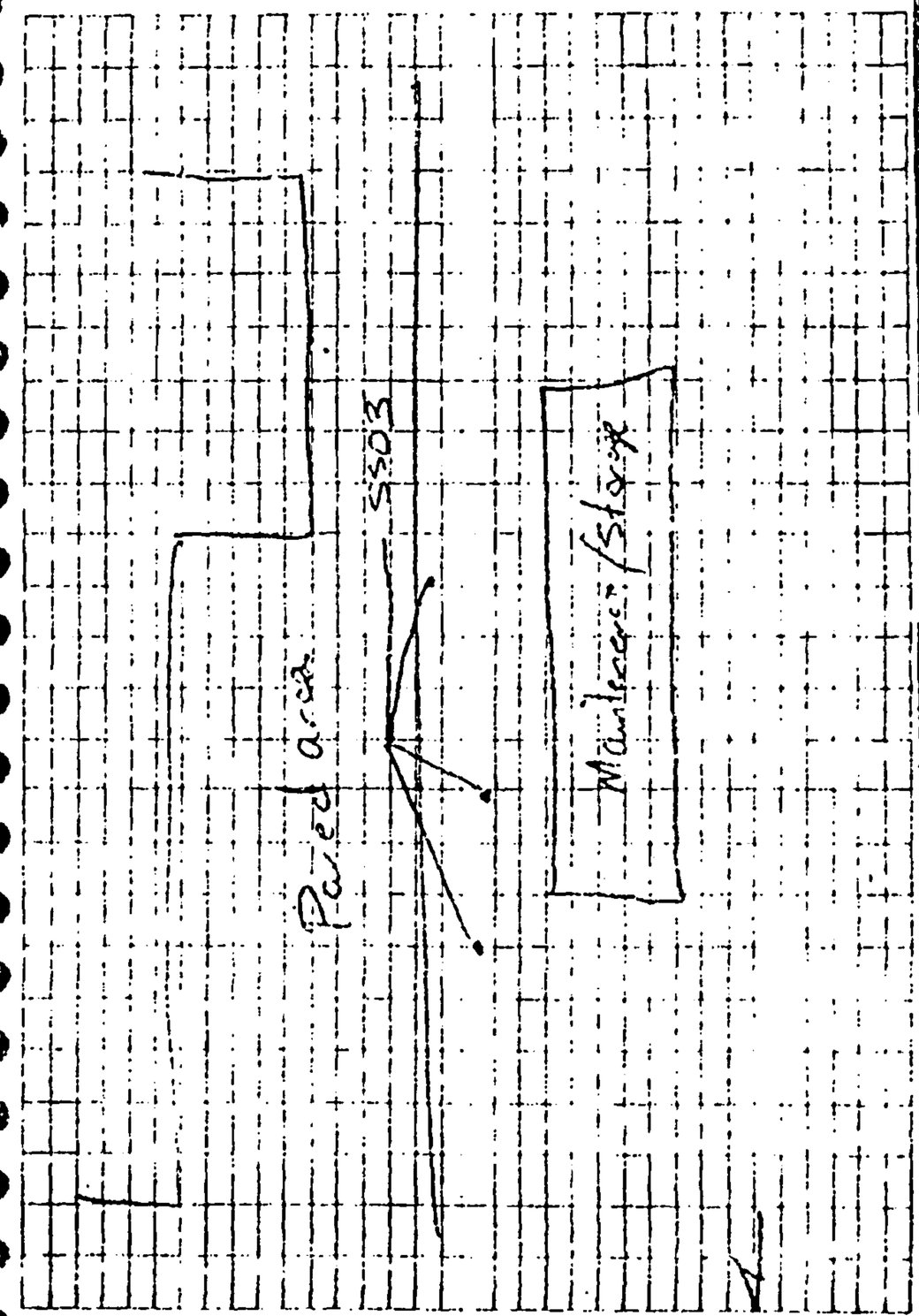
Mr. Acres indicated that the underground butanol tank was RCRA certified cleaned approximately 10 days ago.



SS03 - 1130 4/30/91

Composite Sample from three locations East of new maintenance / storage building & west of Former Haz waste storage Area.

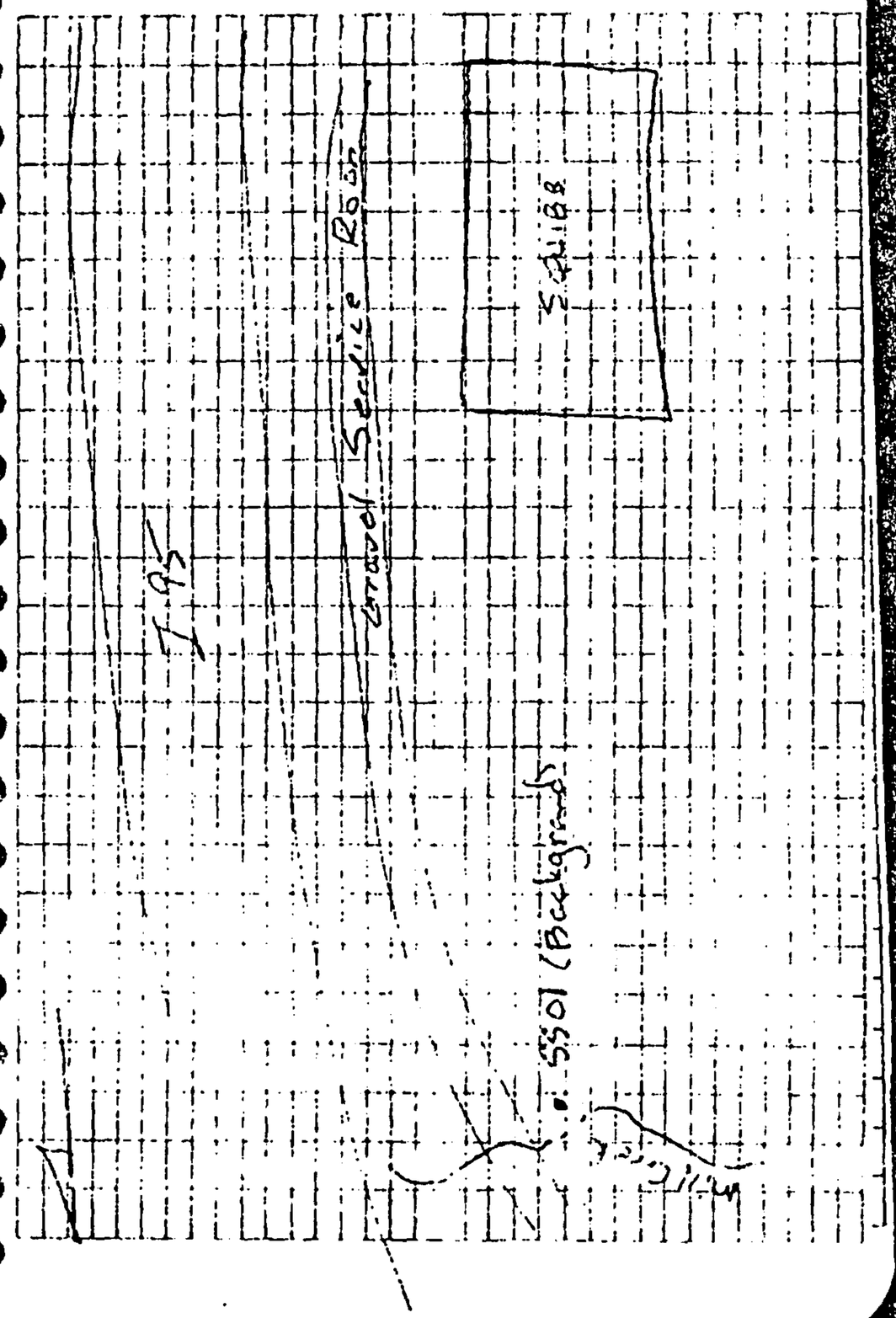
Sample taken @ 1-2' below surface.



SS01 - 4/30/91

SS01 was taken approximately 1-2' below the surface. This sample was dupped for MS/MSD samples. It was taken approximately 30' South of Mill Creek about 30' WEST OF Gravel ROAD.

Approximately 6-8" Topsoil; then a more clayey material referred to locally as "Blue Mold Clay"



GW01 (Background)

GW01 was started at approximately 1230 4/30/91. After breaking through "Blue Mold Clay" we encountered a gravel layer at about 5-6'. The Blue Mold Clay was moist, therefore we thought groundwater would be close. The location of the proposed well is approximately 6' higher in elevation than the Creek Bed of Mill Creek. After we broke through gravel layer we then encountered a material that was gray and was layered. When broken up it was like talc. We continued to auger through this material at a very slow pace.

See SS01 for Location of GW01

GW01 (Cont) 4/30/9

After about 2½ hrs. we had reached only about 13' and there was No sign of moisture in the bottom of the whole; however, there was some infiltration from above or within the gravel layer (6" thick). I decided to let the whole sit over night and see if there would be enough water in it to sample ~~on~~ tomorrow morning. If not we will take a bottom of hole soil Boring

NCD991278730 4/30/91

E.R. SQUIBB & SON

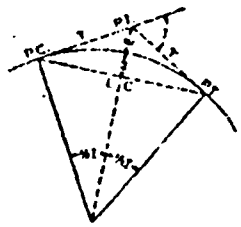
403NW

DIETZGEN

FISHER

CURVE AND REDUCTION TABLES

Published by Eugene Dietzgen Co.



CURVE FORMULAS

1. Radius : $R = \frac{50}{\sin D/2}$
2. Degree of Curve: $D = 100\frac{I}{L}$. Also, $\sin D/2 = \frac{50}{R}$
3. Tangent : $T = R \tan \frac{1}{2} I$. Also, $T = \frac{T \text{ for } 1^\circ \text{ curve}}{D} + C$.
4. Length of Curve: $L = 100\frac{I}{D}$
5. Long Chord : $L.C. = 2R \sin \frac{1}{2} I$.
6. Middle Ordinate: $M = R(1 - \cos \frac{1}{2} I)$
7. External : $E = \frac{R}{\cos \frac{1}{2} I} - R$. Also, $E = T \tan \frac{1}{4} I$.

EXPLANATION AND USE OF TABLES

Given P.I. Sta. 83+40.7, $I = 45^\circ 20'$ and $D = 6^\circ 30'$ find:

Stations – P.C. = P.I. – T. $T = \frac{T \text{ for } 1^\circ \text{ Curve}}{D} + C$. From Tables V and VI $T = \frac{2392.8}{6.5} + .197 = 368.32 = 3+68.32$. Sta. P.C. = 83+40.7 – (3+68.32) = 79+72.38.

P.T. = P.C. + L. and $L = 100\frac{I}{D} = 100\frac{45.33}{6.5} = 697.38$. Therefore, P.T. = (79+72.38) + (6+97.38) = 86+69.76.

Offsets—Tangent offsets vary (approximately) directly with D and with the square of the distance. From Table III Tangent Offset for 100 feet = .1660 feet. Distance = 80 – Sta. P.C. = 27.62. Hence offset = $5.56 \times \left(\frac{27.62}{100}\right)^2 = .432$ ft. Also, square of any distance, divided by twice the radius equals (approximately) the distance from tangent to curve. Thus $(27.62)^2 \div (2 \times 3981.95) = .432$ ft.

Deflections—Deflection angle = ½ D for 100 ft., ¼ D for 50 ft., etc. For "X" ft. Deflection Angle (in minutes) = .3 × X × D. For Sta. 80 (above curve) Deflection Angle = .3 × 27.62 × 6.5 = 53.86'. Also Deflection Angle = dfl for 1 ft. from Table III × X = 1.94 × 27.62 = 53.86'. For Sta. 181 Deflection Angle = $53.86' + \frac{6^\circ 30'}{2} = 4^\circ 8.86'$.

Externals—From Table V for 1° curve, with central angle of 45° 20', E = 479.6. Therefore, for 6° 30' curve, $E = \frac{479.6}{6.5}$ + Correction from Table VI = 7.378 + .135 = 7.513.

4/30/91 Squibb Marie Fiche

3 underground fuel oil tanks

1 5000 gal tank - had
n-butyl Alcohol from
plant process
SD-3 Alcohol
methanol - ethanol - 90% - 3

plant closed over a year
ago - August - 1990
hand full of employees
maintenance & security
guards

City water

no monitoring wells

Arrived onsite at 0750
Harvey onsite at 0800

Talked w/ Plant employee
Card attached

employed at site since beginning

Weather - clear in 80°s F

No haz. waste is on the site now.

Sampling Team walked site determined sample points.

Harvey collected surface water & sediment samples
Departed at 1100.

Calibrated HNU - Background Read 1-2 ppm

SQ5302 - 1015 Fishe + Dixon

Composite soil sample - Taken at two locations around the Butanal underground storage tank. Area covered w/ gravel cleared before obtaining sample collected sample at a depth ranging from 1-2 ft.

Soil - Clay -

HNU readings ranging from 19 to 35 out of hole.

Tank supposedly cleared and empty according to RCRA - but top of tank could be lifted off and could smell Alcohol.

SB SS03 - Former Hazardous Waste Storage Area 1/30

Fisher + Coffin

3 composite soil samples from ~~area~~ grassed area directly across from paved area used to store haz waste in drums.

Sample collected from 6 foot barn

SS01 - Background -
Taken on plant side of
stream.

SB01 - Collected next day
5/1/91 - 0950

Augered to approx. 10 feet
met auger refusal - in weathered
bedrock

Did not have soil bottles
w/me that day -
Returned next day to
collect soil sample

Bailed water that had filled
hole -
Took soil boring sample

Delivered samples to IEA
on 5/2/91

no pictures were taken because camera was not functioning

COMMENTS:

A groundwater sample could not be obtained at the downgradient site. Therefore a soil boring sample was taken at the bottom of the hole.

A upgradient GW sample was not taken for several reasons

1. could not penetrate weathered bedrock to GW
2. No need to collect background GW, because there was no downgradient GW
3. Needed to return on 5/1/91 because did not have enough soil borings to obtain a bottom of the

hole soil sample

Interviewed person below -

KEN ACRES
accounting manager

E. R. Squibb & Sons, Inc.

P.O. Box 1000
Kenly, NC 27542
919-284-5131

He was not aware of any spills or reason why - his waste would be contaminating site.

Site was very well kept - no visible signs of contamination

REFERENCE 7

SEE FIGURE 3 IN APPENDIX A

REFERENCE 8

44

Reference 8

"Rite in the Rain"®

ALL-WEATHER

LEVEL

Notebook No. 311

F4-2089

F4-9002-44
Squibb, E.R. + Sons
Kenly, Johnston County, NC
Alvin L. Wilson
Project Manager

LOGBOOK REQUIREMENTS
REVISED - NOVEMBER 29, 1988

NOTE: ALL LANGUAGE SHOULD BE FACTUAL AND OBJECTIVE

1. Record on front cover of the Logbook: TDD No., Site Name, Site Location, Project Manager.
2. All entries are made using ink. Draw a single line through errors. Initial and date corrections.
3. Statement of Work Plan, Study Plan, and Safety Plan discussion and distribution to field team with team members' signatures.
4. Record weather conditions and general site information.
5. Sign and date each page. Project Manager is to review and sign off on each logbook daily.
6. Document all calibration and pre-operational checks of equipment. Provide serial numbers of equipment used onsite.
7. Provide reference to Sampling Field Sheets for detailed sampling information.
8. Describe sampling locations in detail and document all changes from project planning documents.
9. Provide a site sketch with sample locations and photo locations.
10. Maintain photo log by completing the stamped information at the end of the logbook.
11. If no site representative is on hand to accept the receipt for samples, an entry to that effect must be placed in the logbook.
12. Record I.D. numbers of COC and receipt for sample forms used. Also record numbers of destroyed documents.
13. Complete SMO information in the space provided.

3-13-90

The purpose of this trip is to conduct field recon activities. No study plan or health and safety plan is required. The equipment location log and the project work plan are located in the FIT 4 filer in TDD # F4-9002-44. The undersigned acknowledges that they have read and understand the plans applicable to these field activities.

Alvin L. Williams
Alvin L. Williams

Prince Goins
PRINCE GOINS

3-13-90

Sunny, clear skies, 82°

1330 Arrive at vicinity of facility. Proceeded along service road that travels Northeast along Interstate 95. The facility is a large rectangular shape that is completely fenced with a guard at the main entrance. The facility is located in a sparsely populated area outside the City limits of Kenly, NC. There are large open fields surrounding the facility with a parking lot on the South side of the building. There are few commercial business on the southern border of the property with the closest being a Days Inn approximately 1,000 feet; Texaco about 1,300 feet. There are large areas of green grass and no signs of stressed vegetation

AKW

3-13-90

Surface water drainage appears to be to the Northeast and Southwest. A drainage ditch was identified 500 to 600 feet north of the facility traveling west to east.

1345 Taking representative photos of facility with 35mm and polaroid camera, along service road. The facility is active.

1350 Leaving vicinity of site

1400 Arrive at city of Kenly, NC to gain water distribution information. I spoke with Mike Taylor, Town Manager. Mr. Taylor drew their water distribution system onto my map. He stated that they purchase water from the

AKW

00002

3-13-90

City of Smithfield in Johnston County.
Their Connecting line begins at the intersection of Hwy 2144 and 301.

MR Taylor identified areas that uses private wells as a source of water supply.

He also stated that their system serves approximately 1,100 customers, which includes the city limits and some areas outside the city limits

1415 Left town hall to identify area of private well users.
Took Hwy 301 going South to first road on right.

AKW

3-13-90

1422 Interviewed MR. Roy Gill at Route 2, Box 204 Kenly, NC. MR. Gill has a drilled well at 45ft that is used for household and drinking. MR. Gill stated that there five people that uses the water from his well. He also is identified as being the closest resident to the facility.

1435 Continued South on Hwy 301 to identify other areas of interest. The area is rural and not very populated. There are open fields that appears to be farm land and very few residents. All residents north of Hwy 301 appears to be on private wells.

AKW

000056

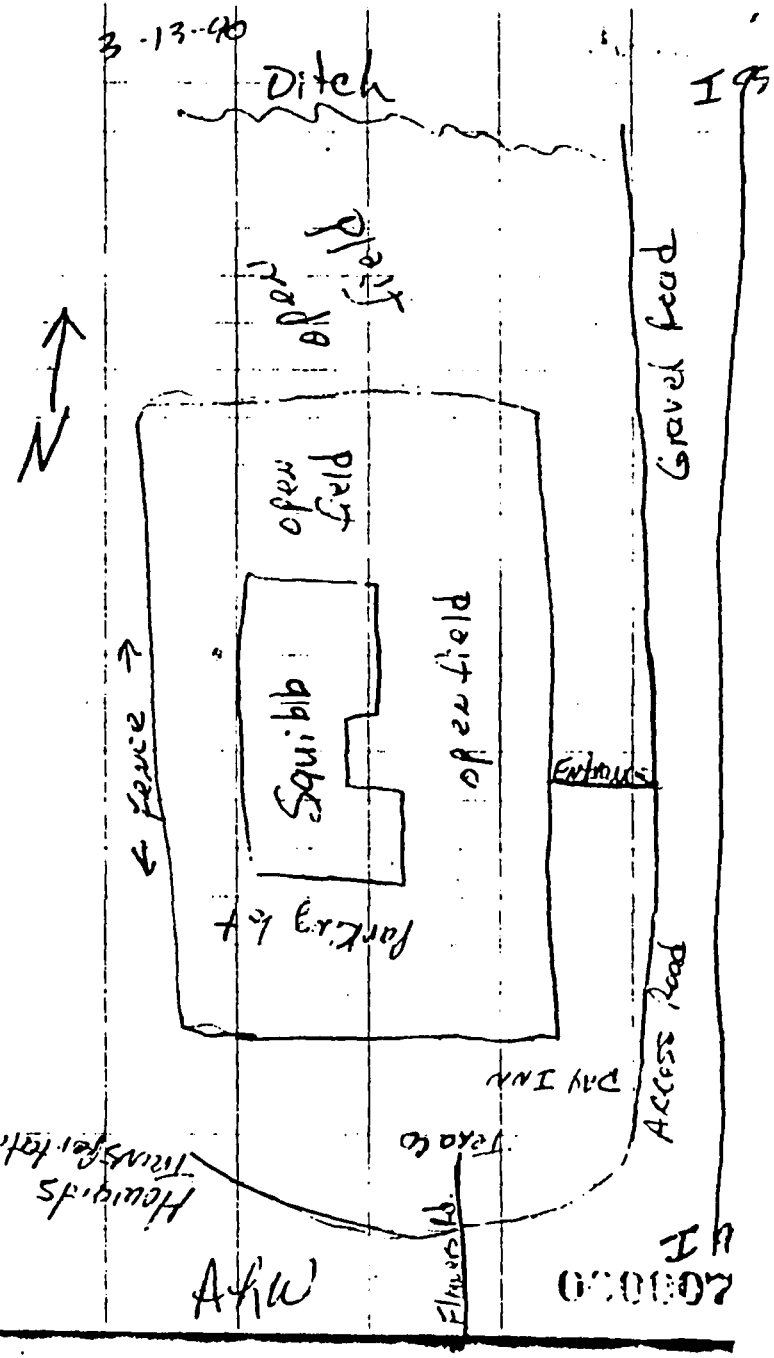
3-13-90

There was a house identified along Hwy 301 on the Southern border that had a private well. This house is within the City of Kenly water distribution system. There was no one home to be interviewed. obtained information from mailbox: D. Fields
Box 207
Hwy 301
Kenly, NC

Will try to contact by phone to ask about the well

1455 Proceeded back in vicinity of facility to do site sketch.

AKW



000057

000008 3-13-90

1517 Leaving area
End of RECON

Adam L. Williams

000009

REFERENCE 9

Reference 9

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

December 19, 1985

Ms. Denise Bland
EPA NC CERCLA Project Officer
Air and Hazardous Material Division
345 Courtland Street, N.E.
Atlanta, GA 30365

Re: E.R. Squibb and Sons/NC D991278730
Flowers Rd.
Kenly, Johnston County, NC

Dear Ms. Bland:

Enclosed please find the Preliminary Assessment report for the subject site. This priority is based on review of available data.

Squibb is a new facility which commenced operation in 1978. The facility receives bulk shipments of unfinished penicillin, which it processes to such finished forms as tablets, capsules, and powders. Squibb generates halogenated and non-halogenated solvents at a rate of 125,000 lbs./yr. This waste is stored in tanks and drums and manifested off-site every 90 days, as required for large generators. At present this waste is being handled by Seaboard Chemical Company of Jamestown, NC; in the past, Squibb is known to have directed their wastes to both, Carochem in Durham, NC, and the Squibb facility in Brunswick, NJ.

Until January 18, 1982, Squibb stored butyl alcohol in a 4000 gallon underground storage tank. Presently, fuel oil is the only substance stored in underground storage tanks at the site.

Squibb generates wastewater at a rate of 5,000 to 15,000 GPD. The company aerates this wastewater in a concrete tank, prior to discharging it to the city sewer.

According to Bill Pharr, plant manager at Squibb, the plant uses water supplied by the city of Smithfield. He believes that local residents also depend on city water, and reports that he knows of no nearby wells. The nearest home, he says, is located about 0.5 miles from the facility.

No on-site disposal, spills, or releases have occurred at Squibb, according to Mr. Pharr. Based on the available data, it appears that this site poses no threat to human health or environment. Priority assigned is Low.

References are:

1. Files at the NC Solid and Hazardous Waste Mgmt. Branch, Raleigh, NC.

2. Bill Pharr, Plant Engineer at Squibb, in Kenly, NC, personal communications, 12-3-85.

On 19 December 1985, this Preliminary Assessment was reviewed by CERCLA Unit personnel and by the following representatives from the North Carolina Department of Natural Resources and Community Development, Division of Environmental Management: Fay Sweat, Groundwater Section and Glen Ross, Air Quality Section.

If you have any questions, please call me at (919) 733-2178.

Sincerely,

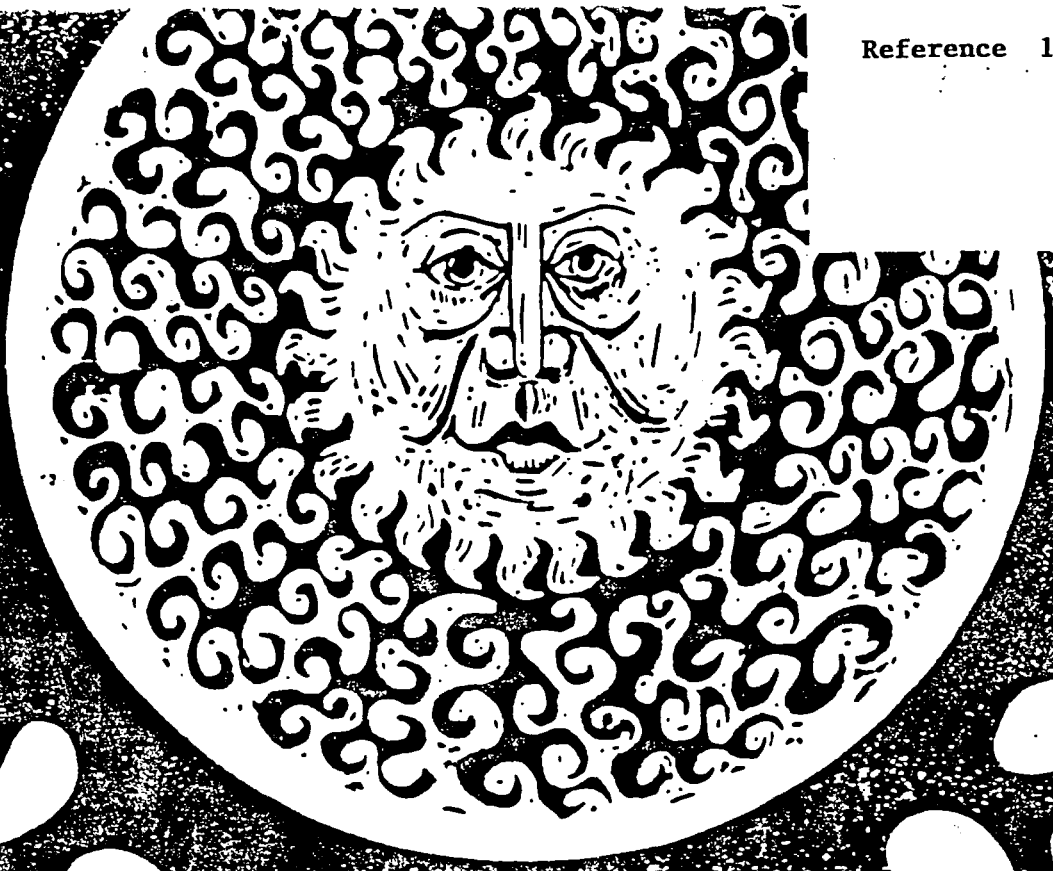
D. Mark Durway

D. Mark Durway, Geologist
Solid and Hazardous Waste Management Branch
Environmental Health Section

DMD/lw/0234b

REFERENCE 10

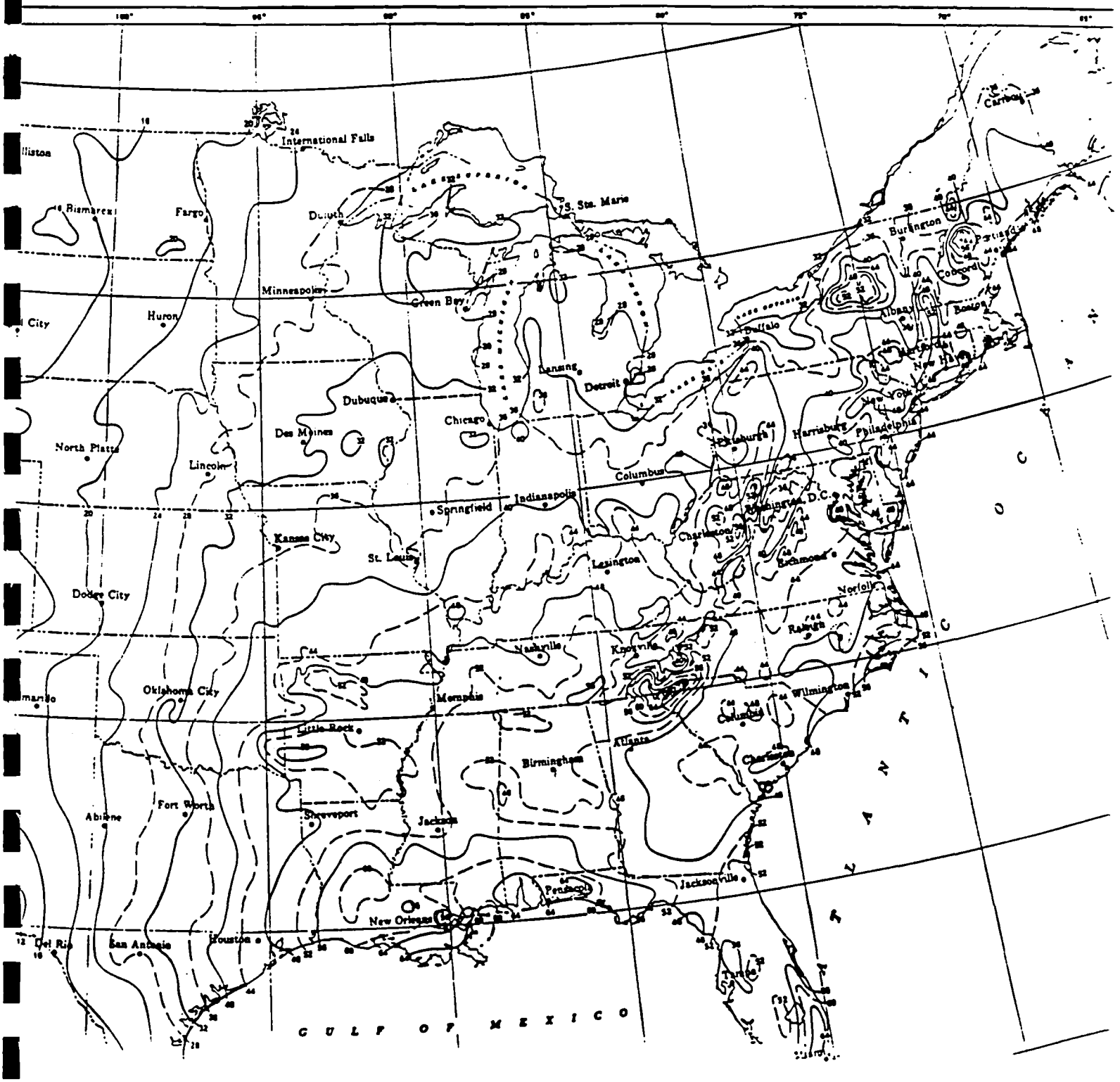
Reference 10



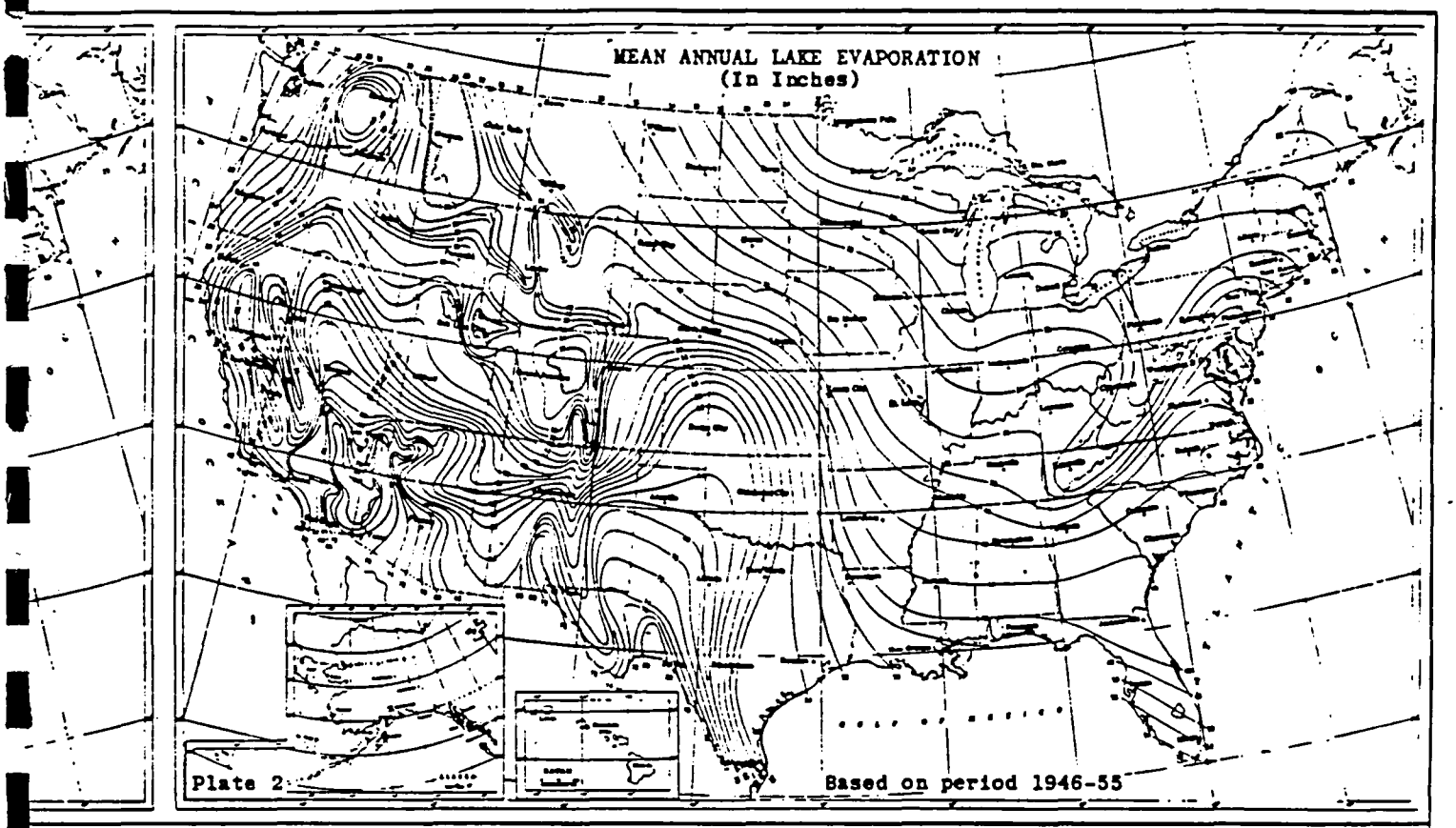
CLIMATIC ATLAS OF THE UNITED STATES

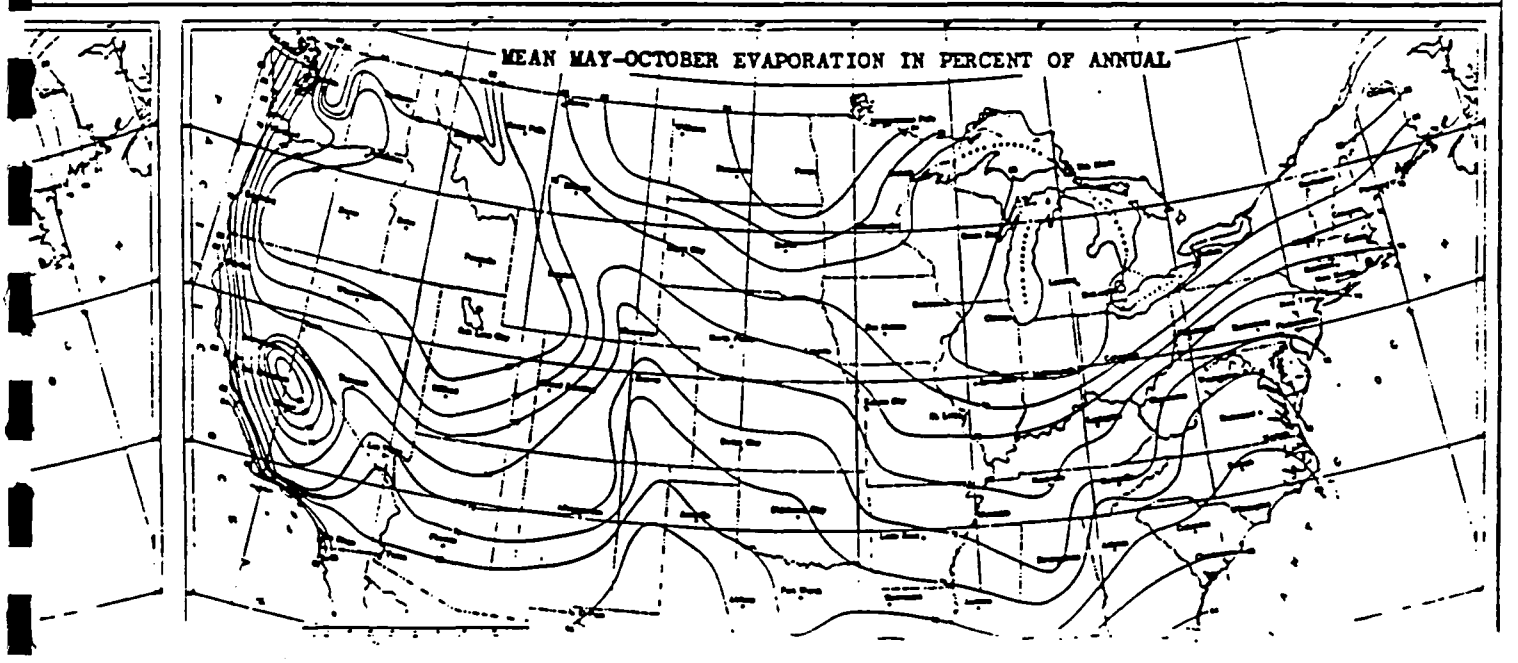
:ronmental Science Services Administration . Environmental

L ANNUAL TOTAL PRECIPITATION (Inches)



N AND LAKE EVAPORATION

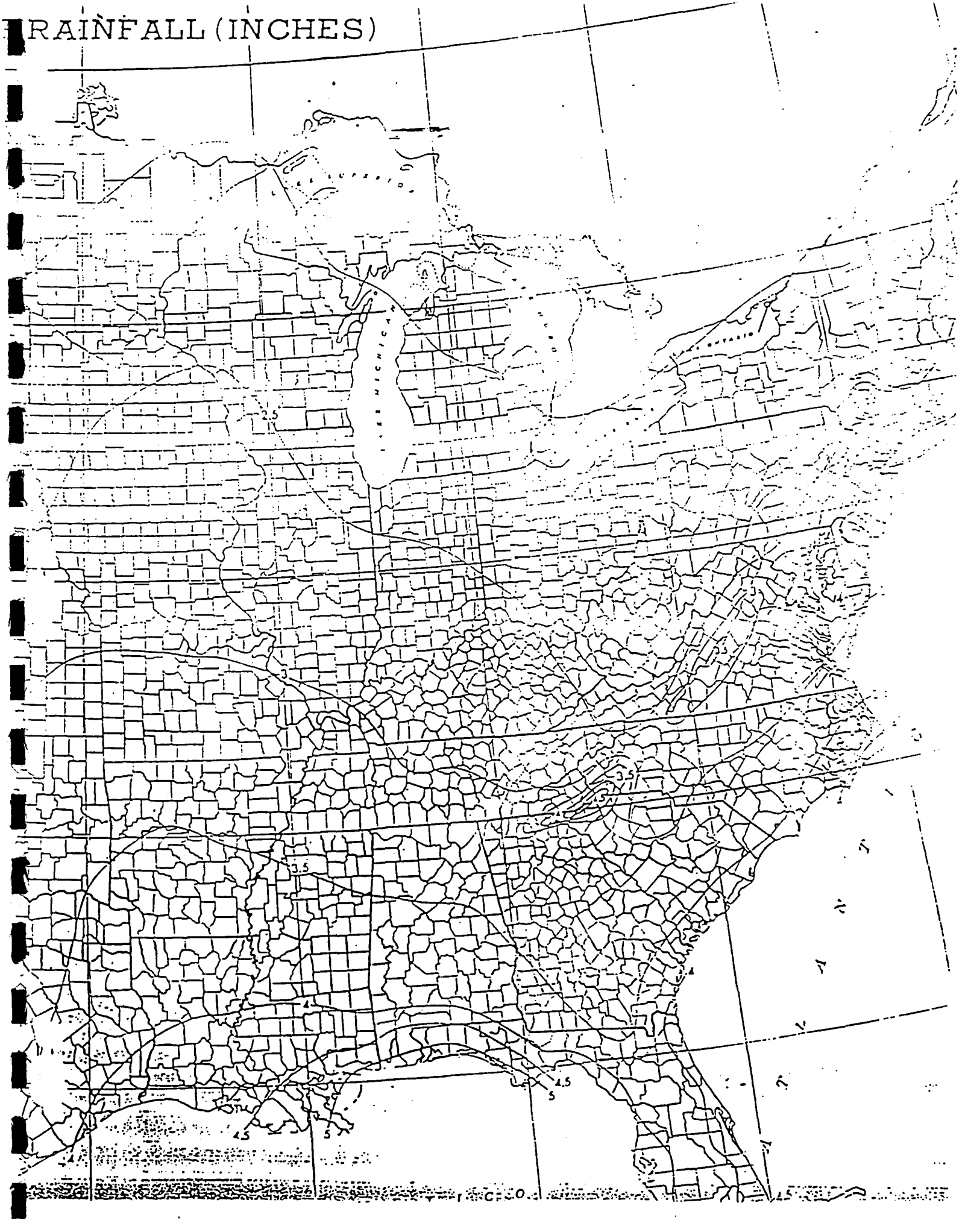


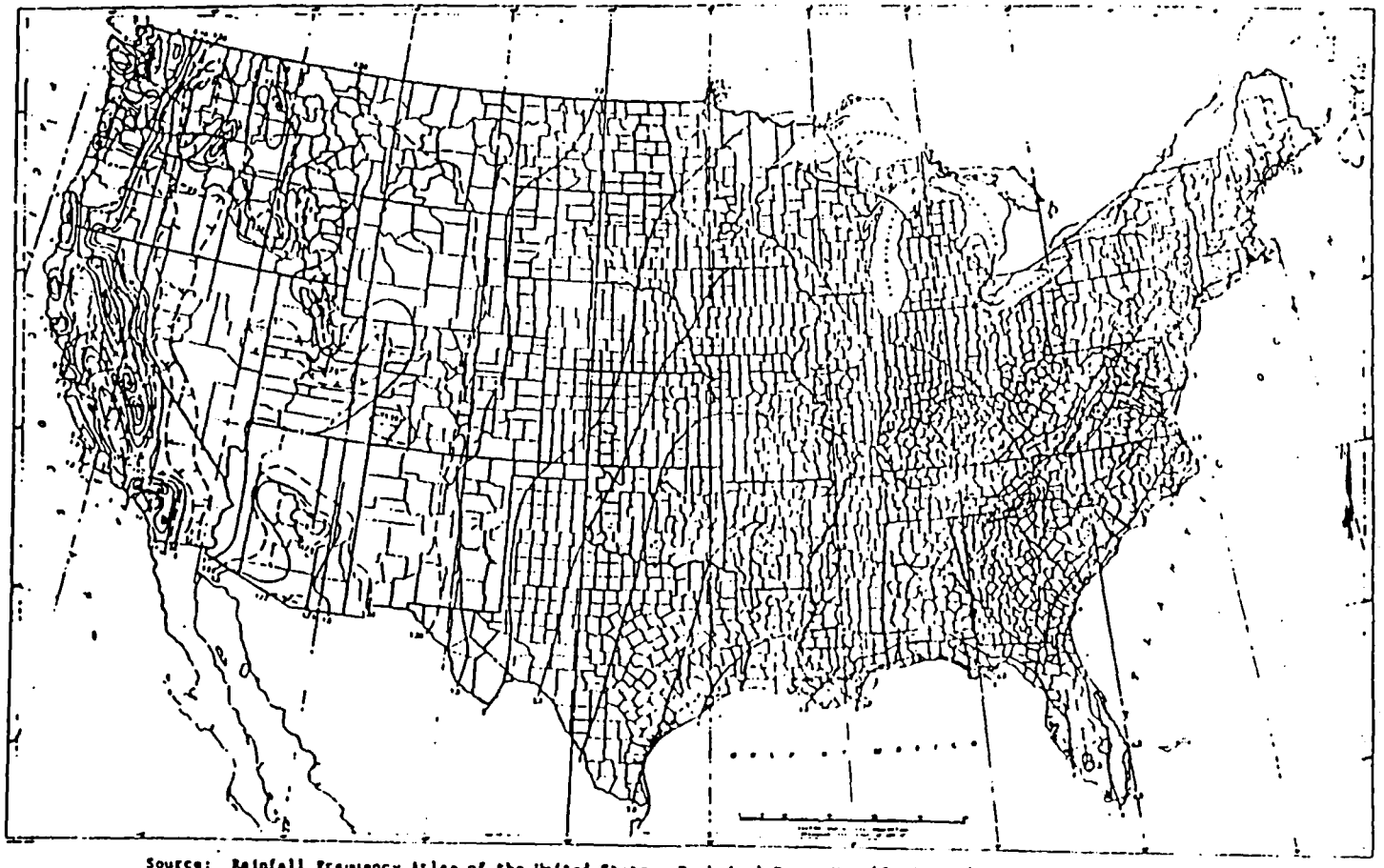


REFERENCE 11

Rainfall Frequency Atlas of the United States, Technical Paper No. 40, US Department of Commerce, US Government Printing Office, Washington, DC, 1963.

RAINFALL (INCHES)





Source: Rainfall Frequency Atlas of the United States, Technical Paper No. 40, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., 1963.

FIGURE 8
1-YEAR 24-HOUR RAINFALL
(INCHES)

REFERENCE 12

Reference 12

NORTH CAROLINA

DEPARTMENT OF WATER RESOURCES

Harry E. Brown, *Director*

DIVISION OF GROUND WATER

Harry M. Peek, *Chief*

GROUND-WATER BULLETIN NUMBER 2

GEOLOGY AND GROUND WATER IN THE GOLDSBORO AREA, NORTH CAROLINA

By

RICHARD D. PUSEY

Geologist, U. S. Geological Survey

PREPARED COOPERATIVELY BY THE GEOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF THE INTERIOR

RALEIGH

1960

try and the practice of irrigation have resulted in increased demands for water.

Climate

The U. S. Weather Bureau maintains 6 stations in the Goldsboro area. The average yearly temperature in the area is 62°F. The average monthly temperatures recorded at Goldsboro for the 60-year period 1897-1956 are given in figure 2. The temperatures recorded at 5 other stations in the area approximate those at Goldsboro and cover a period of 60 years from 1897 to 1957.

Precipitation graphs (fig. 2) show the long-term (60-year) monthly precipitation averages for Goldsboro and Smithfield. The graphs show that the average monthly precipitation during the period of the records is quite similar at both stations, even though the high and low averages vary somewhat. The average annual precipitation is approximately 48 inches at both stations. The precipitation is highest in July and lowest in December or January.

Physiography and Drainage

The area investigated lies in two major physiographic provinces. The northern half of Johnston County is in the Piedmont province, whereas the remainder of the area is in the Coastal Plain province. Local relief in the Piedmont province in the area ranges from less than 50 feet to as much as 200 feet and the elevation ranges from 150 to 400 feet above sea level. Relief in the Coastal Plain section of the area ranges from less than 20 feet to 100 feet and the elevation ranges from 70 to about 150 feet above sea level. The relief is greatest where the larger streams have cut down through post-Miocene terraces and exposed underlying formations of Cretaceous age, as in southern Wayne County and parts of Sampson County.

The area is drained by streams flowing southeastward. Tributary stream valleys have a parallel alignment except where topographic influence of terraces affect their courses. In southern Wayne County, Eocene sediments deposited in ancient stream valleys are more resistant to erosion than surrounding Cretaceous sediments and have influenced the drainage pattern by causing a deflection of the stream channels away from the more resistent sediments. The streams in the Piedmont province generally are incised in narrow valleys about 150 feet deep, whereas in the Coastal Plain province the larger streams tend to meander and the stream valleys are wider and

of kyanite gneiss and hornblende gneiss occur locally in the mica gneiss.

In the southern part of the county the Tuscaloosa formation crops out along the fall line as a feather edge that extends in an east-west direction. The formation dips toward the southeast and, locally attains a thickness of about 150 feet where it overlies depressions in the crystalline basement rock. Unconformably overlying the Tuscaloosa formation are sediments of the Black Creek formation. This formation, generally less than 40 feet thick, is composed of black micaceous clay containing lignitized wood fragments. Locally, marcasite and pyrite occur as concretions or as a replacement of the wood.

A thin blanket of surficial sand, probably of post-Miocene age mantles the Cretaceous sediments throughout much of the county and the crystalline rocks along the fall zone. These surficial deposits do not attain a thickness of more than 30 feet and are absent in some areas.

Ground water.-- Except for public supply of Smithfield, all public and domestic water supplies in Johnston County are obtained from wells. Most domestic wells are dug or bored, whereas municipal wells are drilled.

In the Piedmont, dug and bored wells generally less than 40 feet deep obtain water from weathered crystalline rock or surficial sand. These wells yield 2 to 15 gpm. Drilled wells obtain water from granite, mica gneiss, schist, and slate. The wells in the granite are less than 80 feet deep, and their average yield is less than 20 gpm. Wells in the mica gneiss average about 125 feet in depth and have average yields of 20 to 25 gpm. Wells in the schist and slate are comparable in depth to wells in the mica gneiss, and their average yield is 30 to 35 gpm.

Water from the granite, mica gneiss, and schist is suitable for most uses. Water from the slate is generally high in iron content and may be corrosive.

In the Coastal Plain, domestic wells obtain water from the Tuscaloosa and Black Creek formations and surficial sands. These domestic wells range in depth from 10 to 175 feet and in yield from 10 to 90 gpm. The quality of the water from the Coastal Plain deposits in the county is variable but generally suitable for most uses except that objectionable quantities of iron occur in some places.

of the Tuscaloosa, which is overlain by surficial sand. The static water level was 40 feet below the land surface in both wells when they were drilled in 1957. The deeper well yields 60 gpm, whereas the shallow well yields 40 gpm. The water from both wells is very soft, high in iron content, and corrosive to metals.

Storage is provided by an elevated tank which has a capacity of 100,000 gallons and feeds directly into the water main. There are 360 service connections in Four Oaks and total usage averages 50,000 gpd. The water system has a capacity of 75,000 gpd.

Kenly

Kenly has 3 wells, 2 are 100 feet deep, and the other is 200 feet deep. The wells are cased to slate, which is reached at a depth of about 40 feet. The total yield of these wells is 360 gpm. The water is somewhat high in iron content but is not treated. There are no industrial users. There is an elevated tank having a capacity of 100,000 gallons. There are 400 service connections in Kenly and the total usage averages 100,000 gpd.

Pine Level

Pine Level has one well 200 feet deep, which was finished in slate and yields 100 gpm. Storage facilities include a settling tank having a capacity of 55,000 gallons and an elevated storage tank having a capacity of 75,000 gallons. There are 205 service connections in Pine Level and the total usage averages 20,000 to 30,000 gpd.

Princeton

Princeton has two drilled wells 237 and 145 feet deep, cased to 58 and 50 feet, respectively. The wells were drilled into slate and have yields of 80 and 70 gpm respectively at a drawdown of 20 feet. The water is slightly high in iron content and is moderately hard. Storage is provided by an elevated tank having a capacity of 75,000 gallons. There are 325 service connections in Princeton and the total usage averages 40,000 gpd.

Selma

Selma has four municipal wells having an average depth of 290 feet. The wells penetrate slate and are cased to depths of 21 to 117 feet. Each of the wells yields 300 gpm, and they are used one

REFERENCE 13

SOIL CORRELATION OF
JOHNSTON COUNTY, NORTH CAROLINA

Field symbols	Field mapping unit name	Publication symbol	Approved map unit name
544	Altavista fine sandy loam, 0 to 2 percent slopes	AaA	Altavista fine sandy loam, 0 to 2 percent slopes, occasionally flooded
39B,38B,39B	Appling-Marlboro complex, 1 to 6 percent slopes	AmB	Appling-Marlboro complex, 1 to 6 percent slopes
46	Augusta sandy loam, 0 to 2 percent slopes	AsA	Augusta sandy loam, 0 to 2 percent slopes, occasionally flooded
371B	Autryville sand, 0 to 2 percent slopes	AuA	Autryville sand, 0 to 2 percent slopes
87	Bibb sandy loam, frequently flooded	Bb	Bibb sandy loam, frequently flooded
730B	Blanton sand, 0 to 3 percent slopes	BnA	Blanton sand, 0 to 3 percent slopes
576B	Bonneau sand, 0 to 3 percent slopes	BoA	Bonneau sand, 0 to 3 percent slopes
31B,33B, 205B,25B3	Cecil loam, 1 to 6 percent slopes	CeB	Cecil loam, 2 to 6 percent slopes
31C, 25C	Cecil loam, 6 to 10 percent slopes	CeC	Cecil loam, 6 to 10 percent slopes
13	Chewacla loam, frequently flooded	Ch	Chewacla loam, frequently flooded
354B	Cowarts loamy sand, 2 to 8 percent slopes	CoB	Cowarts loamy sand, 2 to 6 percent slopes
365C,376C, 359C,377C	Cowarts loamy sand, 6 to 10 percent slopes	CoC	Cowarts loamy sand, 6 to 10 percent slopes
541, 424, 546	Dogue fine sandy loam, 0 to 2 percent slopes	DoA	Dogue fine sandy loam, 0 to 2 percent slopes

JOHNSTON COUNTY, NORTH CAROLINA --Continued

Field symbols	Field mapping unit name	Publication symbol	Approved map unit name
376A,359A	Faceville sandy loam, 0 to 2 percent slopes	FaA	Faceville sandy loam, 0 to 2 percent slopes
376B,359B	Faceville sandy loam, 2 to 6 percent slopes	FaB	Faceville sandy loam, 2 to 6 percent slopes
392A	Fuquay sand, 0 to 3 percent slopes	FuA	Fuquay sand, 0 to 3 percent slopes
558B ~~588B~~	Gilead sandy loam, 2 to 8 percent slopes	GeB	Gilead sandy loam, 2 to 8 percent slopes
558C,558D	Gilead sandy loam, 8 to 15 percent slopes	GeD	Gilead sandy loam, 8 to 15 percent slopes
410	Goldsboro sandy loam, 0 to 2 percent slopes	GoA	Goldsboro sandy loam, 0 to 2 percent slopes
829,847	Grantham silt loam	Gr	Grantham silt loam
78B	Lakeland sand, 0 to 6 percent slopes	LaB	Lakeland sand, 0 to 6 percent slopes
88	Leaf silt loam	Le	Leaf silt loam
417	Lynchburg sandy loam	Ly	Lynchburg sandy loam
377A	Marlboro sandy loam, 0 to 2 percent slopes	MaA	Marlboro sandy loam, 0 to 2 percent slopes
377B	Marlboro sandy loam, 2 to 8 percent slopes	MaB	Marlboro sandy loam, 2 to 8 percent slopes
30B,37B	Marlboro-Cecil complex, 2 to 8 percent slopes	McB	Marlboro-Cecil complex, 2 to 8 percent slopes
427	Nahunta silt loam	Na	Nahunta silt loam

Field symbols	Field mapping unit name	Publication symbol	Approved map unit name
378B	Nankin fine sandy loam, 2 to 6 percent slopes	NkB	Nankin fine sandy loam, 2 to 6 percent slopes
212B	Nason silt loam, 2 to 8 percent slopes	NnB	Nason silt loam, 2 to 8 percent slopes
212C,205C	Nason silt loam, 8 to 15 percent slopes	NnD	Nason silt loam, 8 to 15 percent slopes
212D,212E	Nason silt loam, 15 to 25 percent slopes	NnE	Nason silt loam, 15 to 25 percent slopes
365A	Norfolk loamy sand, 0 to 2 percent slopes	NoA	Norfolk loamy sand, 0 to 2 percent slopes
365B	Norfolk loamy sand, 2 to 6 percent slopes	NoB	Norfolk loamy sand, 2 to 6 percent slopes
300	Norfolk-Urban land complex, 0 to 3 percent slopes	NuA	Norfolk-Urban land complex, 0 to 3 percent slopes
324D1, 324C	Pacolet loam, 10 to 15 percent slopes	PaD	Pacolet loam, 10 to 15 percent slopes
324E1	Pacolet loam, 15 to 25 percent slopes	PaE	Pacolet loam, 15 to 25 percent slopes
836	Pantego loam	Pn	Pantego loam occasionally flooded
830,881	Rains sandy loam	Ra	Rains sandy loam
800	Rains-Urban land complex, 0 to 2 percent slopes	RbA	Rains-Urban land complex, 0 to 2 percent slopes
135E,135D 138D,61E1	Rion sandy loam, 15 to 40 percent slopes	RnF	Rion sandy loam, 15 to 40 percent slopes
90	Roanoke loam	Ro	Roanoke loam, occasionally flooded
352A,540A 540B,351A	State sandy loam, 0 to 3 percent slopes	StA	State sandy loam, 0 to 3 percent slopes occasionally flooded
79,330	Tarboro loamy sand	Ta	Tarboro loamy sand, rarely flooded

Field symbols	Field mapping unit name	Publication symbol	Approved map unit name
827	Toisnot loam	Tn	Toisnot loam
814	Tomotley sandy loam	To	Tomotley sandy loam, rarely flooded
575B	Uchee coarse sand, 2 to 6 percent slopes	UcB	Uchee loamy coarse sand, 2 to 6 percent slopes
575C,370C 370D	Uchee loamy sand, 6 to 12 percent slopes	UcC	Uchee loamy coarse sand, 6 to 12 percent slopes
6	Udorthents, loamy	Ud 1/	Udorthents, loamy
136B,57B	Vance coarse sandy loam, 2 to 8 percent slopes	VaB	Vance coarse sandy loam, 2 to 8 percent slopes
393A,394A	Varina loamy sand, 0 to 2 percent slopes	VrA	Varina loamy sand, 0 to 2 percent slopes
393B,394B	Varina loamy sand, 2 to 6 percent slopes	VrB	Varina loamy sand, 2 to 6 percent slopes
370B	Wagram loamy sand, 0 to 6 percent slopes	WaB	Wagram loamy sand, 0 to 6 percent slopes
89	Wahee loam	Wh	Wahee loam, occasionally flooded
36B	Wedowee sandy loam, 2 to 8 percent slopes	WoB	Wedowee sandy loam, 2 to 8 percent slopes
135C,36C, 138C	Wedowee sandy loam, 8 to 15 percent slopes	WoD	Wedowee sandy loam, 8 to 15 percent slopes
43	Wehadkee loam, frequently flooded	Wt	Wehadkee loam, frequently flooded
44	Wehadkee-Chastain association, frequently flooded	Ww	Wehadkee-Chastain association, frequently flooded

1/ Each delineated area is identified by the symbol Ud and further identified with one of four labels on the map. These labels are Borrow Pit or BP, Landfill or LF, Cut and Fill or C&F, and Airfield.

NC0041

SOIL INTERPRETATIONS RECORD

MLRA(S): 133A, 153A, 153B
REV. WLB,BJW, 2-88
AQUIC PALEUDULTS, FINE-LOAMY, SILICEOUS, THERMIC

GOLDSBORO SERIES

THE GOLDSBORO SERIES CONSISTS OF NEARLY LEVEL TO GENTLY SLOPING, MODERATELY WELL DRAINED SOILS ON COASTAL PLAIN UPLANDS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS GRAYISH BROWN LOAMY SAND ABOUT 8 INCHES THICK. THE SUBSURFACE LAYER IS PALE BROWN LOAMY SAND 4 INCHES THICK. THE SUBSOIL EXTENDS TO 76 INCHES. IT IS BROWNISH YELLOW SANDY LOAM IN THE UPPER PART; YELLOWISH BROWN, PALE BROWN AND GRAY SANDY CLAY LOAM IN THE MIDDLE PART; AND GRAY SANDY LOAM AND SANDY CLAY LOAM IN THE LOWER PART. SLOPES RANGE FROM 0 TO 8 PERCENT.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT 3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-15	SL, FSL	SM, SM-SC, SC	A-2, A-4, A-6	0	95-100	95-100	50-100	15-45	25	NP-14
0-15	LS, LFS	SM	A-2	0	95-100	95-100	50-95	13-30	20	NP
15-45	SCL, SL	SM-SC, SC, CL-ML, CL	A-2, A-4, A-6	0	98-100	95-100	60-100	25-55	16-37	4-18
45-65	SCL, CL, SC	SC, CL, CL-ML, CH	A-4, A-6, A-7-6	0	95-100	90-100	65-95	36-70	25-55	6-32
65-76	VAR									

DEPTH (IN.)	CLAY (PCT)	MOIST BULK DENSITY (G/CM3)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	EROSION FACTORS K	T	WIND GROUP	ORGANIC MATTER (PCT)	CORROSIVITY STEEL	CONCRETE
0-15	5-15	1.40-1.60	2.0-6.0	0.08-0.12	3.6-6.0	-	LOW	.20	5	-	.5-2	MODERATE	HIGH
0-15	2-8	1.55-1.75	6.0-20.0	0.06-0.11	3.6-5.5	-	LOW	.17	5	-	.5-2		
15-45	18-30	1.30-1.50	0.6-2.0	0.11-0.15	3.6-5.5	-	LOW	.24					
45-65	20-34	1.30-1.40	0.6-2.0	0.11-0.15	3.6-5.5	-	LOW	.24					
65-76													

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (FT)	KIND	MONTHS	CEMENTED PAN DEPTH (IN)	HARDNESS	BEDROCK DEPTH (IN)	HARDNESS	SUBSIDENCE TOTAL (IN)	INIT. (IN)	HYDIC GRP	POTENTIAL FROST ACTION
NONE			2.0-3.0	APPARENT	DEC-APR	-		60		-		B	-

SANITARY FACILITIES (B)

SEPTIC TANK ABSORPTION FIELDS	SEVERE-WETNESS
SEWAGE LAGOON AREAS	SEVERE-WETNESS
SANITARY LANDFILL (TRENCH)	SEVERE-WETNESS
SANITARY LANDFILL (AREA)	SEVERE-WETNESS
DAILY COVER FOR LANDFILL	FAIR-WETNESS

BUILDING SITE DEVELOPMENT (B)

SHALLOW EXCAVATIONS	SEVERE-WETNESS
DWELLINGS WITHOUT BASEMENTS	MODERATE-WETNESS
DWELLINGS WITH BASEMENTS	SEVERE-WETNESS
SMALL COMMERCIAL BUILDINGS	0-4%: MODERATE-WETNESS 4-8%: MODERATE-WETNESS,SLOPE
LOCAL ROADS AND STREETS	MODERATE-WETNESS
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	SLIGHT

CONSTRUCTION MATERIAL (B)

ROADFILL	FAIR-WETNESS
SAND	IMPROBABLE-EXCESS FINES
GRAVEL	IMPROBABLE-EXCESS FINES
TOPSOIL	FAIR-TOO CLAYEY

WATER MANAGEMENT (B)

POND RESERVOIR AREA	0-3%: MODERATE-SEEPAGE 3-8%: MODERATE-SEEPAGE,SLOPE
EMBANKMENTS DIKES AND LEVEES	MODERATE-PIPING,WETNESS
EXCAVATED PONDS AQUIFER FED	SL,FSL: MODERATE-SLOW REFILL,DEEP TO WATER LS,LFS: MODERATE-SLOW REFILL,CUTBANKS CAVE, DEEP TO WATER
DRAINAGE	0-3%: FAVORABLE 3+%: SLOPE
IRRIGATION	0-3% SL,FSL: WETNESS 0-3% LS,LFS: WETNESS,FAST INTAKE 3+% SL,FSL: SLOPE,WETNESS 3+% LS,LFS: SLOPE,WETNESS,FAST INTAKE
TERRACES AND DIVERSIONS	WETNESS
GRASSED WATERWAYS	FAVORABLE

REGIONAL INTERPRETATIONS

RECREATIONAL DEVELOPMENT (B)

CAMP AREAS	MODERATE-WETNESS	PLAYGROUNDS	0-2%: MODERATE-WETNESS 2-6%: MODERATE-SLOPE,WETNESS 6-10%: SEVERE-SLOPE
PICNIC AREAS	MODERATE-WETNESS	PATHS AND TRAILS	SLIGHT

CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY	COTTON LINT (LBS)		TOBACCO (LBS)		CORN (BU)		SOYBEANS (BU)		WHEAT (BU)		PEANUTS (LBS)		PASTURE (AUM)	
	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.
0-2%	2W		700		3000		125		42		60		3600		11.5	
2-6%	2E		700		2900		115		38		60		3400		11.5	
6-8%	3E		550		2600		90		28		50		8000		10.5	

WOODLAND SUITABILITY (C)

CLASS-DETERMINING PHASE	ORDI SYMI	MANAGEMENT PROBLEMS: EROS HAZARD	EQUIP. LIMIT	SEEDL. MORT	WINDTH HAZARD	PLANT COMPET	POTENTIAL PRODUCTIVITY: COMMON TREES	SITE INDX	PROD CLAS	TREES TO PLANT
ALL	9A	SLIGHT	SLIGHT	SLIGHT	SLIGHT	MODER.	LOBLOLLY PINE	90	9	LOBLOLLY PINE
							LONGLEAF PINE	73	6	
							SLASH PINE	94	12	
							SWEETGUM			
							SOUTHERN RED OAK			
							WHITE OAK			
							WATER OAK			
							YELLOW POPLAR			

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
	NONE							

WILDLIFE HABITAT SUITABILITY (D)

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
0-2%	GOOD	GOOD	GOOD	GOOD	GOOD	-	POOR	POOR	GOOD	GOOD	POOR	-
2-6%	GOOD	GOOD	GOOD	GOOD	GOOD	-	POOR	V. POOR	GOOD	GOOD	V. POOR	-
6-8%	FAIR	GOOD	GOOD	GOOD	GOOD	-	V. POOR	V. POOR	GOOD	GOOD	POOR	-

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE				
AMERICAN HOLLY	ILOP					
BLUEBERRY	VACCI					
FLOWERING DOGWOOD	COFL2					
GREENBRIER	SMILA2					
PERSIMMON	DIVIS					
REDBAY	PEEO					
SOUTHERN BAYBERRY	MYCE					
INKBERRY	ILCL					
HONEYSUCKLE	LONIC					
POISON IVY	TORA2					
SUMMERSWEET CLETHRA	CLAL3					
POTENTIAL PRODUCTION (LBS./AC. DRY WT):						
FAVORABLE YEARS						
NORMAL YEARS						
UNFAVORABLE YEARS						

FOOTNOTES

A ESTIMATES OF ENGINEERING PROPERTIES BASED ON 2 PEDONS FROM DUPLIN AND WILSON COUNTIES, NC.
B RATINGS BASED ON NSH, PART 603, 7-83.
C WOODLAND RATINGS BASED ON NATIONAL FORESTRY MANUAL, SEP. 1980.
D WILDLIFE RATINGS BASED ON SOILS MEMORANDUM-74, JAN. 1972.

NC0037

SOIL INTERPRETATIONS RECORD

MLRA(S): 133A, 153A, 149A
REV. HS,RJW, 4-88
TYPIC KANDIUDULTS, FINE-LOAMY, SILICEOUS, THERMIC

NORFOLK SERIES

THE NORFOLK SERIES CONSISTS OF WELL DRAINED NEARLY LEVEL TO SLOPING SOILS ON UPLANDS IN THE COASTAL PLAIN. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS GRAYISH BROWN LOAMY SAND ABOUT 9 INCHES THICK. THE SUBSURFACE LAYER IS LIGHT YELLOWISH BROWN LOAMY SAND, 5 INCHES THICK. THE SUBSOIL EXTENDS TO A DEPTH OF 82 INCHES. IT IS YELLOWISH BROWN SANDY LOAM IN THE UPPER PART, YELLOWISH BROWN SANDY CLAY LOAM IN THE MIDDLE PART AND MOTTLED BROWNISH YELLOW, STRONG BROWN, YELLOWISH RED SANDY CLAY LOAM IN THE LOWER PART. SLOPES ARE 0 TO 10 PERCENT.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT 3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-14	SL, FSL	SM, SM-SC, SC	A-2	0	95-100	95-100	50-91	15-33	25	NP-14
0-14	LS, LFS	SM	A-2	0	95-100	92-100	50-95	13-30	20	NP
14-38	SL, SCL, CL	SC, SM-SC, CL, CL-ML	A-2, A-4, A-6	0	95-100	91-100	70-96	30-63	20-38	4-15
38-70	SCL, CL, SC	SC, SM-SC, CL, CL-ML	A-4, A-6, A-7-6	0	100	98-100	65-98	36-72	20-52	4-23
70-99	VAR									

DEPTH (IN.)	CLAY (PCT)	MOIST BULK DENSITY (G/CM3)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	EROSION FACTORS K	T	WIND EROD. GROUP	ORGANIC MATTER (PCT)	CORROSIVITY STEEL	CONCRETE
0-14	5-18	1.45-1.65	2.0-6.0	0.10-0.15	3.6-6.0	-	LOW	.20	5	-	.5-2	MODERATE	HIGH
0-14	2-8	1.55-1.70	6.0-20	0.06-0.11	3.6-6.0	-	LOW	.17	5	-	.5-2		
14-38	18-35	1.30-1.65	0.6-2.0	0.10-0.18	3.6-5.5	-	LOW	.24					
38-70	20-43	1.20-1.65	0.6-2.0	0.12-0.18	3.6-5.5	-	LOW	.24					
70-99													

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (FT)	KIND	MONTHS	CEMENTED PAN DEPTH (IN)	HARDNESS	BEDROCK DEPTH (IN)	HARDNESS	SUBSIDENCE INIT. (IN)	TOTAL (IN)	HYD GRP	POTENT'L FROST ACTION
NONE			4.0-6.0	APPARENT	JAN-MAR	-		60		-		B	-

SANITARY FACILITIES (B)

SEPTIC TANK ABSORPTION FIELDS	MODERATE-WETNESS,PERCS SLOWLY
SEWAGE LAGOON AREAS	0-7%: MODERATE-SEEPAGE,WETNESS 7+%: SEVERE-SLOPE
SANITARY LANDFILL (TRENCH)	SEVERE-WETNESS
SANITARY LANDFILL (AREA)	0-8%: SLIGHT 8-10%: MODERATE-SLOPE
DAILY COVER FOR LANDFILL	0-8%: GOOD 8-10%: FAIR-SLOPE

BUILDING SITE DEVELOPMENT (B)

SHALLOW EXCAVATIONS	0-8%: MODERATE-WETNESS 8-10%: MODERATE-WETNESS,SLOPE
DWELLINGS WITHOUT BASEMENTS	0-8%: SLIGHT 8-10%: MODERATE-SLOPE
DWELLINGS WITH BASEMENTS	0-8%: MODERATE-WETNESS 8-10%: MODERATE-WETNESS,SLOPE
SMALL COMMERCIAL BUILDINGS	0-4%: SLIGHT 4-8%: MODERATE-SLOPE 8+%: SEVERE-SLOPE
LOCAL ROADS AND STREETS	0-8%: SLIGHT 8-10%: MODERATE-SLOPE
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	0-8%: SLIGHT 8-10%: MODERATE-SLOPE

CONSTRUCTION MATERIAL (B)

ROADFILL	GOOD
SAND	IMPROBABLE-EXCESS FINES
GRAVEL	IMPROBABLE-EXCESS FINES
TOPSOIL	FAIR-TOO CLAYEY

WATER MANAGEMENT (B)

POND RESERVOIR AREA	0-3%: MODERATE-SEEPAGE 3-8%: MODERATE-SEEPAGE,SLOPE 8+%: SEVERE-SLOPE
EMBANKMENTS DIKES AND LEVEES	SEVERE-PIPING
EXCAVATED PONDS AQUIFER FED	MODERATE-DEEP TO WATER,SLOW REFILL
DRAINAGE	DEEP TO WATER
IRRIGATION	0-3% SL,FSL: FAVORABLE 3+% SL,FSL: SLOPE 0-3% LS,LFS: FAST INTAKE 3+% LS,LFS: SLOPE,FAST INTAKE
TERRACES AND DIVERSIONS	0-8%: FAVORABLE 8+%: SLOPE
GRASSED WATERWAYS	0-8%: FAVORABLE 8+%: SLOPE

REGIONAL INTERPRETATIONS

RECREATIONAL DEVELOPMENT (B)

CAMP AREAS	0-8%: SLIGHT 8-10%: MODERATE-SLOPE	PLAYGROUNDS	0-2%: SLIGHT 2-6%: MODERATE-SLOPE 6+%: SEVERE-SLOPE
PICNIC AREAS	0-8%: SLIGHT 8-10%: MODERATE-SLOPE	PATHS AND TRAILS	SLIGHT

CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPA-BILITY		COTTON LINT (LBS)		TOBACCO (LBS)		CORN (BU)		SOYBEANS (BU)		WHEAT (BU)		PEANUTS (LBS)		PASTURE (AUM)	
	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
0-2%	1		700		3000		110		40		60		4000		10.5	
2-6%	2E		650		2900		100		35		55		3700		10.0	
6-10%	3E		600		2700		90		30		50		3300		9.5	

WOODLAND SUITABILITY (C)

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROS'N HAZARD	EQUIP. LIMIT	SEEDL. MORT'Y	WINDTH HAZARD	PLANT COMPET	POTENTIAL PRODUCTIVITY: COMMON TREES	SITE INDX	PROD CLAS	TREES TO PLANT
ALL	8A	SLIGHT	SLIGHT	SLIGHT	SLIGHT	MODER.	LOBLOLLY PINE	84	8	LOBLOLLY PINE
							LONGLEAF PINE	77	7	
							SLASH PINE	78	10	
							SOUTHERN RED OAK			
							WHITE OAK			
							YELLOW POPLAR			
							BLACKGUM			
							HICKORY			

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
	NONE							

WILDLIFE HABITAT SUITABILITY (D)

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
0-6%	GOOD	GOOD	GOOD	GOOD	GOOD	-	POOR	V. POOR	GOOD	GOOD	V. POOR	-
6-10%	FAIR	GOOD	GOOD	GOOD	GOOD	-	V. POOR	V. POOR	GOOD	GOOD	V. POOR	-

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE				
AMERICAN HOLLY	ILOP					
FLOWERING DOGWOOD	COFL2					
PERSIMMON	DIVI5					
BLUERIDGE BLUEBERRY	VAVA					
GREENBRIER	SMILA2					
POTENTIAL PRODUCTION (LBS./AC. DRY WT):						
FAVORABLE YEARS						
NORMAL YEARS						
UNFAVORABLE YEARS						

FOOTNOTES

A ESTIMATES OF ENGINEERING PROPERTIES BASED ON 2 PEDONS FROM ROBESON AND WAYNE COUNTIES, ADDITIONAL UNIFIED ENTIRES
A FOR LINES#4 ARE SM, ML AND MH.
B RATINGS BASED ON NSH, 7/83.
C WOODLAND RATINGS BASED ON NATIONAL FORESTRY MANUAL, SEPT. 1980
D WILDLIFE RATTINGS BASED ON SOILS MEMORANDUM-74, JAN 1972.

VA0031

SOIL INTERPRETATIONS RECORD

MLRA(S): 133A, 136, 153A, 153B, 153C
REV. DDR,MHC, 2-88
TYPIC HAPLUDULTS, FINE-LOAMY, MIXED, THERMIC

STATE SERIES

SOILS OF THE STATE SERIES ARE VERY DEEP AND WELL DRAINED. THEY ARE ON TERRACES AND FORMED IN STRATIFIED FLUVIAL SEDIMENTS. TYPICALLY, THESE SOILS HAVE A DARK BROWN SILT LOAM SURFACE LAYER 10 INCHES THICK. THE SUBSOIL FROM 10 TO 15 INCHES IS BROWN LOAM, FROM 15 TO 35 INCHES IS STRONG BROWN LOAM, AND FROM 35 TO 45 INCHES IS BROWN LOAM. THE SUBSTRATUM FROM 45 TO 60 INCHES IS YELLOWISH BROWN, PALE BROWN, AND BROWN FINE SANDY LOAM. SLOPES RANGE FROM 0 TO 6 PERCENT.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT 3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-10	FSL, SL	SM, ML, CL-ML, SM-SC	A-2, A-4	0	95-100	95-100	45-85	25-55	28	NP-7
0-10	SIL, L	SM, SC, ML, CL	A-4, A-6	0	95-100	95-100	65-95	45-85	28	NP-15
0-10	LS, LFS	SM, SM-SC	A-2, A-1	0	95-100	95-100	45-75	15-30	18	NP-6
10-45	L, CL, SCL	CL, SC	A-4, A-6	0	95-100	95-100	75-100	35-80	24-40	8-22
45-60	SR-S-FSL	SM, SM-SC, SP-SM	A-1, A-2, A-3, A-4	0	85-100	60-100	40-90	5-50	25	NP-7

DEPTH (IN.)	CLAY (PCT)	MOIST BULK DENSITY (G/CM3)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	EROSION FACTORS K	T	WIND EROD. GROUP	ORGANIC MATTER (PCT)	CORROSIVITY STEEL	CORROSIVITY CONCRETE
0-10	5-15	1.25-1.40	0.6-6.0	0.08-0.15	3.6-5.5	-	LOW	.28	5	3	2	MODERATE	HIGH
0-10	10-18	1.20-1.35	0.6-2.0	0.12-0.17	3.6-5.5	-	LOW	.28	5	3	2		
0-10	2-8	1.35-1.45	2.0-6.0	0.06-0.09	3.6-5.5	-	LOW	.28	5	2	1		
10-45	18-34	1.35-1.50	0.6-2.0	0.14-0.19	3.6-5.5	-	LOW	.28					
45-60	2-15	1.35-1.50	2.0	0.02-0.10	3.6-6.5	-	LOW	.17					

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (FT)	KIND	MONTHS	CEMENTED PAN DEPTH (IN)	HARDNESS	BEDROCK DEPTH (IN)	HARDNESS	SUBSIDENCE INIT. (IN)	TOTAL (IN)	HYDR GRP	POTENTIAL FROST ACTION
NONE-OCCASIONAL	BRIEF	DEC-JUN	4.0-6.0	APPARENT	DEC-JUN	-		60		-	-	B	-

SANITARY FACILITIES (B)

SEPTIC TANK ABSORPTION FIELDS	NONE: MODERATE-WETNESS,PERCS SLOWLY RARE: MODERATE-FLOODING,WETNESS,PERCS SLOWLY OCCAS: SEVERE-FLOODING
SEWAGE LAGOON AREAS	NONE,RARE: SEVERE-SEEPAGE OCCAS: SEVERE-SEEPAGE,FLOODING
SANITARY LANDFILL (TRENCH)	NONE,RARE: SEVERE-SEEPAGE,WETNESS OCCAS: SEVERE-FLOODING,SEEPAGE,WETNESS
SANITARY LANDFILL (AREA)	NONE: MODERATE-WETNESS RARE: MODERATE-FLOODING,WETNESS OCCAS: SEVERE-FLOODING
DAILY COVER FOR LANDFILL	FAIR-TOO CLAYEY,THIN LAYER

BUILDING SITE DEVELOPMENT (B)

SHALLOW EXCAVATIONS	SEVERE-CUTBANKS CAVE
DWELLINGS WITHOUT BASEMENTS	NONE: SLIGHT RARE,OCCAS: SEVERE-FLOODING
DWELLINGS WITH BASEMENTS	NONE: MODERATE-WETNESS RARE,OCCAS: SEVERE-FLOODING
SMALL COMMERCIAL BUILDINGS	0-4% NONE: SLIGHT 4-6% NONE: MODERATE-SLOPE RARE,OCCAS: SEVERE-FLOODING
LOCAL ROADS AND STREETS	NONE: MODERATE-LOW STRENGTH RARE: MODERATE-LOW STRENGTH,FLOODING OCCAS: SEVERE-FLOODING
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	NONE,RARE: SLIGHT OCCAS: MODERATE-FLOODING

CONSTRUCTION MATERIAL (B)

ROADFILL	GOOD
SAND	PROBABLE
GRAVEL	IMPROBABLE-TOO SANDY
TOPSOIL	FAIR-TOO CLAYEY

WATER MANAGEMENT (B)

POND RESERVOIR AREA	SEVERE-SEEPAGE
EMBANKMENTS DIKES AND LEVEES	MODERATE-THIN LAYER,PIPING
EXCAVATED PONDS AQUIFER FED	SEVERE-CUTBANKS CAVE
DRAINAGE	DEEP TO WATER
IRRIGATION	0-3% SIL,L,FSL,SL: SOIL BLOWING 3+% SIL,L,FSL,SL: SOIL BLOWING,SLOPE 0-3% LS,LFS: FAST INTAKE,SOIL BLOWING 3+% LS,LFS: FAST INTAKE,SOIL BLOWING,SLOPE
TERRACES AND DIVERSIONS	SOIL BLOWING
GRASSED WATERWAYS	FAVORABLE

REGIONAL INTERPRETATIONS

RECREATIONAL DEVELOPMENT (B)

CAMP AREAS	NONE: SLIGHT RARE,OCCAS: SEVERE-FLOODING	PLAYGROUNDS	0-2% NONE,RARE: SLIGHT 0-2% OCCAS: MODERATE-FLOODING 2-6% NONE,RARE: MODERATE-SLOPE 2-6% OCCAS: MODERATE-SLOPE,FLOODING
PICNIC AREAS	SLIGHT	PATHS AND TRAILS	SLIGHT

CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT) (C)

CLASS-DETERMINING PHASE	CAPABILITY		CORN (BU)		PEANUTS (LBS)		TOBACCO (LBS)		SOYBEANS (BU)		WHEAT (BU)		GRASS-LEGUME HAY (TONS)		TALL FESCUE (AUM)	
	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.	IRR	IRR.
0-2% NONE,RARE	1		130		3300		3000		45		60		5.1		8.5	
0-6% OCCAS	2W		110		3300		2700		35		-		4.6		8.5	
2-6% NONE,RARE	2E		120		3000		2700		40		60		5.1		8.0	

WOODLAND SUITABILITY (D)

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROS HAZARD	EQUIP. LIMIT	SEEDL. MORT	WINDTH HAZARD	PLANT COMPET	POTENTIAL PRODUCTIVITY: COMMON TREES	INDX	CLAS	TREES TO PLANT
ALL	9A	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SEVERE	LOBLOLLY PINE	86	9	LOBLOLLY PINE
							SOUTHERN RED OAK	85	5	BLACK WALNUT
							YELLOW POPLAR	100	8	YELLOW POPLAR
							VIRGINIA PINE	85	9	
							HICKORY			
							AMERICAN BEECH			
							WHITE OAK			

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
	NONE							

WILDLIFE HABITAT SUITABILITY (E)

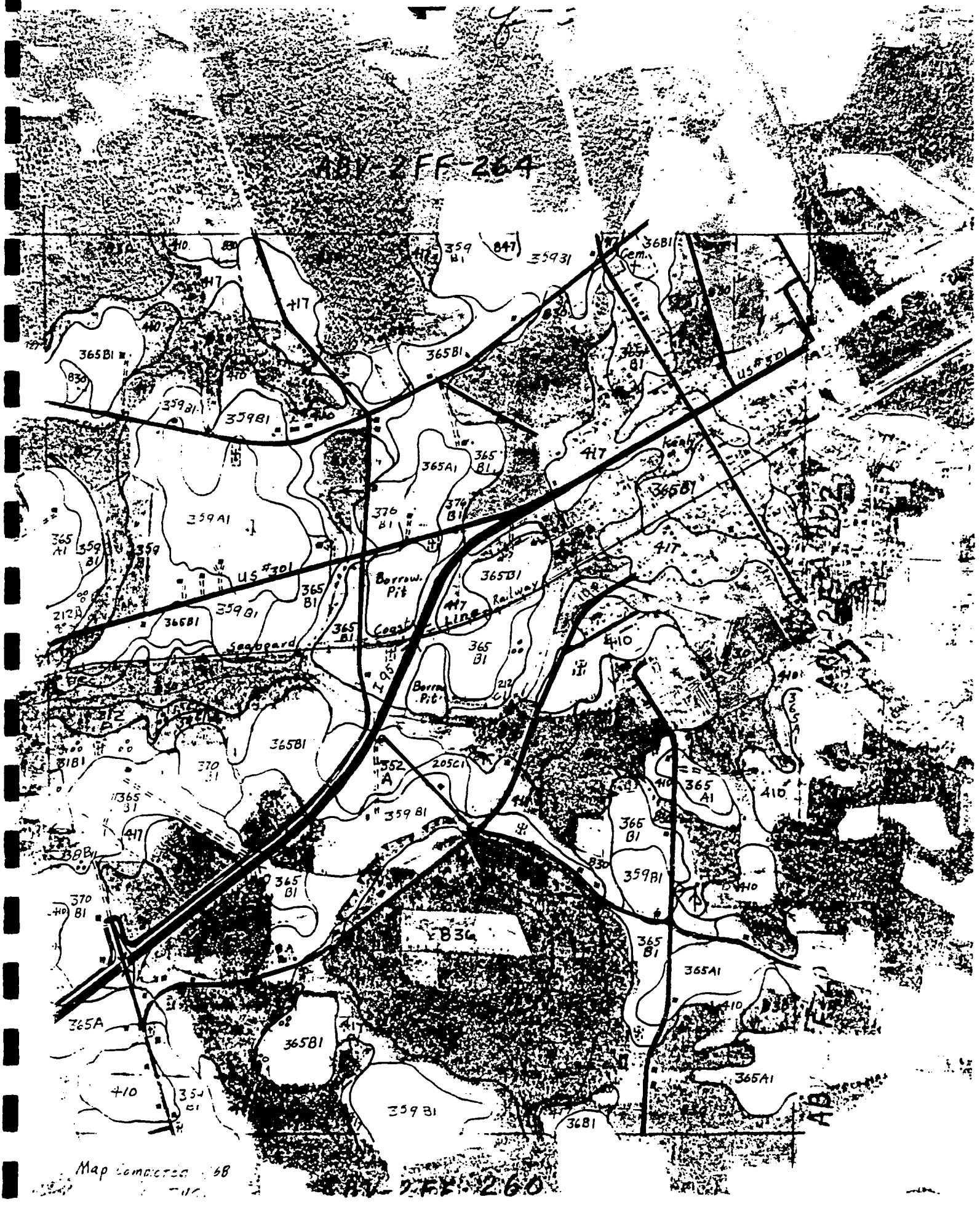
CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	OPENLD WILDLF	POTENTIAL AS HABITAT FOR: WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
SIL,L,FSL,SL	GOOD	GOOD	GOOD	GOOD	GOOD	-	POOR	IV. POOR	GOOD	GOOD	IV. POOR	-
LS,LFS	POOR	FAIR	GOOD	GOOD	GOOD	-	POOR	IV. POOR	FAIR	GOOD	IV. POOR	-

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE				
SOURWOOD	OXAR					
AMERICAN HOLLY	ILOP					
BLUEBERRY	VACCI					
FLOWERING DOGWOOD	COFL2					
GREENBRIER	SMILA2					
SASSAFRAS	SAAL5					
WAXMYRTLE	MYCE					
POTENTIAL PRODUCTION (LBS./AC. DRY WT):						
FAVORABLE YEARS						
NORMAL YEARS						
UNFAVORABLE YEARS						

FOOTNOTES

A ESTIMATES OF ENGINEERING PROPERTIES BASED ON 1 PEDON FROM VIRGINIA AND 1 PEDON FROM NORTH CAROLINA.
B RATINGS BASED ON NSH, PART 603.
C YIELDS BASED ON AREA 3 TECHNICAL COMMITTEE RECOMMENDATION, 1977.
D RATINGS BASED ON NATIONAL FORESTRY MANUAL, SEPT 1980.
E RATINGS BASED ON SOILS MEMO 74 JAN 1972.


US #301
Borrow Pit
Coast Line Railway
Seaboard
Cem.
Map compiled 68

REFERENCE 14

43

"Rite in the Rain"

ALL-WEATHER
LEVEL
Notebook No. 311

F4-2088

F4-9002-43
Union Camp Smithfield Saw
Smithfield, Johnston County, NC
Alvin L. Williams
Project Manager

LOGBOOK REQUIREMENTS
REVISED - NOVEMBER 29, 1988

NOTE: ALL LANGUAGE SHOULD BE FACTUAL AND OBJECTIVE

1. Record on front cover of the Logbook: TDD No., Site Name, Site Location, Project Manager.
2. All entries are made using ink. Draw a single line through errors. Initial and date corrections.
3. Statement of Work Plan, Study Plan, and Safety Plan discussion and distribution to field team with team members' signatures.
4. Record weather conditions and general site information.
5. Sign and date each page. Project Manager is to review and sign off on each logbook daily.
6. Document all calibration and pre-operational checks of equipment. Provide serial numbers of equipment used onsite.
7. Provide reference to Sampling Field Sheets for detailed sampling information.
8. Describe sampling locations in detail and document all changes from project planning documents.
9. Provide a site sketch with sample locations and photo locations.
10. Maintain photo log by completing the stamped information at the end of the logbook.
11. If no site representative is on hand to accept the receipt for samples, an entry to that effect must be placed in the logbook.
12. Record I.D. numbers of COC and receipt for sample forms used. Also record numbers of destroyed documents.
13. Complete SMO information in the space provided.

3-13-90

The purpose of this trip is to conduct field recon activities. No study plan or health and safety plan is required. The equipment location log and the project work plan are located in the FIT 4 files in TDD # F4-9002-43. The undersigned acknowledges that they have read and understand the plans applicable to these field activities.

Alvin L. Williams
Alvin L. Williams

Prince Goins

000002

3-13-90

Sunny, Clear Skies 75°

0900 Arrive at Johnston County Courthouse in Smithfield, NC to review records of Union Camp Smithfield SAW and Squibb, E.R. + Sons.
Purchased copies of Deed of Partial Release.

0940 Went to Chamber of Commerce in Smithfield to obtain map and phone book of Johnston County, NC.

0955 Proceeding onto the area of Union Camp Smithfield SAW.

1002 Arrive at facility which is located approximately 150 foot from intersection of I-95 and Hwy 1007 traveling North.

AHW

3-13-90

The facility is surrounded by a residential community with several houses along Brogden Road within the city limits.
The main entrance has a sign posted with the name Jerry G. Williams + Son, Inc.
There are several buildings and sheds.
The facility is very active with machinery and people walking around. There is a smoke stake emmitting white smoke on site.

There are railroad tracks along the south side of the facility that is active. I can see railcars filled with wood chips and a gas pump while traveling along Brogden Road going Northwest, there are stacks of lumber approximately 100 feet behind the residents along that street.

AHW

There is a Commercial district approximately 2590 feet North and Northwest of the facility along Bragden Road. East of Bragden Road about 50 feet from my facility are several other houses that are lived in.

1030 Taking Photos with 35mm and Polaroid
The facility is partially fenced but access is possible along Bragden Road.

Proceeded west then Southwest and identified more residents and commercial businesses along Hwy 301. There are several more stacks of lumber, but this area is fenced

1038 Taking Photos with 35mm and Polaroid on East Bingham St.

AKW

1040 There are two schools located within a 1/2 mile of facility South Smithfield Primary, Northwest of facility, and Smithfield Elementary North of facility.
Also identified an industrial park within a 1/2 mile South of the facility along Wallratt Dr.

1052 Leaving area of interest to go to water department and obtain water distribution information

1102 Arrive at Smithfield Public Utilities and Spoke with Charles Hicks, water Superintendent. Mr. Hicks outlined the water distribution on my map and also identifying areas they supply water but do not maintain.

AKW

[redacted]06 3-15-90

MR. Hicks stated that Smithfield supplies water to several other Cities including, Selma, Kenly, Clayton, Princeton, Four oaks, and West Smithfield. He said their System Supplies the water but each independent has a tie in with their System. Other Communities Maintain on accounts MR. Hicks said that their are approximately 8,500 connections on their System. He pointed out areas that are using private wells as Source of water.

Will try to contact other areas to get number of Customers by Telephone.

MR. Hicks stated that this is the only intake in the County.

AHW

1130 Proceeding to [redacted] [redacted] [redacted] [redacted] Private well site along Hwy 1007 traveling South.
Identified Mr. B. M. Dupree
Route 2, Box 86AA
Smithfield, NC
This well is approximately 3500 feet Southeast of the facility

1140 Going back North on Hwy 1007 to facility and do Site Sketch.

1150 End of Recon activities
Arlen T. Williams

AHW

000030
3-13-90
000030

REFERENCE 15

SITE: Squibb, E R. + Sons
TDD NO.: F4-9002-44
LOGBOOK NO.: F4-2089

WATER USE SURVEY

Reference 15

Name and address of resident

Roy Gill
Route 2, Box 204
Kenly, NC
(919) 284-4167

Check water source(s) used by resident

1. DRILLED WELL ____ DEPTH ____ WATER LEVEL ____
2. DUG WELL ✓ DEPTH 45 feet WATER LEVEL unknown
3. SPRING ____ ARTESIAN ____ GRAVITY ____
4. SURFACE WATER ____ ____
5. PUBLIC SUPPLY ____ ____
6. OTHER ____ ____

Check water use(s) and specify water source of each

DRINKING ✓ NUMBER OF USERS 5 SOURCE ____
HOUSEHOLD ✓ NUMBER OF USERS 5 SOURCE ____
IRRIGATION ____ ACRES ____ CROP ____ SOURCE ____
OTHER ____

ANY PROBLEMS WITH WATER? NO

HOW LONG HAVE SOURCES BEEN IN USE? over 90 years

ANY MONITORING WELLS ON PROPERTY? NO

PREPARED BY Alvin Williams DATE 3-13-90

COMMENTS ____

REFERENCE 16

Rachel Spangenberg - Calculations re-done for E.R. Spoil using 1990 Census data. - Groundwater and Air Population Counts.

① population not served by Kenly water system; utilizes private wells:

Radius	Houses	persons/household	TOT. Population
1/4	0	2.35	0
1/2	18	2.35	42.3 (42)
1	38	2.35	89.3 (89)
2	150	2.35	352.5 (353)
3	224	2.35	526.4 (526)
4	462	2.35	1085.7 (1086)
		Total:	2096.

② Population served by Kenly System:

Radius	Houses	persons/household	TOT. Population
1/4	0	2.35	0
1/2	4	2.35	9
1	168	2.35	395
2	259	2.35	609
3	0	2.35	0
4	0	2.35	0
		Total:	1013

③ Total air population (Kenly system + GW users)

Radius

1/4 - 0

1/2 - 51

1 - ~~573~~ 484

2 - ~~1137~~ 962

3 ~~623~~ 526

4 ~~128~~ 1086

total: 3109

REFERENCE 17

September 16, 1991

TO: Technical Staff

FROM: Pat DeRosa

RE: US Census Bureau 1990 Population Data
Persons Per Household by County
Persons Per Household by Town
Total Population by County
Total Population by Town

Please find attached the subject population data which I recently received from the US Census Bureau. Please note that the Persons Per Household by County data which I distributed in June has not been revised and is still accurate as included here. I have also included the remainder of Table 6 which lists information on Persons Per Household by Town, and Table 5 which lists Total Population Values for each County or Town. Please let me know if you have any questions about using this data or if you require additional census data.

Attachments

Table 6. Household, Family, and Group Quarters Characteristics: 1990

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	Householder living alone, 65 years and over: Total	Householder living alone, 65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Persons in group quarters: Institutionalized persons	Persons in group quarters: Other persons in group quarters
The State	6 404 167	2 517 026	1 812 053	1 424 306	300 876	704 973	596 889	226 394	182 328	2.54	3.03	224 470	83 400	141 070
COUNTY														
Alamance County	105 327	42 652	30 745	24 295	5 130	11 907	10 467	4 586	3 748	2.47	2.94	2 886	1 173	1 713
Alexander County	27 245	10 331	8 049	6 715	952	2 282	2 022	839	651	2.64	3.02	276	276	–
Alleghany County	9 381	3 894	2 829	2 421	303	1 065	990	539	433	2.41	2.88	149	133	16
Anson County	23 117	8 531	6 359	4 552	1 475	2 172	2 042	1 073	860	2.71	3.23	357	344	13
Ashe County	21 965	8 840	6 740	5 643	[illegible]	2 100	1 935	1 014	809	2.48	2.88	244	223	21
Avery County	13 818	5 520	4 162	3 500	440	1 358	1 225	548	420	2.32	2.35	[illegible]	[illegible]	673
Beaufort County	41 704	16 157	11 840	9 140	2 186	4 317	3 915	1 674	1 605	2.58	2.97	579	443	136
Bertie County	20 321	7 412	5 501	3 831	1 416	1 911	1 757	957	755	2.74	3.23	[illegible]	[illegible]	–
Bladen County	28 153	10 780	8 017	5 854	1 782	2 743	2 570	1 243	1 000	2.61	3.11	513	509	4
Brunswick County	50 487	20 089	15 291	12 626	2 001	4 778	4 227	1 840	1 194	2.52	2.91	488	307	181
Buncombe County	169 713	70 802	46 335	38 637	7 664	21 467	18 868	8 174	6 842	2.40	2.90	5 108	2 966	2 142
Burke County	73 281	28 184	21 711	17 482	3 148	7 473	6 586	2 708	2 229	2.51	2.93	2 463	2 410	53
Cabarrus County	87 255	38 515	29 367	22 279	3 572	9 148	8 036	3 500	2 971	2.56	3.02	1 680	1 223	457
Caldwell County	69 917	27 172	20 656	16 653	2 844	6 516	5 680	2 287	1 846	2.57	2.97	762	705	57
Camden County	5 875	2 180	1 802	1 385	225	378	337	234	169	2.80	3.11	29	–	29
Carteret County	51 554	21 238	15 276	12 461	2 221	5 962	5 081	1 901	1 431	2.43	2.88	1 004	752	252
Caswell County	20 053	7 448	5 781	4 454	1 124	1 667	1 563	727	573	2.69	3.12	640	624	16
Catawba County	116 387	45 700	33 773	27 418	4 841	11 927	10 270	3 844	3 115	2.55	2.96	1 995	1 134	861
Chatham County	38 315	15 293	11 227	9 115	1 605	4 066	3 445	1 412	1 141	2.51	2.96	444	[illegible]	67
Cherokee County	19 899	7 964	6 080	5 065	763	1 887	1 764	875	759	2.50	2.91	171	126	45
Chowan County	13 233	5 113	3 775	2 842	787	1 338	1 236	641	496	2.59	3.07	273	273	–
Clay County	7 150	2 929	2 177	1 864	253	751	699	418	314	2.44	2.80	5	4	1
Cleveland County	83 612	32 007	24 282	19 011	4 166	7 735	7 011	3 202	2 624	2.56	3.02	1 602	815	787
Columbus County	48 957	18 459	13 754	10 381	2 757	4 705	4 351	2 152	1 806	2.65	3.15	634	624	10
Craven County	78 014	29 542	22 481	18 199	3 511	7 061	6 121	2 436	1 830	2.64	3.07	3 589	811	2 778
Cumberland County	253 302	91 900	69 966	54 433	12 863	21 934	17 718	4 724	3 752	2.77	3.19	21 224	1 409	19 795
Currituck County	13 488	5 038	3 854	3 272	407	1 184	984	418	312	2.68	3.08	250	217	33
Dare County	22 542	8 348	6 425	5 439	642	2 924	2 264	714	522	2.41	2.86	206	142	64
Davidson County	125 358	48 944	37 176	30 410	5 120	11 768	10 282	4 189	3 319	2.56	2.96	1 319	1 277	42
Davie County	27 541	10 785	8 270	6 999	953	2 515	2 244	1 025	817	2.55	2.95	318	288	30
Duplin County	39 368	14 925	11 036	8 378	2 006	3 889	3 553	1 779	1 438	2.64	3.12	627	550	77
Durham County	173 310	72 257	45 385	33 614	10 321	26 872	21 957	5 553	4 471	2.40	2.96	8 525	2 175	6 350
Edgecombe County	55 854	20 319	15 085	10 000	4 293	5 234	4 722	2 124	1 717	2.75	3.25	702	657	45
Forsyth County	257 466	107 419	72 621	55 715	14 052	34 798	28 870	9 770	7 675	2.40	2.94	8 412	3 433	4 979
Franklin County	35 237	13 503	10 047	7 640	1 865	3 456	3 120	1 384	1 128	2.61	3.07	1 174	568	606
Gaston County	172 781	65 347	46 754	38 905	6 439	18 593	15 580	5 723	4 720	2.64	3.07	2 300	1 456	844
Gates County	9 202	3 352	2 563	2 040	404	789	735	364	284	2.73	3.19	123	122	1
Graham County	7 176	2 772	2 166	1 836	246	606	562	294	225	2.59	2.98	20	18	2
Granville County	35 181	13 134	9 883	7 501	1 857	3 251	2 889	1 236	978	2.68	3.12	3 154	3 079	75
Greene County	14 665	5 395	4 066	3 000	875	1 329	1 189	574	461	2.72	3.18	719	704	15
Guilford County	335 348	137 736	92 891	71 195	17 570	44 815	36 578	12 180	9 951	2.44	2.97	12 082	3 094	8 988
Halifax County	54 122	20 335	14 874	10 002	4 018	5 461	5 005	2 306	1 897	2.66	3.18	1 394	1 356	38
Harnett County	65 340	25 150	18 529	14 499	3 154	6 621	5 773	2 438	1 962	2.60	3.06	2 482	1 240	1 242
Haywood County	46 152	19 211	14 120	11 831	1 774	5 091	4 601	2 337	1 866	2.40	2.83	790	[illegible]	36
Henderson County	68 206	28 708	21 168	17 113	2 344	7 540	6 638	3 531	2 858	2.38	2.80	979	867	112
Hertford County	21 612	8 150	5 921	4 164	1 473	2 229	2 083	877	766	2.65	3.19	911	279	632
Hoke County	21 612	7 405	5 794	3 847	1 805	1 611	1 419	523	420	2.92	3.34	1 244	1 244	–
Hyde County	5 383	2 094	1 533	1 151	321	561	516	259	191	2.57	3.07	28	19	9
Iredell County	90 082	35 573	26 869	21 736	4 023	8 704	7 646	3 271	2 662	2.53	3.02	849	814	35
Jackson County	23 834	9 683	6 970	5 740	981	2 713	2 242	986	745	2.46	2.91	3 012	280	2 732
Johnston County	80 341	31 589	23 217	18 586	3 634	8 349	7 441	3 380	2 730	2.55	3.01	965	893	72
Jones County	9 412	3 482	2 630	2 004	442	853	774	406	311	2.70	3.17	2	2	–
Lee County	40 651	15 649	11 730	9 087	2 135	3 950	3 462	1 389	1 107	2.59	3.03	723	672	51
Lenoir County	55 652	21 938	15 611	11 131	3 728	6 327	5 736	2 580	2 073	2.54	3.06	1 622	1 559	63
Lincoln County	49 802	18 764	14 661	12 207	1 827	4 103	3 580	1 467	1 173	2.65	3.03	517	517	–
McDowell County	35 064	13 680	10 366	8 578	1 363	3 314	2 906	1 309	1 135	2.56	2.99	637	416	221
Macon County	22 892	9 834	7 235	6 236	773	2 599	2 389	1 307	1 021	2.34	2.76	507	233	274
Madison County	16 104	6 488	4 806	4 058	516	1 682	1 510	789	581	2.48	2.92	849	[illegible]	745
Martin County	24 813	9 317	6 900	5 087	1 519	2 417	2 213	1 100	906	2.66	3.17	265	257	8
Mecklenburg County	499 888	200 219	134 361	103 211	25 813	65 858	52 027	12 990	10 610	2.50	3.05	11 547	3 570	7 989
Mitchell County	14 288	5 776	4 420	3 777	479	1 356	1 285	669	539	2.47	2.88	145	130	15
Montgomery County	22 279	8 290	6 274	4 823	1 119	2 016	1 838	878	690	2.69	3.14	1 087	667	70
Moore County	58 010	23 827	17 483	14 312	2 473	6 344	5 662	2 744	2 201	2.43	2.87	1 003	970	33
Nash County	75 450	28 041	21 224	16 322	3 986	7 817	6 926	2 880	2 316	2.60	3.08	1 290	867	423
New Hanover County	118 988	48 138	32 400	24 723	6 365	15 738	12 434	4 372	3 512	2.43	2.95	3 285	1 321	1 964
Northampton County	20 055	7 581	5 644	3 958	1 436	1 947	1 816	964	734	2.64	3.13	743	742	1
Onslow County	115 274	40 668	32 971	28 037	3 843	7 687	6 271	1 752	1 384	2.84	3.16	34 564	954	33 610
Orange County	84 627	36 104	21 123	16 854	3 380	14 981	10 110	2 257	1 839	2.34	2.93	9 226	772	8 454
Pamlico County	11 247	4 523	3 382	2 717	547	1 141	1 055	528	410	2.49	2.93	125	112	13
Pasquotank County	29 884	11 384	8 326	6 386	1 681	3 058	2 725	1 342	1 065	2.63	3.13	1 414	383	1 031
Pender County	28 467	11 112	8 430	6 727	1 371	2 682	2 389	1 055	794	2.56	2.95	358	348	10
Perquimans County	10 303	3 988	3 038	2 444	460	950	862	443	342	2.58	3.02	144	144	–
Person County	29 830	11 423	8 570	6 907	1 347	2 853	2 675	1 229	994	2.61	3.07	350	304	46
Pitt County	102 400	40 491	26 434	19 369	5 857	14 057	10 412	3 104	2 511	2.53	3.10	5 524	946	4 578
Polk County	14 187	6 110	4 346	3 663	511	1 764	1 594	852	784	2.32	2.75	[illegible]	227	2
Randolph County	105 440	41 086	31 353	26 136	3 957	9 733	8 591	3 436	2 789	2.57	2.97	1 106	1 050	56
Richmond County	43 534	16 793	12 270	9 126	2 551	4 523	4 174	2 011	1 600	2.59	3.10	984	873	108
Robeson County	103 186	36 154	27 429	18 451	7 353	8 725	7 951	3 355	2 651	2.85	3.34	1 933	1 220	713
Rockingham County	85 242	33 446	24 671	19 351	4 193	8 775	7 953	3 689	2 992	2.55	3.02	822	781	41
Rowan County	107 079	42 512	31 055	25 100	4 618	11 457	10 226	4 748	3 815	2.52	2.96	3 526	2 408	1 118
Rutherford County	56 197	22 198	16 480	13 191	2 551	5 718	5 253	2 556	2 050	2.53	2.96	721	721	–
Sampson County	46 754	17 526	13 161	10 058	2 525	4 335	3 875	[illegible]	1 610	2.67	3.10	543	460	83
Scotland County	32 675	11 837	8 871	6 223	2 338	2 966	2 616	1 173	935	2.78	3.22	1 075	401	674
Stanly County	50 734	18 747	14 967	12 451	1 975	4 780	4 306	2 164	1 725	2.57	3.02	1 014	473	541
Stokes County	36 862	14 123	11 022	9 341	1 273	3 101	2 825	1 246	1 016	2.61	3.00	361	361	–
Surry County	60 950	24 252	18 252	15 253	2 341	6 000	5 474	2 732	2 258	2.51	2.95	754	650	104
Swain County	10 863	4 173	3 077	2 382	553	1 000	985	467	369	2.55	3.02	615	215	400
Transylvania County	24 283	9 874	7 444	6 442	757	2 430	2 224	1 131	912	2.45	2.90	1 227	178	1 050
Tyrrell County	3 852	1 471	1 078	810	213	393	359	209	148	2.62	3.13	4	4	–
Union County	82 633	29 307	23 530	19 607	3 063	5 777	5 010	2 148	1 735	2.82	3.18	1 578	455	1 123

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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State / County / Place and [In Selected States] County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	Householder living alone, 65 years and over: Total	Householder living alone, 65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Persons in group quarters: Institutionalized persons	Persons in group quarters: Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Buies Creek CDP, Harnett County	833	427	234	164	53	193	154	43	38	2.18	2.87	1 152	-	1 152
Bunn town, Franklin County	364	157	100	77	22	57	54	35	29	2.32	3.04	-	-	-
Burgaw town, Pender County	1 527	623	427	313	101	196	186	123	122	2.41	3.00	300	300	-
Burlington city, Alamance County	38 021	16 627	11 217	8 466	2 255	5 410	4 803	2 182	1 775	2.35	2.89	477	420	57
Burnsville town, Yancey County	1 408	673	400	317	58	273	264	177	142	2.09	2.81	24	24	-
Butner CDP, Granville County	3 152	1 216	887	642	196	329	254	73	62	2.50	3.07	1 527	1 527	-
Cajah's Mountain town, Caldwell County	2 180	847	682	578	73	165	143	73	58	2.55	2.84	258	258	-
Calabash town, Brunswick County	1 210	589	464	416	24	125	82	46	34	2.02	2.21	-	-	-
Calypso town, Duplin County	481	186	136	104	27	50	47	35	23	2.59	3.09	-	-	-
Cameron town, Moore County	215	79	57	37	16	22	20	11	9	2.72	3.23	-	-	-
Camp Lejeune Central CDP, Onslow County	14 871	4 088	4 043	3 883	116	45	38	-	-	3.58	3.60	22 045	310	21 735
Candor town, Montgomery County	745	309	237	156	40	92	88	33	32	2.40	3.05	3	-	3
Canton town, Haywood County	3 683	1 715	1 102	886	174	613	577	366	307	2.15	2.71	107	107	-
Cape Carteret town, Carteret County	1 008	441	348	322	22	93	81	57	43	2.29	2.56	-	-	-
Carolina Beach town, New Hanover County	3 574	1 605	1 004	835	133	601	478	125	85	2.23	2.77	56	55	1
Carrboro town, Orange County	11 543	5 637	2 614	1 848	645	3 023	2 329	154	122	2.05	2.73	10	-	10
Carthage town, Moore County	912	377	252	194	46	125	113	62	46	2.42	3.03	64	64	-
Cary town, Wake County	43 782	16 808	12 239	10 770	1 146	4 569	3 572	440	341	2.59	3.06	76	76	-
Casar town, Cleveland County	328	127	101	83	11	26	25	13	8	2.58	2.93	-	-	-
Castalia town, Nash County	261	98	74	53	17	24	23	15	11	2.66	3.12	-	-	-
Castle Hayne CDP, New Hanover County	1 178	444	342	256	56	102	87	24	20	2.65	3.22	4	4	-
Caswell Beach town, Brunswick County	175	84	56	51	-	28	26	7	4	2.08	2.56	-	-	-
Catawba town, Catawba County	467	186	145	112	28	41	40	23	19	2.51	2.90	-	-	-
Cedar Point town, Carteret County	628	283	156	151	10	107	97	41	31	2.27	2.56	-	-	-
Centerville town, Franklin County	115	48	35	23	5	13	13	8	7	2.40	2.86	-	-	-
Cerro Gordo town, Columbus County	227	88	68	56	11	20	20	7	6	2.58	3.04	-	-	-
Chadbourn town, Columbus County	2 005	796	541	351	168	255	241	123	98	2.52	3.16	-	-	-
Chapel Hill town	30 054	13 780	6 766	5 391	1 122	7 014	6 522	1 046	882	2.18	2.83	8 665	245	8 420
Durham County	1 115	498	287	246	36	211	152	11	8	2.24	2.85	-	-	-
Orange County	28 939	13 282	6 479	5 145	1 086	6 803	6 370	1 035	874	2.18	2.82	8 665	245	8 420
Charlotte city, Mecklenburg County	390 037	158 991	102 864	75 403	22 334	56 087	44 565	11 058	9 043	2.45	3.05	5 867	2 656	3 211
Cherryville city, Gaston County	4 650	1 950	1 372	1 043	257	578	531	316	258	2.38	2.88	156	156	-
China Grove town, Rowan County	2 719	1 096	777	564	146	319	292	144	117	2.48	3.00	13	-	13
Chocowinity town, Beaufort County	610	253	185	142	34	68	63	29	20	2.41	2.86	14	-	14
Claremont city, Catawba County	980	402	289	238	36	113	97	56	47	2.44	2.81	-	-	-
Clarkton town, Bladen County	661	250	190	131	60	58	57	32	27	2.64	3.08	58	58	-
Clayton town, Johnston County	4 680	1 867	1 330	986	282	537	481	213	168	2.51	3.02	67	67	-
Clemmons village, Forsyth County	5 850	2 182	1 769	1 584	144	413	357	116	82	2.68	3.02	170	170	-
Cleveland town, Rowan County	806	252	197	138	51	55	52	28	23	2.78	3.15	-	-	-
Clinton city, Sampson County	8 005	3 319	2 222	1 527	603	1 097	1 018	525	443	2.41	3.02	198	198	-
Clyde town, Haywood County	893	431	296	247	41	135	121	50	42	2.30	2.82	48	48	-
Coats town, Harnett County	1 463	636	411	323	71	225	182	102	86	2.35	2.82	-	-	-
Cofield village, Hertford County	407	150	105	58	35	45	38	23	11	2.71	3.25	-	-	-
Colerain town, Bertie County	139	62	45	38	5	17	17	12	12	2.24	2.84	-	-	-
Columbia town, Tyrrell County	832	337	218	127	80	119	109	68	53	2.47	3.14	4	4	-
Columbus town, Polk County	786	376	236	180	41	140	132	85	74	2.09	2.65	26	26	-
Como town, Hertford County	71	31	21	17	4	10	9	5	5	2.29	2.86	-	-	-
Concord city, Cabarrus County	26 341	10 807	7 451	5 621	1 466	3 356	2 958	1 378	1 154	2.44	2.97	1 006	630	376
Conetoe town, Edgecombe County	232	105	75	46	23	30	24	14	14	2.21	3.38	-	-	-
Connelly Springs town, Burke County	1 348	533	404	323	52	129	114	49	45	2.53	2.91	-	-	-
Conover city, Catawba County	5 415	2 135	1 589	1 308	223	546	487	191	157	2.54	2.98	50	47	3
Conway town, Northampton County	758	316	231	180	42	85	82	51	42	2.40	2.86	-	-	-
Cooleemee town, Davie County	971	408	300	240	46	108	104	64	54	2.37	2.81	-	-	-
Cornelius town, Mecklenburg County	2 581	982	720	549	138	262	229	77	61	2.63	3.14	-	-	-
Cove City town, Craven County	497	184	139	110	24	45	40	23	21	2.70	3.19	-	-	-
Cramerton town, Gaston County	2 371	950	690	578	84	260	238	140	114	2.50	2.98	-	-	-
Creedmoor city, Granville County	1 504	634	427	308	102	207	184	77	67	2.37	2.95	-	-	-
Creswell town, Washington County	361	137	105	80	43	32	31	21	18	2.64	3.10	-	-	-
Cricket CDP, Wilkes County	2 015	838	591	462	95	247	219	92	78	2.40	2.88	-	-	-
Crossnore town, Avery County	217	89	66	50	11	23	20	12	11	2.44	2.83	54	42	12
Cullowhee CDP, Jackson County	1 274	599	375	322	40	224	206	35	25	2.13	2.52	2 735	75	2 660
Dallas town, Gaston County	3 007	1 184	839	598	191	345	306	126	123	2.54	3.07	5	-	5
Danbury town, Stokes County	119	48	38	32	6	10	9	6	4	2.48	2.84	-	-	-
Davidson town	2 581	1 115	691	538	125	424	387	112	90	2.29	2.91	1 485	265	1 220
Iredell County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mecklenburg County	2 581	1 115	691	538	125	424	387	112	90	2.29	2.91	1 485	265	1 220
Dellview town, Gaston County	10	3	3	2	1	-	-	-	-	3.33	3.33	-	-	-
Denton town, Davidson County	1 282	530	373	304	52	157	140	80	67	2.44	2.97	-	-	-
Dillsboro town, Jackson County	86	50	26	21	5	24	22	8	6	1.80	2.46	-	-	-
Dobbins Heights town, Richmond County	1 144	486	294	151	119	192	186	106	73	2.35	3.17	-	-	-
Dobson town, Surry County	1 032	460	286	216	60	174	160	82	68	2.22	2.81	163	163	-
Dortches town, Nash County	840	309	246	225	34	63	56	33	31	2.72	3.[illegible]	-	-	-
Dover town, Craven County	451	173	130	95	28	43	43	24	20	2.61	3.[illegible]	-	-	-
Drexel town, Burke County	1 631	696	448	372	61	248	189	95	77	2.34	2.78	115	115	-
Dublin town, Bladen County	246	104	71	52	15	33	29	12	10	2.37	2.86	-	-	-
Dunn city, Harnett County	8 156	3 343	2 252	1 531	634	1 091	1 018	532	447	2.44	3.02	190	156	34
Durham city	128 621	56 001	32 778	22 081	8 029	23 223	18 286	4 757	3 833	2.30	2.86	7 990	1 640	6 350
Durham County	128 604	55 996	32 771	22 078	8 026	23 225	18 286	4 757	3 833	2.30	2.86	7 990	1 640	6 350
Orange County	17	5	5	3	2	-	-	-	-	3.40	3.40	-	-	-
Earl town, Cleveland County	230	91	68	51	12	23	21	16	13	2.53	3.00	-	-	-
East Arcadia town, Bladen County	468	155	124	52	67	31	30	17	13	3.02	3.44	-	-	-
East Bend town, Yadkin County	619	247	184	153	25	63	59	25	14	2.51	2.88	-	-	-
East Flat Rock CDP, Henderson County	3 218	1 364	942	740	162	422	387	157	127	2.36	2.83	-	-	-
East Laurinburg town, Scotland County	332	133	99	64	17	34	32	18	16	2.48	2.90	-	-	-
Eastover CDP, Cumberland County	1 185	487	357	265	66	130	125	53	45	2.43	2.86	56	56	-
East Rockingham CDP, Richmond County	4 158	1 644	1 176	883	276	468	436	214	185	2.53	3.06	-	-	-
East Spencer town, Rowan County	2 050	798	505	247	227	293	278	124	83	2.57	3.38	5	5	-
Eden city, Rockingham County	15 015	6 308	4 308	3 178	945	2 000	1 830	946	788	2.38	2.91	223	207	16
Edenton town, Chowan County	4 906	2 001	1 372	863	453	656	610	347	298	2.45	3.07	273	273	-
Elizabeth City city	12 865	5 340	3 499	2 236	1 127	1 841	1 670	890	722	2.41	3.07	1 337	313	1 024
Camden County	29	16	11	10	1	5	5	2	2	1.81	2.18	-	-	-
Pasquotank County	12 826	5 324	3 488	2 226	1 126	1 836	1 665	888	720	2.41	3.07	1 337	313	1 024

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Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	65 years and over: Total	65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Elizabethtown town, Bladen County	3 328	1 404	998	580	361	406	475	285	222	2.35	2.98	185	185	-
Elkin town	3 597	1 674	1 050	835	175	624	586	300	237	2.15	2.73	163	163	-
Surry County	3 527	1 647	1 028	822	167	619	582	297	236	2.14	2.74	163	163	-
Wilkes County	70	27	22	13	8	5	4	3	1	2.59	2.61	-	-	-
Elk Park town, Avery County	446	198	141	108	23	57	52	23	17	2.45	2.84	-	-	-
Ellenboro town, Rutherford County	514	225	154	104	41	71	60	38	27	2.28	2.84	-	-	-
Ellerbe town, Richmond County	1 132	457	325	236	104	132	121	73	55	2.48	2.97	-	-	-
Elm City town, Wilson County	1 577	596	429	292	115	167	144	67	56	2.65	3.19	47	[illegible]	[illegible]
Elon College town, Alamance County	2 737	1 066	683	581	77	383	213	72	58	2.58	3.22	1 437	[illegible]	[illegible]
Elroy CDP, Wayne County	4 028	1 545	1 133	921	158	412	331	63	44	2.61	3.12	-	-	-
Emerald Isle town, Carteret County	2 411	1 128	772	714	37	354	283	55	42	2.14	[illegible]	23	-	23
Enfield town, Halifax County	2 892	1 054	740	366	334	314	296	178	152	2.74	3.36	150	150	-
Enochville CDP, Rowan County	2 873	1 103	894	754	121	209	167	103	80	2.60	2.90	28	28	-
Erwin town, Harnett County	4 054	1 747	1 186	950	181	556	526	232	235	2.32	2.86	[illegible]	3	4
Etowah CDP, Henderson County	1 967	853	637	574	52	216	165	82	67	2.34	2.74	-	-	-
Eureka town, Wayne County	282	117	81	67	13	36	36	24	19	2.41	3.07	-	-	-
Everetts town, Martin County	143	63	45	33	8	18	18	14	14	2.27	2.66	-	-	-
Fair Bluff town, Columbus County	1 062	425	277	190	67	152	143	86	62	2.48	3.22	6	6	-
Fairmont town, Robeson County	2 475	997	686	372	294	311	294	172	155	2.48	3.06	14	14	-
Fairplains CDP, Wilkes County	2 330	966	692	544	114	274	249	114	94	2.42	2.82	-	-	-
Fairview CDP, Buncombe County	1 830	682	559	485	53	123	104	38	31	2.68	2.90	-	-	-
Faison town, Duplin County	707	288	176	127	33	112	98	60	47	2.43	3.13	-	-	-
Faith town, Rowan County	553	221	163	146	12	58	54	38	35	2.50	3.22	-	-	-
Falcon town	216	86	62	52	4	24	22	8	8	2.51	3.08	-	-	-
Cumberland County	216	86	62	52	4	24	22	8	8	2.51	3.08	-	-	-
Sampson County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Falkland town, Pitt County	108	41	29	21	5	12	11	8	7	2.63	3.22	-	-	-
Fallston town, Cleveland County	496	203	149	129	16	54	50	27	22	2.45	2.95	-	-	-
Farmville town, Pitt County	4 392	1 804	1 225	778	380	596	563	336	289	2.43	3.07	-	-	-
Fayetteville city, Cumberland County	73 201	29 639	20 431	14 854	4 892	9 208	7 796	2 315	2 047	2.47	2.96	2 464	945	1 519
Fearrington CDP, Chatham County	1 101	544	420	404	13	124	103	45	37	2.02	2.27	-	-	-
Flat Rock CDP, Surry County	1 812	736	541	423	83	195	180	85	80	2.46	2.61	-	-	-
Fletcher town, Henderson County	2 787	1 135	846	710	110	289	252	88	77	2.46	2.87	-	-	-
Forest City town, Rutherford County	7 450	3 092	2 112	1 387	609	980	912	440	360	2.41	2.97	25	25	-
Forest Oaks CDP, Guilford County	3 054	1 088	976	820	45	112	98	30	27	2.81	2.96	-	-	-
Fort Bragg CDP, Cumberland County	17 760	4 732	4 598	4 315	231	134	130	1	1	3.75	3.81	16 984	-	16 984
Fountain town, Pitt County	445	205	132	81	47	73	73	52	47	2.17	2.80	-	-	-
Four Oaks town, Johnston County	1 300	566	379	278	83	177	161	84	69	2.34	2.88	5	5	-
Foxfire village, Moore County	334	164	135	134	1	29	29	22	16	2.04	2.25	-	-	-
Franklin town, Macon County	2 809	1 357	830	658	145	527	483	289	237	2.07	2.66	65	65	-
Franklinton town, Franklin County	1 615	674	439	278	130	235	215	125	102	2.40	3.05	-	-	-
Franklinville town, Randolph County	666	240	150	145	24	90	81	30	26	2.87	3.15	-	-	-
Fremont town, Wayne County	1 634	667	443	281	139	224	210	126	101	2.45	3.11	75	75	-
Fuquay-Varina town, Wake County	4 458	1 856	1 246	898	294	610	540	279	237	2.40	2.96	104	102	[illegible]
Gamewell town, Caldwell County	3 357	1 287	1 035	813	163	252	218	56	41	2.61	2.81	-	-	-
Garland town, Sampson County	667	287	201	137	51	86	56	25	25	2.57	3.21	56	56	-
Garner town, Wake County	14 840	5 764	4 338	3 561	629	1 426	1 233	236	234	2.57	3.22	127	127	-
Garysburg town, Northampton County	1 057	378	277	137	123	101	94	41	30	2.80	3.35	-	-	-
Gaston town, Northampton County	1 003	413	308	214	83	105	93	56	46	2.43	2.73	-	-	-
Gastonia city, Gaston County	53 645	20 983	15 085	11 730	3 556	5 898	5 148	2 233	1 879	2.56	3.05	1 027	[illegible]	[illegible]
Gatesville town, Gates County	308	132	93	75	13	39	38	25	23	2.33	2.86	-	-	-
Gibson town, Scotland County	532	197	145	80	59	52	46	24	22	2.70	3.22	-	-	-
Gibsonville town	3 441	1 342	946	729	177	396	314	141	119	2.56	3.02	-	-	-
Alamance County	1 480	583	404	324	65	179	129	43	32	2.54	3.02	-	-	-
Guilford County	1 961	759	542	404	112	217	186	98	87	2.58	3.11	-	-	-
Glen Alpine town, Burke County	557	224	155	132	18	69	62	36	31	2.46	3.07	[illegible]	6	-
Glen Raven CDP, Alamance County	2 604	1 022	789	622	121	233	204	109	81	2.55	2.93	[illegible]	12	-
Godwin town, Cumberland County	77	33	20	13	6	13	12	7	6	2.33	3.15	-	-	-
Goldsboro city, Wayne County	34 387	13 423	9 423	6 354	2 648	4 000	3 600	1 489	1 212	2.56	3.12	6 342	2 027	4 315
Goldston town, Chatham County	298	125	92	78	14	33	31	20	18	2.38	2.87	-	-	-
Gorman CDP, Durham County	1 090	423	319	259	38	104	82	43	38	2.58	3.02	-	-	-
Graham city, Alamance County	9 904	4 290	2 953	2 237	596	1 337	1 202	550	463	2.33	2.84	432	425	[illegible]
Grandfather village, Avery County	34	14	10	8	1	4	2	-	-	2.43	2.80	-	-	-
Granite Falls town, Caldwell County	3 086	1 287	885	661	185	402	351	185	160	2.40	2.82	167	167	-
Granite Quarry town, Rowan County	1 640	642	475	394	68	167	154	58	41	2.56	3.03	-	-	-
Greenevers town, Duplin County	512	186	136	75	52	50	47	24	23	2.75	3.22	-	-	-
Greensboro city, Guilford County	174 900	74 808	46 107	33 601	10 304	28 708	22 826	6 802	5 557	2.33	2.95	8 621	1 572	7 046
Greenville city, Pitt County	38 871	17 017	9 066	6 174	2 455	7 952	5 199	1 140	931	2.35	3.04	5 001	576	4 425
Grifton town	2 308	921	666	490	152	255	242	134	107	2.51	3.02	84	84	-
Lenoir County	253	97	67	35	29	30	28	17	14	2.61	3.25	-	-	-
Pitt County	2 056	824	599	455	123	225	214	117	93	2.50	3.02	84	84	-
Grimesland town, Pitt County	460	182	126	97	28	56	53	38	32	2.58	3.17	-	-	-
Grover town, Cleveland County	516	215	157	120	22	58	53	33	29	2.40	2.84	-	-	-
Half Moon CDP, Onslow County	6 326	1 969	1 723	1 500	177	246	194	31	30	3.20	3.42	-	-	-
Halifax town, Halifax County	275	119	84	70	12	35	33	21	17	2.31	2.83	52	52	-
Hamilton town, Martin County	524	196	149	111	28	46	41	30	15	2.66	3.13	[illegible]	[illegible]	-
Hamlet city, Richmond County	6 095	2 419	1 721	1 194	443	698	632	351	296	2.52	3.04	161	[illegible]	[illegible]
Harkers Island CDP, Carteret County	1 739	679	544	472	56	135	122	60	45	2.56	2.93	-	-	-
Harmony town, Iredell County	431	178	134	113	19	44	40	23	21	2.42	2.82	-	-	-
Harrells town	187	74	55	42	10	19	18	11	6	2.53	2.96	-	-	-
Duplin County	2	1	1	1	-	-	-	-	-	2.00	2.00	-	-	-
Sampson County	185	73	54	41	10	19	18	11	6	2.53	2.88	-	-	-
Harrellsville town, Hertford County	132	[illegible]	[illegible]	28	4	12	12	7	6	2.41	2.91	-	-	-
Harrisburg town, Cabarrus County	1 625	614	511	467	44	103	93	37	34	2.65	2.93	-	-	-
Hassell town, Martin County	86	36	25	17	7	11	12	4	3	2.44	3.08	-	-	-
Havelock city, Craven County	17 560	5 861	4 924	4 368	431	737	563	95	73	3.13	3.33	2 716	-	2 716
Haw River town, Alamance County	1 856	786	562	423	116	224	215	91	73	2.36	2.84	-	-	-
Hayesville town, Clay County	275	158	74	58	11	84	80	51	44	1.74	2.46	4	4	-
Hays CDP, Wilkes County	1 522	566	451	379	52	115	98	38	31	2.69	3.02	-	-	-
Hazelwood town, Haywood County	1 598	701	465	347	96	236	214	125	105	2.28	2.79	42	42	-
Hemby Bridge CDP, Union County	2 576	824	799	696	80	125	95	17	14	3.11	3.38	-	-	-

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Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State / County / Place and (In Selected States) County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	65 years and over: Total	65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Henderson city, Vance County	15 308	6 017	4 165	2 543	1 419	1 852	1 661	817	657	2.54	3.10	346	346	-
Hendersonville city, Henderson County	6 867	3 192	1 904	1 344	467	1 288	1 186	677	554	2.15	2.82	417	318	[illegible]
Hertford town, Perquimans County	2 028	809	550	387	163	259	243	147	124	2.51	3.15	77	77	-
Hickory city	26 878	11 800	7 364	5 421	1 562	4 436	3 714	1 296	1 047	2.28	2.86	1 423	568	855
Burke County	40	15	14	12	-	1	1	1	1	2.67	2.79	36	36	-
Catawba County	26 838	11 785	7 350	5 409	1 562	4 435	3 713	1 295	1 046	2.28	2.86	1 388	532	855
Highlands town	834	432	280	243	27	152	148	85	72	2.16	2.74	14	14	-
Jackson County	4	2	2	2	-	-	-	-	-	2.00	2.00	-	-	-
Macon County	830	430	278	241	27	152	148	85	72	2.16	2.74	14	14	-
High Point city	67 640	27 528	18 898	13 407	4 580	8 631	7 435	3 171	2 646	2.46	2.98	1 356	821	535
Davidson County	471	186	126	85	29	60	37	4	4	2.53	2.[illegible]	-	-	-
Forsyth County	6	3	3	3	-	-	-	-	-	2.00	2.00	-	-	-
Guilford County	67 126	27 325	18 758	13 310	4 549	8 567	7 396	3 166	2 641	2.46	2.96	1 356	821	535
Randolph County	37	15	11	9	2	4	2	1	1	2.47	2.82	-	-	-
High Shoals city, Gaston County	605	229	187	128	54	42	40	21	16	2.64	2.96	-	-	-
Hildebran town, Burke County	730	303	243	182	32	85	80	51	41	2.41	2.84	-	-	-
Hillsborough town, Orange County	4 131	1 648	1 163	751	350	485	430	196	158	2.51	3.02	123	123	-
Hobgood town, Halifax County	435	173	123	78	35	50	48	33	23	2.51	3.28	-	-	-
Hoffman town, Richmond County	348	139	89	61	24	50	43	24	[illegible]	2.50	3.22	-	-	-
Holden Beach town, Brunswick County	626	304	[illegible]	210	[illegible]	94	[illegible]	[illegible]	[illegible]	2.28	2.62	-	-	-
Holly Ridge town, Onslow County	724	273	209	141	63	64	55	[illegible]	15	2.66	3.07	-	-	-
Holly Springs town, Wake County	908	311	239	152	69	72	65	29	22	2.92	3.37	-	-	-
Hookerton town, Greene County	422	173	121	94	33	52	50	33	33	2.44	3.03	-	-	-
Hope Mills town, Cumberland County	8 124	2 955	2 313	1 772	475	642	537	155	134	2.75	3.13	80	80	-
Hot Springs town, Madison County	478	199	137	114	21	62	57	33	28	2.40	2.96	-	-	-
Hudson town, Caldwell County	2 819	1 152	882	722	118	270	241	117	80	2.45	2.83	-	-	-
Huntersville town, Mecklenburg County	3 014	1 257	860	666	158	397	360	127	108	2.40	2.95	-	-	-
Icard CDP, Burke County	2 547	997	740	612	81	257	225	80	66	2.55	2.98	6	6	-
Indian Beach town, Carteret County	148	66	48	43	5	18	15	2	-	2.16	2.47	4	-	4
Indian Trail town, Union County	1 642	600	475	528	44	125	102	36	30	2.73	3.06	-	-	-
Jackson town, Northampton County	576	236	161	123	25	77	75	36	32	2.44	3.08	16	16	-
Jacksonville city, Onslow County	29 364	10 916	8 463	6 805	1 435	2 423	2 006	563	478	2.69	3.08	617	595	22
James City CDP, Craven County	4 165	1 674	1 203	941	214	471	403	157	126	2.49	2.95	114	112	2
Jamestown town, Guilford County	2 800	995	747	637	83	248	195	66	46	2.61	3.02	-	-	-
Jamesville town, Martin County	608	262	163	123	57	99	83	48	44	2.32	3.07	4	-	4
Jefferson town, Ashe County	1 080	474	329	256	65	145	135	72	63	2.28	2.78	220	220	-
Jonesville town, Yadkin County	1 540	669	455	319	111	214	196	123	79	2.32	2.85	-	-	-
Kannapolis city	29 320	12 018	8 476	6 405	1 690	3 542	3 150	1 651	1 387	2.44	2.94	378	315	61
Cabarrus County	21 084	8 632	6 109	4 641	1 221	2 523	2 238	1 138	961	2.44	2.94	136	75	61
Rowan County	8 236	3 386	2 367	1 764	468	1 019	912	513	426	2.43	2.94	242	240	-
Kelford town, Bertie County	204	80	52	31	18	28	28	17	15	2.55	3.31	-	-	-
Kenansville town, Duplin County	656	290	136	155	34	64	60	41	33	2.28	2.82	220	220	-
Kenly town	1 549	657	437	287	134	220	208	109	83	2.36	2.88	-	-	-
Johnston County	1 396	594	395	266	113	199	188	102	67	2.35	2.86	-	-	-
Wilson County	153	63	42	21	21	21	20	7	6	2.43	3.10	-	-	-
Kernersville town	10 664	4 755	3 013	2 254	609	1 742	1 462	367	313	2.24	2.82	169	163	5
Forsyth County	10 664	4 755	3 013	2 254	609	1 742	1 462	367	313	2.24	2.82	169	163	5
Guilford County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kill Devil Hills town, Dare County	4 238	1 817	1 142	843	143	675	455	88	64	2.33	2.81	2	-	2
King city	4 008	1 509	1 207	1 036	138	302	267	130	88	2.66	3.01	50	50	-
Forsyth County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stokes County	4 008	1 509	1 207	1 036	138	302	267	130	88	2.66	3.01	50	50	-
Kings Mountain city	8 639	3 464	2 511	1 797	595	953	877	482	386	2.49	2.99	124	124	-
Cleveland County	7 883	3 234	2 310	1 679	518	924	852	475	381	2.44	2.94	124	124	-
Gaston County	756	230	201	118	77	29	25	7	5	3.29	3.55	-	-	-
Kingstown town, Cleveland County	956	270	235	156	64	35	29	14	8	3.54	3.88	-	-	-
Kinston city, Lenoir County	24 155	9 987	6 576	3 998	2 253	3 411	3 153	1 520	1 254	2.42	3.06	1 146	1 091	45
Kittrell town, Vance County	228	81	66	46	16	15	14	5	5	2.81	3.12	-	-	-
Kitty Hawk town, Dare County	1 902	799	541	474	50	258	222	56	40	2.38	2.88	36	-	36
Knightdale town, Wake County	1 884	733	556	456	78	177	153	38	34	2.57	2.98	-	-	-
Kure Beach town, New Hanover County	619	282	199	178	18	83	73	31	18	2.20	2.59	-	-	-
La Grange town, Lenoir County	2 805	1 123	796	495	258	327	308	158	129	2.53	3.20	-	-	-
Lake Junaluska CDP, Haywood County	2 482	1 096	785	672	99	311	278	134	111	2.28	2.86	-	-	-
Lake Lure town, Rutherford County	661	334	247	223	17	87	78	43	28	2.07	2.42	-	-	-
Lake Waccamaw town, Columbus County	751	333	227	181	40	106	95	43	34	2.28	2.73	223	223	-
Landis town, Rowan County	2 333	987	713	580	102	274	249	152	131	2.38	2.82	-	-	-
Lansing town, Ashe County	171	83	53	41	7	30	28	18	13	2.06	2.57	-	-	-
Lasker town, Northampton County	138	62	42	36	6	20	20	13	11	2.24	2.79	-	-	-
Lattimore town, Cleveland County	163	72	53	40	8	19	17	12	11	2.54	2.86	-	-	-
Laurel Park town, Henderson County	1 [illegible]	628	450	422	23	178	167	120	88	2.11	2.52	-	-	-
Laurinburg city, Scotland County	10 765	4 281	2 905	1 664	1 102	1 376	1 291	668	551	2.52	3.16	848	174	674
Lawndale town, Cleveland County	573	239	172	140	26	67	63	45	41	2.40	2.87	-	-	-
Leggett town, Edgecombe County	108	36	27	24	1	9	8	1	-	3.00	3.56	-	-	-
Leland town, Brunswick County	1 801	679	520	413	80	159	141	41	28	2.65	3.07	-	-	-
Lenoir city, Caldwell County	13 989	5 929	4 046	2 993	847	1 883	1 738	808	673	2.36	2.86	203	158	45
Lewiston Woodville town, Bertie County	788	290	228	128	71	63	66	41	36	2.64	3.29	-	-	-
Lewisville CDP, Forsyth County	3 208	1 280	982	831	124	298	261	53	41	2.50	2.85	-	-	-
Lexington city, Davidson County	16 481	6 985	4 644	3 177	1 231	2 341	2 058	962	773	2.36	2.91	100	70	30
Liberty town, Randolph County	2 047	865	539	440	131	286	244	140	122	2.37	2.86	-	-	-
Light Oak CDP, Cleveland County	1 213	384	315	190	102	69	65	31	25	3.16	3.58	125	125	-
Lilesville town, Anson County	468	185	125	98	21	60	60	38	36	2.53	3.19	-	-	-
Lillington town, Harnett County	1 400	636	387	280	111	249	225	129	115	2.20	2.97	648	644	-
Lincolnton city, Lincoln County	6 582	2 713	1 861	1 344	434	852	778	415	353	2.43	2.95	285	285	-
Linden town, Cumberland County	180	65	50	43	6	15	13	8	8	2.77	3.24	-	-	-
Littleton town, Halifax County	801	320	228	140	65	112	104	88	63	2.18	2.77	-	-	-
Locust city, Stanly County	1 840	689	582	517	50	107	96	45	41	2.82	3.12	-	-	-
Long Beach town, Brunswick County	3 816	1 683	1 225	1 078	107	458	395	131	85	2.27	2.64	-	-	-

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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	Householder living alone, 65 years and over: Total	Householder living alone, 65 years and over: Female	Persons per—: Household	Persons per—: Family	Persons in group quarters: Total	Persons in group quarters: Institutionalized persons	Persons in group quarters: Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Long View town	3 229	1 309	952	744	158	447	363	184	155	2.21	2.70	-	-	-
Burke County	358	153	113	90	14	37	34	15	14	2.36	2.7?	-	-	-
Catawba County	2 871	1 249	839	654	144	410	355	169	141	2.30	2.81	-	-	-
Louisburg town, Franklin County	2 193	963	602	369	208	361	342	200	167	2.28	2.97	644	138	506
Love Valley town, Iredell County	67	29	23	20	1	6	6	1	-	2.31	2.52	-	-	-
Lowell city, Gaston County	2 654	1 073	769	564	137	304	264	133	108	2.47	2.95	50	50	-
Lowesville CDP, Lincoln County	1 092	385	312	271	33	73	61	28	21	2.84	3.22	-	-	-
Lucama town, Wilson County	927	368	271	198	63	97	88	42	40	2.52	2.97	6	6	-
Lumber Bridge town, Robeson County	102	41	30	23	6	11	10	4	4	2.49	3.00	-	-	-
Lumberton city, Robeson County	17 894	7 093	4 963	3 165	1 580	2 130	1 966	861	737	2.52	3.06	707	692	15
McAdenville town, Gaston County	830	298	245	196	30	53	50	24	22	2.79	3.13	-	-	-
Macclesfield town, Edgecombe County	493	218	144	116	21	74	70	47	42	2.26	2.81	-	-	-
McDonald town, Robeson County	88	35	27	17	8	8	8	6	3	2.51	2.89	-	-	-
McFarlan town, Anson County	98	38	26	19	7	12	11	7	6	2.58	3.27	-	-	-
McLeansville CDP, Guilford County	1 154	453	349	301	34	101	92	31	22	2.56	2.97	-	-	-
Macon town, Warren County	154	57	41	38	2	16	14	8	7	2.70	3.12	-	-	-
Madison town, Rockingham County	2 371	943	658	467	149	285	254	129	100	2.51	3.04	-	-	-
Maggie Valley town, Haywood County	185	89	62	52	9	27	22	10	7	2.08	2.47	-	-	-
Magnolia town, Duplin County	747	290	213	138	62	76	69	31	16	2.58	3.03	-	-	-
Maiden town	2 574	975	748	567	142	227	212	129	86	2.64	3.08	-	-	-
Catawba County	2 574	975	748	567	142	227	212	129	86	2.64	3.08	-	-	-
Lincoln County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manteo town, Dare County	964	444	232	175	46	132	164	72	57	2.17	2.86	27	26	1
Marietta town, Robeson County	226	64	52	30	22	12	10	5	4	3.22	3.65	-	-	-
Marion city, McDowell County	4 718	2 091	1 334	962	29?	757	712	406	355	2.26	2.90	47	22	25
Mar-Mac CDP, Wayne County	3 282	1 250	940	832	113	271	235	63	53	2.61	2.97	-	-	-
Marshall town, Madison County	802	343	232	156	53	111	108	71	55	2.34	2.87	-	-	-
Mars Hill town, Madison County	911	416	253	223	43	163	138	74	67	2.19	2.83	700	2	698
Marshville town, Union County	1 922	776	517	358	132	152	180	99	83	2.71	3.25	38	38	-
Masonboro CDP, New Hanover County	7 010	2 524	2 150	1 843	164	374	311	78	62	2.78	3.03	-	-	-
Matthews town, Mecklenburg County	13 567	4 812	3 905	3 544	252	907	759	281	244	2.83	3.18	54	50	4
Maxton town	2 371	826	616	366	226	210	199	116	54	2.87	3.41	2	-	2
Robeson County	2 162	761	559	323	214	202	191	115	53	2.84	3.40	2	-	2
Scotland County	209	65	57	43	12	8	8	1	1	3.22	3.47	-	-	-
Mayodan town, Rockingham County	2 471	1 137	742	554	161	395	373	190	178	2.17	2.73	-	-	-
Maysville town, Jones County	892	347	241	163	80	106	100	57	41	2.57	3.16	-	-	-
Mebane city	4 744	1 891	1 375	1 050	282	516	474	212	177	2.51	3.00	10	10	-
Alamance County	4 259	1 687	1 229	939	251	468	432	196	165	2.51	3.01	10	10	-
Orange County	485	194	146	111	31	48	42	16	12	2.50	2.93	-	-	-
Mesic town, Pamlico County	310	118	90	72	16	29	27	23	13	2.61	3.07	-	-	-
Micro town, Johnston County	417	180	122	96	20	58	56	35	29	2.32	2.86	-	-	-
Middleburg town, Vance County	131	47	34	21	11	13	11	5	5	2.78	3.29	-	-	-
Middlesex town, Nash County	730	294	206	143	53	88	78	50	47	2.48	2.95	-	-	-
Millers Creek CDP, Wilkes County	1 787	689	557	460	82	132	116	44	30	2.59	2.92	-	-	-
Milton town, Caswell County	165	84	55	41	10	29	23	16	14	2.20	2.80	-	-	-
Minnesott Beach town, Pamlico County	266	129	99	81	6	30	25	18	15	2.06	2.36	-	-	-
Mint Hill town, Mecklenburg County	11 567	3 987	3 444	3 128	242	543	449	168	144	2.90	3.15	-	-	-
Mocksville town, Davie County	3 225	1 383	922	693	150	461	417	161	163	2.33	2.80	174	163	11
Monroe city, Union County	15 868	5 935	4 184	2 797	1 166	1 751	1 507	664	563	2.67	3.21	259	216	43
Montreat town, Buncombe County	394	181	131	117	12	50	43	14	13	2.18	2.54	299	-	296
Mooresboro town, Cleveland County	294	126	81	58	21	45	40	26	19	2.33	3.01	-	-	-
Mooresville town, Iredell County	8 089	3 592	2 524	1 815	511	1 068	961	470	402	2.52	3.07	248	248	-
Moravian Falls CDP, Wilkes County	1 729	730	498	384	88	232	193	50	43	2.37	2.85	8	-	8
Morehead City town, Carteret County	5 746	2 675	1 573	1 058	419	1 102	978	446	343	2.15	2.82	300	295	5
Morganton city, Burke County	13 610	6 048	3 956	2 918	866	2 092	1 863	753	644	2.25	2.80	1 475	1 422	53
Morrisville town	1 022	415	291	236	37	124	96	22	15	2.46	2.94	-	-	-
Durham County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wake County	1 022	415	291	236	37	124	96	22	15	2.46	2.94	-	-	-
Morven town, Anson County	590	221	154	84	64	67	62	35	30	2.67	3.27	-	-	-
Mountain Home CDP, Henderson County	1 906	774	595	503	72	179	158	74	58	2.65	2.82	-	-	-
Mountain View CDP, Catawba County	3 087	1 203	1 092	930	127	191	171	52	41	2.88	3.17	-	-	-
Mount Airy city, Surry County	6 983	3 214	1 988	1 382	506	1 226	1 140	626	517	2.17	2.80	173	127	46
Mount Gilead town, Montgomery County	1 279	480	348	236	99	132	124	74	64	2.66	3.25	57	57	-
Mount Holly city, Gaston County	7 710	3 115	2 220	1 693	425	895	782	330	283	2.48	2.97	-	-	-
Mount Olive town	4 177	1 710	1 130	675	364	580	545	298	254	2.44	3.10	405	147	258
Duplin County	1	1	-	-	-	1	1	-	-	1.00	-	-	-	-
Wayne County	4 176	1 709	1 130	675	364	579	544	298	254	2.44	3.10	405	147	258
Mount Pleasant town, Cabarrus County	1 027	420	301	242	45	119	109	96	53	2.45	2.94	-	-	-
Mulberry CDP, Wilkes County	2 330	897	718	619	83	179	151	65	56	2.61	2.92	-	-	-
Murfreesboro town, Hertford County	1 993	854	588	452	117	266	247	145	126	2.33	2.87	587	4	583
Murphy town, Cherokee County	1 547	711	441	304	118	270	250	145	127	2.18	2.84	28	24	4
Myrtle Grove CDP, New Hanover County	4 275	1 681	1 222	1 127	132	389	313	93	73	2.54	2.80	-	-	-
Nags Head town, Dare County	1 720	768	478	425	42	290	220	50	31	2.24	2.78	118	114	4
Nashville town, Nash County	3 351	1 291	927	702	187	344	318	158	126	2.62	3.14	284	284	-
Navassa town, Brunswick County	445	135	114	67	33	21	20	8	7	3.30	3.68	-	-	-
Neuse Forest CDP, Craven County	1 110	382	343	315	24	39	29	7	4	2.51	3.06	-	-	-
New Bern city, Craven County	16 626	7 284	4 567	3 010	1 376	2 667	2 382	1 083	869	2.33	2.97	437	415	22
New Hope CDP, Wake County	5 508	2 240	1 686	1 449	172	553	436	98	71	2.46	2.84	125	125	-
New Hope CDP, Wayne County	4 497	1 522	1 298	1 109	151	229	184	48	37	2.95	3.22	4	4	-
Newland town, Avery County	637	284	194	139	67	90	86	42	36	2.26	2.74	8	8	-
New London town, Stanly County	414	158	128	125	22	30	27	10	9	2.62	2.97	-	-	-
Newport town, Carteret County	2 229	856	646	553	74	210	190	46	40	2.60	3.03	237	232	5
New River Station CDP, Onslow County	1 651	442	432	415	9	10	9	1	-	3.74	3.79	8 081	-	8 081
Newton city, Catawba County	9 065	3 783	2 580	1 873	575	1 203	1 078	518	433	2.42	2.94	239	223	16
Newton Grove town, Sampson County	511	205	147	130	31	58	56	25	22	2.49	3.02	-	-	-
Norlina town, Warren County	906	419	290	203	75	129	119	79	61	2.38	2.86	-	-	-
Norman town, Richmond County	105	45	27	23	4	18	18	7	6	2.33	3.04	-	-	-
North Hickory CDP, Catawba County	4 299	1 606	1 306	1 181	98	300	264	108	88	2.68	3.01	-	-	-

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Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	65 years and over: Total	65 years and over: Female	Persons per—: Household	Persons per—: Family	Persons in group quarters: Total	Persons in group quarters: Institutionalized persons	Persons in group quarters: Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Northlakes CDP, Caldwell County	1 219	449	377	355	17	72	63	8	8	2.71	2.90	-	-	-
North Wilkesboro town, Wilkes County	3 258	1 471	867	565	266	604	550	274	222	2.21	2.84	125	121	5
Norwood town, Stanly County	1 617	629	474	342	109	155	147	78	66	2.57	3.02	-	-	-
Oakboro town, Stanly County	600	232	168	130	31	64	60	38	31	2.56	3.14	-	-	-
Oak City town, Martin County	386	147	105	86	15	42	38	19	14	2.63	3.22	-	-	-
Ocean Isle Beach town, Brunswick County	523	242	183	171	8	59	56	18	14	2.16	2.51	-	-	-
Ogden CDP, New Hanover County	3 223	1 216	984	827	106	232	197	44	32	2.65	2.98	-	-	-
Old Fort town, McDowell County	720	305	204	139	51	101	92	46	34	2.36	2.57	-	-	-
Oriental town, Pamlico County	786	365	275	231	38	90	87	50	38	2.15	2.50	-	-	-
Orrum town, Robeson County	103	38	26	16	9	12	11	7	5	2.71	3.38	-	-	-
Oxford city, Granville County	7 364	2 934	2 040	1 305	630	894	835	467	383	2.52	3.09	519	513	6
Pantego town, Beaufort County	171	74	48	32	13	26	25	20	17	2.31	2.90	-	-	-
Parkton town, Robeson County	387	165	106	81	20	59	58	34	30	[illegible]	2.95	-	-	-
Parkwood CDP, Durham County	4 123	1 428	1 145	988	137	283	210	43	38	2.89	3.25	-	-	-
Parmele town, Martin County	321	117	81	43	30	36	32	19	14	2.74	3.44	-	-	-
Patterson Springs town, Cleveland County	630	246	204	165	26	42	37	24	21	2.56	2.88	-	-	-
Peachland town, Anson County	384	135	107	81	23	28	23	17	15	2.84	3.33	-	-	-
Pembroke town, Robeson County	2 212	863	576	293	255	287	253	103	76	2.56	3.20	32	32	-
Pikeville town, Wayne County	568	258	184	154	25	73	71	41	38	2.31	2.79	-	-	-
Pilot Mountain town, Surry County	1 181	522	350	280	71	172	158	90	79	2.25	2.81	-	-	-
Pinebluff town, Moore County	878	342	256	214	34	86	81	36	36	2.56	3.02	-	-	-
Pinehurst village, Moore County	4 910	2 445	1 841	1 754	64	604	562	332	255	2.01	2.31	153	152	-
Pine Knoll Shores town, Carteret County	1 360	642	490	463	23	152	137	64	45	2.12	2.42	-	-	-
Pine Level town, Johnston County	1 217	526	372	305	54	154	144	78	60	2.31	2.78	-	-	-
Pinetops town, Edgecombe County	1 514	566	409	253	125	157	152	85	65	2.67	3.21	-	-	-
Pineville town, Mecklenburg County	2 817	1 342	775	582	153	567	505	98	80	2.10	2.82	53	46	7
Piney Green CDP, Onslow County	8 990	3 143	2 574	2 151	319	569	432	65	51	2.86	3.13	-	-	-
Pink Hill town, Lenoir County	547	214	147	109	33	67	58	24	19	2.56	3.13	-	-	-
Pittsboro town, Chatham County	1 332	564	364	284	63	200	180	95	82	2.23	2.82	54	54	-
Pleasant Garden CDP, Guilford County	2 196	839	652	521	96	187	158	46	36	2.60	2.97	43	43	-
Pleasant Hill CDP, Wilkes County	1 114	472	354	306	32	118	110	60	53	2.36	2.77	-	-	-
Plymouth town, Washington County	4 313	1 646	1 187	738	392	461	450	250	222	2.62	3.19	15	15	-
Polkton town, Anson County	662	236	168	110	46	68	64	40	31	2.81	3.42	-	-	-
Polkville city, Cleveland County	1 514	596	446	392	41	150	140	78	66	2.54	3.20	-	-	-
Pollocksville town, Jones County	236	134	89	73	13	45	42	25	22	2.23	2.78	-	-	-
Pope AFB CDP, Cumberland County	1 751	468	455	419	22	13	12	-	-	3.74	3.81	1 108	-	1 108
Poplar Tent CDP, Cabarrus County	3 872	1 414	1 139	980	118	275	244	90	72	2.74	3.09	-	-	-
Powellsville town, Bertie County	103	46	28	21	6	18	15	11	10	2.24	2.93	-	-	-
Princeton town, Johnston County	1 181	505	338	245	80	167	152	87	74	2.34	2.92	-	-	-
Princeville town, Edgecombe County	1 646	621	432	175	234	189	180	106	87	2.65	3.30	4	-	4
Proctorville town, Robeson County	168	63	46	36	8	17	15	8	7	2.67	3.07	-	-	-
Pumpkin Center CDP, Onslow County	2 857	907	790	687	72	117	96	38	31	3.15	3.38	-	-	-
Raeford city, Hoke County	3 312	1 250	942	641	271	308	287	149	131	2.65	3.13	157	157	-
Raleigh city, Wake County	194 230	85 822	48 253	36 325	9 [illegible]	37 569	27 657	5 850	4 842	2.25	2.92	13 721	5 493	8 228
Ramseur town, Randolph County	1 196	503	354	286	52	149	137	87	73	2.36	2.85	-	-	-
Randleman city, Randolph County	2 612	1 090	758	532	183	332	293	137	120	2.40	2.90	-	-	-
Ranlo town, Gaston County	1 653	627	470	365	85	157	143	78	63	2.63	3.06	-	-	-
Raynham town, Robeson County	106	40	31	23	6	9	9	1	1	2.65	3.23	-	-	-
Red Oak town, Nash County	280	107	75	56	12	32	30	14	12	2.62	3.23	-	-	-
Red Springs town, Robeson County	3 761	1 433	1 005	631	327	428	399	229	196	2.62	3.24	38	38	-
Reidsville city, Rockingham County	11 971	5 054	3 329	2 744	636	1 725	1 565	808	673	2.37	2.96	212	206	6
Rennert town, Robeson County	217	79	53	34	13	26	26	14	12	2.73	3.40	-	-	-
Rhodhiss town	638	230	174	128	32	56	51	28	25	2.77	3.21	-	-	-
Burke County	226	88	64	50	10	24	21	10	7	2.57	3.06	-	-	-
Caldwell County	412	142	110	78	22	32	30	18	18	2.90	3.29	-	-	-
Richfield town, Stanly County	535	188	144	122	15	44	41	15	12	2.85	3.33	-	-	-
Richlands town, Onslow County	906	386	273	198	62	113	104	64	55	2.34	3.13	-	-	-
Rich Square town, Northampton County	964	395	284	227	67	111	107	64	52	2.44	2.94	24	24	-
River Bend town, Craven County	2 225	1 023	804	747	50	219	181	89	66	2.17	2.45	153	153	-
River Road CDP, Beaufort County	3 892	1 521	1 154	980	158	367	331	108	80	2.56	2.96	-	-	-
Roanoke Rapids city, Halifax County	15 549	6 321	4 406	3 268	944	1 915	1 787	835	735	2.46	3.01	173	135	38
Robbins city, Moore County	957	395	277	192	62	118	105	61	56	2.42	2.88	13	13	-
Robbinsville town, Graham County	723	311	204	145	47	107	99	47	41	2.28	2.87	6	6	-
Robersonville town, Martin County	1 940	769	537	366	153	232	220	136	111	2.52	3.13	-	-	-
Rockingham city, Richmond County	9 041	3 727	2 559	1 828	637	1 168	1 089	511	419	2.43	3.00	358	341	17
Rockwell town, Rowan County	1 522	616	459	377	66	157	144	73	56	2.47	2.83	78	78	-
Rocky Mount city	48 648	18 871	13 223	8 878	3 758	5 648	4 980	2 103	1 736	2.58	3.13	349	314	35
Edgecombe County	17 040	6 124	4 416	2 327	1 856	1 708	1 520	713	583	2.78	3.33	17	4	13
Nash County	31 608	12 747	8 807	6 552	1 902	3 940	3 460	1 390	1 153	2.48	3.02	332	310	22
Rolesville town, Wake County	572	220	177	147	26	43	41	22	22	2.60	2.95	-	-	-
Ronda town, Wilkes County	367	149	107	86	15	42	38	21	15	2.46	2.90	-	-	-
Roper town, Washington County	669	234	175	104	63	59	56	30	26	2.86	3.42	-	-	-
Roseboro town, Sampson County	1 441	534	398	257	117	136	132	75	61	2.70	3.27	-	-	-
Rose Hill town, Duplin County	1 278	538	356	286	68	182	172	114	92	2.37	2.99	11	11	-
Rosman town, Transylvania County	385	147	101	79	16	46	44	25	19	2.62	3.23	-	-	-
Rowland town, Robeson County	1 139	451	296	168	114	155	149	91	74	2.53	3.22	-	-	-
Roxboro city, Person County	7 087	3 020	1 978	1 279	578	1 042	951	474	[illegible]	2.34	2.92	275	262	13
Roxobel town, Bertie County	244	102	71	56	9	31	30	22	[illegible]	2.36	2.87	-	-	-
Royal Pines CDP, Buncombe County	4 414	1 688	1 323	1 184	108	365	314	88	57	2.61	2.99	4	4	-
Rural Hall town, Forsyth County	1 652	736	454	368	76	282	245	82	69	2.24	2.80	-	-	-
Ruth town, Rutherford County	386	136	111	83	19	24	24	15	11	2.71	3.08	-	-	-
Rutherford College town, Burke County	1 128	468	339	279	46	129	123	59	50	2.41	2.88	-	-	-
Rutherfordton town, Rutherford County	3 433	1 473	973	761	180	[illegible]	460	236	202	2.33	2.92	184	184	-
St. Helena village, Pender County	321	127	87	78	8	40	38	15	12	2.53	3.15	-	-	-
St. Pauls town, Robeson County	1 988	800	556	401	130	245	223	117	101	2.49	3.04	4	4	-
St. Stephens CDP, Catawba County	8 673	3 247	2 617	2 192	315	630	543	144	125	2.67	3.02	61	55	6
Salem CDP, Burke County	2 271	903	699	560	96	204	180	61	55	2.51	2.86	-	-	-
Salemburg town, Sampson County	436	194	132	108	20	62	61	38	33	2.11	2.62	-	-	-
Salisbury city, Rowan County	21 082	9 162	5 822	4 130	1 412	3 340	3 012	1 452	1 232	2.30	2.82	2 395	[illegible]	1 372
Saluda city	489	208	153	124	24	55	51	25	21	2.35	2.77	-	-	-
Henderson County	3	2	1	1	-	1	1	-	-	1.50	2.00	-	-	-
Polk County	486	206	152	123	24	54	50	25	21	2.36	2.78	-	-	-
Sandy Creek town, Brunswick County	243	78	68	64	3	10	9	2	1	3.08	3.30	-	-	-

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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State / County / Place and [In Selected States] County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	65 years and over: Total	65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Sanford city, Lee County	14 089	5 735	3 810	2 474	1 054	1 925	1 635	682	562	2.46	3.02	344	[illegible]	15
Santeetlah town, Graham County	47	27	15	14	1	12	9	6	5	1.74	2.13	-	-	-
Saratoga town, Wilson County	342	135	96	83	8	39	37	18	18	2.53	3.11	-	-	-
Sawmills town, Caldwell County	4 098	1 513	1 157	977	124	356	289	75	60	2.73	3.07	-	-	-
Saxapahaw CDP, Alamance County	1 178	425	344	265	66	81	72	23	17	2.77	3.12	-	-	-
Scotland Neck town, Halifax County	2 503	982	678	416	233	304	296	159	145	2.55	3.18	72	72	-
Seaboard town, Northampton County	781	296	211	115	86	85	76	45	37	2.67	3.24	-	-	-
Seagate CDP, New Hanover County	5 394	2 101	1 579	1 348	174	522	405	134	106	2.57	2.95	50	50	-
Seagrove town, Randolph County	244	103	75	63	9	28	27	14	12	2.37	2.83	-	-	-
Sedge Garden CDP, Forsyth County	2 784	1 053	877	800	60	176	154	73	60	2.64	2.94	-	-	-
Selma town, Johnston County	4 509	1 857	1 255	816	364	602	561	315	289	2.43	3.08	1	-	-
Seven Devils town	117	55	38	33	4	17	17	3	-	2.13	2.63	-	-	-
Avery County	20	10	6	5	-	4	4	2	-	2.00	2.67	-	-	-
Watauga County	97	45	32	28	4	13	13	1	-	2.16	2.63	-	-	-
Seven Lakes CDP, Moore County	1 991	869	771	741	23	98	88	56	43	2.29	2.42	58	58	-
Seven Springs town, Wayne County	163	79	47	36	11	32	32	17	17	2.06	2.77	-	-	-
Severn town, Northampton County	260	107	75	57	14	32	31	23	18	2.43	2.67	-	-	-
Shallotte town, Brunswick County	857	367	282	253	22	85	80	30	25	2.34	2.73	108	108	-
Sharpsburg town	1 536	576	424	278	131	152	124	33	25	2.67	3.12	-	-	-
Edgecombe County	70	25	21	17	2	4	3	-	-	2.80	3.13	-	-	-
Nash County	1 054	421	295	222	62	126	103	25	20	2.50	3.00	-	-	-
Wilson County	412	130	108	37	67	22	18	8	5	3.17	3.44	-	-	-
Shelby city, Cleveland County	14 284	6 081	3 995	2 488	1 315	2 086	1 937	949	811	2.35	2.96	403	372	31
Sherrills Ford CDP, Catawba County	3 174	1 268	968	884	67	300	238	81	40	2.50	2.85	11	-	11
Siler City town, Chatham County	4 827	1 906	1 339	943	319	567	506	230	191	2.44	2.92	181	181	-
Silver City CDP, Hoke County	1 343	434	327	151	154	107	87	46	34	3.09	3.66	-	-	-
Silver Lake CDP, New Hanover County	4 071	1 435	1 149	943	145	286	212	47	33	2.84	3.16	-	-	-
Simpson village, Pitt County	410	161	117	88	23	44	42	21	20	2.56	3.08	-	-	-
Sims town, Wilson County	124	56	35	28	7	21	20	16	16	2.21	2.91	-	-	-
Skippers Corner CDP, New Hanover County	7 461	2 660	2 173	1 845	256	487	366	81	68	2.80	3.10	-	-	-
Smithfield town, Johnston County	7 174	3 056	1 997	1 252	554	1 059	981	460	386	2.35	2.96	364	338	26
Sneads Ferry CDP, Onslow County	2 031	824	630	512	58	194	161	65	43	2.46	2.83	-	-	-
Snow Hill town, Greene County	1 380	556	387	257	113	172	159	94	85	2.43	2.84	18	3	15
Southern Pines town, Moore County	8 777	3 953	2 423	1 734	634	1 530	1 385	626	530	2.22	2.87	332	332	-
Southern Shores town, Dare County	1 447	617	499	466	24	118	103	47	30	2.35	2.62	-	-	-
South Gastonia CDP, Gaston County	5 487	2 011	1 572	1 216	257	439	371	137	107	2.73	3.11	-	-	-
South Henderson CDP, Vance County	1 374	509	378	255	81	131	123	64	48	2.70	3.16	-	-	-
Southport city, Brunswick County	2 274	981	650	483	133	331	305	166	138	2.32	2.91	95	95	-
South Rosemary CDP, Halifax County	1 955	781	551	366	151	230	200	83	56	2.50	2.97	-	-	-
South Weldon CDP, Halifax County	1 640	542	417	216	172	125	111	56	47	3.03	3.53	-	-	-
Sparta town, Alleghany County	1 759	809	484	365	100	325	307	180	155	2.17	2.88	198	193	5
Speed town, Edgecombe County	88	32	25	16	6	7	7	3	2	2.75	3.16	-	-	-
Spencer town, Rowan County	3 033	1 279	837	609	183	442	394	238	178	2.37	2.97	186	186	-
Spencer Mountain town, Gaston County	135	42	38	34	3	4	2	-	-	3.21	3.36	-	-	-
Spindale town, Rutherford County	3 868	1 628	1 093	804	232	535	499	305	251	2.38	2.96	172	172	-
Spring Hope town, Nash County	1 221	522	360	255	85	162	146	89	75	2.34	2.88	-	-	-
Spring Lake town, Cumberland County	7 524	2 739	2 019	1 335	506	720	546	72	48	2.75	3.16	-	-	-
Spruce Pine town, Mitchell County	2 010	858	610	474	118	248	234	134	109	2.34	2.84	-	-	-
Staley town, Randolph County	204	81	57	45	6	24	23	8	8	2.52	3.07	-	-	-
Stallings town, Union County	2 132	744	617	523	72	127	106	36	31	2.87	3.17	-	-	-
Stanfield town, Stanly County	517	202	146	125	17	56	54	28	20	2.56	3.12	-	-	-
Stanley town, Gaston County	2 734	1 073	801	632	152	272	247	112	87	2.55	3.01	86	86	-
Stanleyville CDP, Forsyth County	4 779	2 043	1 417	1 151	195	626	531	164	139	2.34	2.81	-	-	-
Stantonsburg town, Wilson County	782	316	224	167	48	92	88	55	45	2.47	3.00	-	-	-
Star town, Montgomery County	708	291	202	146	36	89	85	41	36	2.43	3.00	67	57	10
Statesville city, Iredell County	17 270	7 315	4 791	3 137	1 418	2 524	2 270	1 105	921	2.36	2.96	257	222	35
Stedman town, Cumberland County	577	210	165	143	17	45	41	23	22	2.75	3.15	-	-	-
Stem town, Granville County	249	103	69	56	8	34	31	19	15	2.42	3.01	-	-	-
Stokesdale town, Guilford County	2 052	766	606	524	59	160	147	85	75	2.68	3.06	42	42	-
Stoneville town, Rockingham County	1 109	460	314	237	65	146	135	84	74	2.41	2.97	-	-	-
Stonewall town, Pamlico County	279	120	80	63	14	40	34	24	21	2.33	2.86	-	-	-
Stony Point CDP	1 286	492	366	303	51	126	106	63	52	2.61	3.06	-	-	-
Alexander County	1 131	436	331	274	46	105	93	58	49	2.59	3.03	-	-	-
Iredell County	155	56	35	29	5	21	13	5	3	2.77	3.34	-	-	-
Stovall town, Granville County	409	155	122	91	26	33	32	22	18	2.64	3.04	-	-	-
Sugar Mountain village, Avery County	132	65	41	35	5	24	21	5	3	2.03	2.51	-	-	-
Summerfield CDP, Guilford County	2 051	747	608	511	74	139	123	52	45	2.75	3.06	-	-	-
Sunset Beach town, Brunswick County	311	139	113	110	1	26	24	10	6	2.24	2.49	-	-	-
Surf City town	970	494	310	279	21	184	151	35	23	1.96	2.36	-	-	-
Onslow County	317	156	109	99	5	47	39	14	9	2.03	2.36	-	-	-
Pender County	653	338	201	180	16	137	112	21	14	1.93	2.36	-	-	-
Swannanoa CDP, Buncombe County	3 347	1 377	977	756	156	400	354	190	158	2.43	2.94	191	130	61
Swansboro town, Onslow County	1 160	522	358	276	70	164	152	67	56	2.22	2.72	5	-	5
Swepsonville CDP, Alamance County	1 195	466	358	313	34	108	92	34	28	2.56	2.98	-	-	-
Sylva town, Jackson County	1 683	797	484	382	90	313	283	132	102	2.12	2.73	115	100	15
Tabor City town, Columbus County	2 287	938	635	440	156	303	296	169	132	2.42	3.03	63	54	9
Tarboro town, Edgecombe County	10 533	4 241	3 005	2 155	730	1 236	1 163	600	520	2.48	3.05	[illegible]	446	16
Tar Heel town, Bladen County	115	42	34	25	6	8	7	2	2	2.74	3.06	-	-	-
Taylorsville town, Alexander County	1 417	637	397	277	99	240	229	116	96	2.22	2.82	148	145	-
Taylortown town, Moore County	543	206	141	81	50	65	57	25	19	2.64	3.32	-	-	-
Teachey town, Duplin County	244	95	69	50	15	26	25	12	8	2.57	3.07	-	-	-
Thomasville city, Davidson County	15 598	6 529	4 381	2 995	1 137	2 148	1 885	839	684	2.39	2.94	323	322	1
Toast CDP, Surry County	2 072	848	614	476	113	234	218	110	98	2.44	2.93	53	53	-
Topsail Beach town, Pender County	346	179	112	108	1	67	61	28	20	1.93	2.42	-	-	-
Trenton town, Jones County	248	111	68	53	14	43	42	27	22	2.23	2.38	-	-	-
Trent Woods town, Craven County	2 306	898	779	725	45	119	109	55	44	2.63	2.87	-	-	-
Trinity CDP, Randolph County	5 468	2 102	1 648	1 352	208	454	396	152	125	2.60	2.96	-	-	-
Troutman town, Iredell County	1 463	554	412	333	58	142	130	68	56	2.66	3.19	-	-	-
Troy town, Montgomery County	2 868	1 095	734	557	179	361	329	177	149	2.44	3.02	738	727	[illegible]
Tryon town, Polk County	1 578	846	434	335	87	412	382	304	284	1.87	2.61	102	102	-
Turkey town, Sampson County	234	92	65	56	8	27	27	15	13	2.54	3.17	-	-	-
Valdese town, Burke County	3 914	1 692	1 166	900	206	526	482	257	225	2.31	2.80	-	-	-

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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and (In Selected States) County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Nonfamily households: Householder living alone: Total	Nonfamily households: Householder living alone: 65 years and over: Total	Nonfamily households: Householder living alone: 65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Persons in group quarters: Institutionalized persons	Persons in group quarters: Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Valley Hill CDP, Henderson County	1 794	780	540	445	73	239	201	95	81	2.35	2.92	[illegible]	[illegible]	-
Vanceboro town, Craven County	541	261	218	186	23	103	89	55	51	2.47	2.99	-	-	-
Vandemere town, Pamlico County	230	103	84	62	19	38	32	15	13	2.43	3.06	-	-	-
Vander CDP, Cumberland County	1 179	450	341	258	61	109	95	36	24	2.62	3.51	-	-	-
Varnamtown town, Brunswick County	404	160	127	117	9	33	32	18	13	2.53	2.97	-	-	-
Vass town, Moore County	670	252	197	145	40	55	47	25	22	2.66	3.21	-	-	-
Wade town, Cumberland County	330	119	98	83	8	22	21	6	6	2.71	3.04	-	-	-
Wadesboro town, Anson County	238	121	86	50	13	35	33	18	14	2.36	3.05	-	-	-
Wagram town, Scotland County	3 513	1 437	943	567	200	494	435	225	197	2.50	3.15	[illegible]	[illegible]	[illegible]
Wake Forest town, Wake County	480	120	133	88	36	57	52	35	23	2.53	3.12	-	-	-
Walkertown town, Forsyth County	5 563	2 143	1 615	1 237	306	528	452	152	[illegible]	2.61	3.06	[illegible]	[illegible]	[illegible]
	1 230	511	374	315	50	137	128	73	[illegible]	2.35	2.90	-	-	-
Wallace town	2 878	1 170	851	564	196	319	302	[illegible]	146	2.46	2.96	[illegible]	[illegible]	-
Duplin County	2 851	1 157	811	566	195	346	319	[illegible]	143	2.46	2.96	[illegible]	[illegible]	-
Pender County	28	13	10	8	1	3	3	-	-	2.15	2.50	-	-	-
Walnut Cove town, Stokes County	982	436	278	198	66	148	140	55	46	2.31	[illegible]	[illegible]	[illegible]	-
Walnut Creek village, Wayne County	623	275	201	195	5	74	73	5	5	2.30	[illegible]	-	-	-
Walnutbend town, Greene County	188	84	54	43	8	30	28	18	15	2.24	2.55	-	-	-
Wanchese CDP, Dare County	1 380	513	371	310	44	142	116	48	41	2.69	3.15	-	-	-
Warrenton town, Warren County	908	417	263	130	56	154	134	56	44	2.29	3.36	-	-	-
Warsaw town, Duplin County	2 733	1 306	757	473	204	549	514	165	125	2.51	3.13	[illegible]	[illegible]	-
Washington city, Beaufort County	8 729	3 578	2 115	1 453	760	1 464	1 119	584	500	2.44	3.08	[illegible]	[illegible]	[illegible]
Washington Park town, Beaufort County	403	153	133	112	14	54	54	30	29	2.63	2.69	-	-	-
Watha town, Pender County	98	36	30	23	4	6	6	5	4	2.54	3.00	-	-	-
Waxhaw town, Union County	1 258	478	346	274	55	83	78	30	25	3.00	3.43	-	-	-
Weaverville town, Henderson County	6 578	2 858	1 834	1 473	306	864	674	461	412	2.27	2.79	[illegible]	[illegible]	-
Webster town, Jackson County	2 107	882	606	492	95	276	252	98	85	2.38	2.95	-	-	-
	410	188	129	99	26	61	58	23	18	2.43	2.84	-	-	-
Weddington town	3 803	1 223	1 111	1 034	45	112	89	32	25	3.11	3.28	-	-	-
Mecklenburg County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Union County	3 803	1 223	1 111	1 034	45	112	89	32	25	3.11	3.28	-	-	-
Welcome CDP, Davidson County	3 377	1 290	1 128	832	83	254	224	95	84	2.62	2.98	-	-	-
Weldon town, Halifax County	1 392	574	368	247	104	205	191	100	79	2.43	3.14	-	-	-
Wendell town, Wake County	2 719	1 084	774	604	143	290	269	136	119	2.56	3.08	103	91	12
West Canton CDP, Haywood County	1 119	450	345	287	48	105	103	52	48	2.48	2.80	-	-	-
West Jefferson town, Ashe County	1 032	478	291	203	77	185	173	84	74	2.11	2.74	-	-	-
West Marion CDP, McDowell County	1 591	548	367	305	70	143	128	54	42	2.38	2.78	-	-	-
Westport CDP, Lincoln County	1 290	530	430	405	16	73	58	16	15	2.56	2.77	-	-	-
West Smithfield CDP, Johnston County	2 246	912	560	538	112	352	334	124	98	2.46	2.67	165	165	-
Whispering Pines village, Moore County	1 243	648	513	488	11	139	136	104	83	1.92	2.15	-	-	-
Williams town	880	321	225	147	63	96	91	46	40	2.84	3.23	-	-	-
Edgecombe County	464	158	119	78	31	39	38	[illegible]	17	2.94	3.46	-	-	-
Nash County	306	163	106	69	32	57	54	[illegible]	23	2.43	3.15	-	-	-
White Lake town, Bladen County	386	173	119	105	11	54	53	14	10	2.21	2.72	-	-	-
White Plains CDP, Surry County	1 027	429	304	250	29	125	125	46	38	2.39	2.67	-	-	-
Whiteville city, Columbus County	4 830	2 078	1 350	912	362	728	663	313	264	2.37	3.00	144	144	-
Wilkesboro town, Wilkes County	2 238	984	673	503	142	311	275	90	79	2.29	2.78	334	333	-
Williamston town, Martin County	5 353	2 178	1 474	942	482	704	652	344	290	2.46	3.06	150	146	-
Wilmington city, New Hanover County	53 399	20 557	13 600	9 031	4 238	6 954	7 736	3 053	2 522	2.26	2.91	2 221	[illegible]	[illegible]
Wilson city, Wilson County	36 351	14 461	9 688	6 267	2 958	4 773	4 258	1 146	1 457	2.44	3.04	1 578	[illegible]	[illegible]
Windsor town, Bertie County	4 231	1 673	1 224	1 088	114	449	379	105	88	2.53	2.98	173	-	173
Winfall town, Perquimans County	2 042	556	506	460	116	250	247	144	117	2.39	2.54	-	-	-
Winghan town, Union County	405	218	147	111	30	71	64	36	36	2.25	2.80	-	-	-
	1 775	632	481	361	69	151	131	51	45	2.81	3.25	1 046	-	1 046
Winston-Salem city, Forsyth County	136 239	58 910	36 269	24 545	10 025	23 630	20 277	6 794	5 529	2.27	2.63	7 246	2 365	4 881
Winterville town, Pitt County	2 703	1 057	776	518	234	287	259	113	101	2.63	3.16	33	33	-
Winton town, Hertford County	771	332	218	141	69	64	59	34	29	2.55	3.10	[illegible]	[illegible]	-
Woodfin town, Buncombe County	2 736	1 167	784	587	157	413	365	162	148	2.39	2.85	-	-	-
Woodland town, Northampton County	780	272	226	137	64	64	61	30	30	2.79	3.24	-	-	-
Wrightsboro CDP, New Hanover County	4 544	1 867	1 329	1 081	191	368	317	107	86	2.68	3.06	224	224	-
Wrightsville Beach town, New Hanover County	2 934	1 401	873	558	71	728	632	75	57	2.09	2.57	3	-	3
Yadkinville town, Yadkin County	2 198	958	656	461	137	301	278	130	83	2.29	2.81	[illegible]	-	-
Yanceyville town, Caswell County	1 823	730	456	256	178	241	234	139	[illegible]	2.32	2.96	350	[illegible]	-
Yaupon Beach town, Brunswick County	734	342	233	225	20	109	102	40	23	2.15	2.82	-	-	-
Youngsville town, Franklin County	424	166	117	82	30	51	47	30	30	2.52	3.13	-	-	-
Zebulon town, Wake County	3 002	1 176	848	555	246	328	303	165	145	2.63	3.16	81	69	12

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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

	Race							Not of Hispanic origin			
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other races	Hispanic origin (of any race)	White	Black	Other races	Hispanic origin
North Carolina	6,628,637	5,008,491	1,456,323	80,155	52,166	31,502	76,726	4,871,127	1,449,142	131,643	2,818,153
18 years and over...	5,022,488	3,902,539	1,007,858	53,649	36,824	21,620	52,769	3,876,739	1,003,427	89,553	
Alamance County	108,213	86,373	20,822	303	487	228	736	85,913	20,763	801	45,312
18 years and over...	84,538	68,636	15,190	239	325	148	473	68,241	15,163	561	
Alexander County	27,544	25,667	1,673	52	49	103	184	25,597	1,662	101	11,197
18 years and over...	20,771	19,462	1,179	34	25	71	128	19,415	1,170	58	
Alleghany County	9,590	9,338	177	8	5	62	85	9,316	176	13	5,344
18 years and over...	7,535	7,337	140	8	2	48	64	7,322	139	10	
Anson County	23,474	12,264	11,106	69	27	8	67	12,232	11,078	97	9,255
18 years and over...	17,130	9,622	7,434	47	20	7	50	9,595	7,417	68	
Ashe County	22,209	21,960	144	21	31	53	102	21,910	144	53	11,119
18 years and over...	17,406	17,205	113	15	23	50	94	17,160	113	39	
Avery County	14,867	14,596	158	23	23	67	118	14,554	156	39	8,923
18 years and over...	11,529	11,300	137	16	17	59	94	11,269	136	30	
Beaufort County	42,283	28,949	13,194	28	48	64	197	28,845	13,155	86	19,598
18 years and over...	31,328	22,442	8,786	25	36	39	123	22,368	8,769	68	
Bertie County	20,388	7,790	12,531	46	14	7	32	7,782	12,512	62	8,331
18 years and over...	14,547	6,154	8,351	30	11	1	25	6,147	8,336	39	
Bladen County	28,663	16,926	11,199	464	30	44	150	16,860	11,167	486	12,685
18 years and over...	21,057	13,067	7,624	314	21	31	97	13,022	7,607	331	
Brunswick County	50,985	41,336	9,211	242	81	115	376	41,120	9,172	317	37,114
18 years and over...	38,960	32,438	6,210	174	62	76	243	32,303	6,186	228	
Buncombe County	174,821	158,979	14,336	486	765	255	1,173	158,117	14,279	1,352	77,951
18 years and over...	135,886	124,838	10,026	346	530	146	788	124,242	9,993	863	
Burke County	75,744	69,521	5,178	133	794	118	344	69,306	5,159	935	31,575
18 years and over...	57,937	53,688	3,693	95	282	79	232	53,546	3,684	475	
Cabarrus County	98,935	85,286	12,853	313	375	108	483	84,964	12,805	683	39,713
18 years and over...	75,038	65,610	8,863	213	267	85	330	65,400	8,834	474	
Caldwell County	70,709	66,506	3,881	105	111	106	315	66,322	3,864	208	29,454
18 years and over...	54,022	51,087	2,695	80	82	78	208	50,973	2,685	156	
Camden County	5,904	4,388	1,481	21	9	5	24	4,375	1,481	24	2,466
18 years and over...	4,469	3,354	1,088	14	9	4	18	3,344	1,088	19	
Carteret County	52,556	47,445	4,385	269	293	164	450	47,188	4,369	549	34,576
18 years and over...	40,749	37,305	2,916	204	225	99	291	37,132	2,907	419	
Caswell County	20,693	12,155	8,436	26	20	56	136	12,099	8,409	49	8,254
18 years and over...	15,774	9,376	6,326	19	19	34	86	9,341	6,307	40	
Catawba County	118,412	106,370	10,689	232	830	291	921	105,795	10,649	1,047	49,192
18 years and over...	90,127	82,057	7,177	173	521	199	629	81,665	7,150	683	
Chatham County	38,759	29,423	8,845	125	69	297	564	29,194	8,794	207	16,642
18 years and over...	30,073	23,306	6,419	87	49	212	413	23,137	6,385	138	
Cherokee County	20,170	19,313	361	405	42	49	131	19,233	358	448	10,319
18 years and over...	15,599	14,950	270	320	33	26	79	14,899	269	352	
Chowan County	13,506	8,349	5,087	24	29	17	95	8,314	5,041	56	5,910
18 years and over...	9,970	6,481	3,438	18	23	10	60	6,458	3,411	41	
Clay County	7,155	7,061	41	39	7	7	40	7,028	41	46	4,158
18 years and over...	5,540	5,465	32	34	4	5	31	5,439	32	38	
Cleveland County	84,714	66,362	17,741	114	394	103	376	66,152	17,701	485	34,232
18 years and over...	63,940	51,480	12,041	91	256	72	265	51,335	12,019	321	
Columbus County	49,587	32,897	15,181	1,370	53	86	242	32,816	15,122	1,407	20,513
18 years and over...	35,986	25,030	9,924	936	42	54	159	24,972	9,886	969	
Craven County	81,613	58,660	21,116	319	765	753	1,821	57,796	20,940	1,056	32,293
18 years and over...	59,570	44,115	14,142	224	578	511	1,172	43,588	14,045	765	
Cumberland County	274,566	170,069	87,496	4,425	5,769	6,807	13,298	165,057	86,216	9,995	58,300
18 years and over...	197,792	127,233	58,773	3,082	4,231	4,473	8,620	124,006	58,050	7,116	
Currituck County	13,736	12,051	1,545	66	51	23	110	11,965	1,542	119	7,367
18 years and over...	10,242	9,026	1,117	47	39	13	63	8,979	1,115	85	
Dare County	22,746	21,766	811	37	79	53	199	21,626	807	114	21,567
18 years and over...	17,657	16,956	574	32	53	42	142	16,862	570	83	
Davidson County	126,677	113,290	12,314	395	477	195	602	112,937	12,275	863	53,266
18 years and over...	96,357	87,041	8,611	287	292	126	409	86,805	8,553	503	
Davie County	27,859	25,194	2,482	86	53	44	129	25,115	2,473	142	11,496
18 years and over...	21,333	19,407	1,821	49	31	25	82	19,355	1,817	79	
Duplin County	39,995	25,927	13,259	104	47	658	1,015	25,635	13,200	145	16,335
18 years and over...	29,441	19,826	9,031	66	35	483	713	19,628	9,003	97	
Durham County	181,835	109,886	67,654	425	3,233	637	2,054	108,722	67,385	3,674	77,713
18 years and over...	140,425	88,355	48,788	316	2,498	468	1,558	87,446	48,621	2,800	
Edgecombe County	56,558	24,665	31,661	73	68	91	255	24,581	31,565	157	21,627
18 years and over...	40,539	19,245	21,123	56	44	71	181	19,181	21,066	111	
Forsyth County	265,878	196,918	66,102	551	1,662	645	2,102	195,660	65,858	2,258	115,715
18 years and over	205,470	156,596	46,855	409	1,214	396	1,456	155,709	46,691	1,614	
Franklin County	36,414	23,288	12,843	74	63	146	290	23,197	12,791	136	14,957
18 years and over...	27,577	18,279	9,097	50	47	104	205	18,212	9,067	93	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

	Race							Not of Hispanic origin			
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Perquimans County	10,447	6,979	3,426	18	20	4	28	6,959	3,421	39	4,972
18 years and over	7,875	5,483	2,358	16	15	3	23	5,467	2,354	31	
Person County	30,180	20,740	9,106	181	15	138	249	20,655	9,080	196	12,546
18 years and over	22,761	16,034	6,477	149	13	89	155	15,984	6,461	161	
Pitt County	107,924	70,643	35,921	214	709	437	977	70,217	35,813	917	43,670
18 years and over	81,820	56,670	24,144	167	520	319	695	56,365	24,085	625	
Polk County	14,416	13,276	1,053	17	25	45	115	13,201	1,053	47	7,273
18 years and over	11,623	10,828	744	16	15	20	75	10,773	744	31	
Randolph County	106,546	99,042	6,367	453	358	326	734	98,659	6,350	603	43,634
18 years and over	80,829	75,449	4,563	325	257	235	508	75,201	4,549	571	
Richmond County	44,518	30,816	12,969	502	195	136	293	30,729	12,798	698	18,218
18 years and over	32,745	23,615	8,582	337	108	103	205	23,556	8,539	445	
Robeson County	105,179	37,986	26,185	40,511	239	258	704	37,850	26,125	40,500	39,045
18 years and over	72,903	29,518	16,870	26,162	169	184	445	29,421	16,834	26,203	
Rockingham County	86,064	67,893	17,548	149	190	284	620	67,603	17,492	348	35,657
18 years and over	65,632	52,694	12,520	114	121	183	389	52,521	12,479	233	
Rowan County	110,605	91,851	17,773	262	444	275	651	91,521	17,719	714	46,264
18 years and over	84,409	71,303	12,431	188	314	173	445	71,073	12,389	502	
Rutherford County	56,918	50,133	6,514	95	98	78	342	49,896	6,488	192	25,220
18 years and over	43,037	38,457	4,392	67	69	52	237	38,295	4,372	133	
Sampson County	47,297	30,273	15,686	876	75	387	727	30,016	15,630	924	19,183
18 years and over	34,852	23,274	10,695	583	53	247	460	23,105	10,662	625	
Scotland County	33,754	19,025	12,176	2,430	83	40	318	18,867	12,071	2,458	12,759
18 years and over	23,823	14,353	7,792	1,591	61	26	209	14,248	7,725	1,641	
Stanly County	51,765	45,269	5,972	155	249	120	309	45,102	5,954	400	21,808
18 years and over	39,064	34,784	3,976	93	147	64	214	34,651	3,963	236	
Stokes County	37,223	34,917	2,069	52	79	106	254	34,787	2,063	119	15,160
18 years and over	28,146	26,485	1,524	35	47	55	150	26,396	1,520	80	
Surry County	61,704	58,383	2,780	66	84	391	602	58,160	2,765	177	26,022
18 years and over	47,583	45,241	1,976	50	65	251	391	45,097	1,964	131	
Swain County	11,268	7,950	196	3,075	31	16	78	7,930	191	3,069	5,664
18 years and over	8,413	6,336	138	1,907	20	12	44	6,321	135	1,913	
Transylvania County	25,520	24,121	1,189	79	99	32	154	24,004	1,185	177	12,893
18 years and over	19,948	18,993	800	53	76	26	112	18,912	796	128	
Tyrrell County	3,856	2,297	1,543	4	5	7	11	2,294	1,542	9	1,907
18 years and over	2,792	1,747	1,034	4	3	4	8	1,744	1,033	7	
Union County	84,211	70,023	13,427	294	257	210	675	69,674	13,358	554	33,765
18 years and over	61,201	52,041	8,628	212	166	154	473	51,760	8,590	378	
Vance County	38,892	21,146	17,512	69	60	105	271	21,019	17,475	127	15,743
18 years and over	28,497	16,478	11,856	55	44	64	189	16,377	11,833	98	
Wake County	423,380	324,011	88,057	1,148	8,177	1,987	5,396	321,008	87,565	9,411	177,146
18 years and over	325,565	253,422	63,937	918	5,901	1,387	3,878	251,281	63,587	6,819	
Warren County	17,265	6,593	9,847	763	14	48	98	6,571	9,818	778	8,714
18 years and over	12,916	5,372	6,959	542	9	34	62	5,358	6,944	552	
Washington County	13,997	7,556	6,366	13	35	27	65	7,531	6,351	50	5,644
18 years and over	10,116	5,865	4,207	8	23	13	37	5,849	4,199	31	
Watauga County	36,952	35,930	768	59	152	43	248	35,735	766	213	19,538
18 years and over	30,630	29,722	687	51	132	38	188	29,573	685	182	
Wayne County	104,666	69,172	33,793	265	839	597	1,356	68,529	33,683	1,654	39,483
18 years and over	77,298	53,020	23,099	208	584	385	883	52,617	23,028	771	
Wilkes County	59,393	56,237	2,824	69	100	163	302	56,044	2,818	169	24,960
18 years and over	45,423	43,143	2,029	55	68	128	272	43,003	2,026	122	
Wilson County	66,061	40,623	24,896	70	177	295	537	40,461	24,817	246	26,002
18 years and over	48,833	31,777	16,697	43	131	185	341	31,675	16,647	135	
Yadkin County	30,488	28,884	1,295	22	26	261	388	28,755	1,294	51	12,921
18 years and over	23,648	22,461	969	21	22	175	248	22,386	969	45	
Yancey County	15,419	15,221	151	27	11	9	49	15,181	151	38	7,594
18 years and over	11,985	11,837	119	17	8	4	38	11,803	119	25	
Aberdeen town	2,700	2,25[illegible]	400	17	25	3	19	2,244	395	42	1,239
18 years and over	2,085	1,778	278	13	13	3	14	1,769	276	26	
Ahoskie town	4,391	2,185	2,146	34	24	2	21	2,174	2,139	57	1,897
18 years and over	3,250	1,777	1,432	24	15	2	14	1,768	1,430	38	
Alamance village	258	256	-	-	-	2	2	256	-	-	123
18 years and over	213	213	-	-	-	-	-	213	-	-	
Albemarle city	14,939	12,102	2,633	24	170	10	66	12,058	2,626	189	6,542
18 years and over	11,521	9,667	1,734	21	90	9	52	9,633	1,728	108	
Alexander Mills town	662	573	83	1	-	5	13	565	83	1	299
18 years and over	496	444	49	-	-	3	8	439	49	-	
Allenton town	583	499	78	2	4	-	-	499	78	6	256
18 years and over	438	378	57	1	2	-	-	378	57	3	
Altamahaw-Ossipee CDP	1,076	983	92	-	1	-	2	981	92	1	468
18 years and over	800	736	63	-	1	-	1	735	63	1	

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		Race						Hispanic origin (of any race)	Not of Hispanic origin			Housing units
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other races		White	Black	Other races	
Benson town		2,810	1,871	892	6	8	33	45	1,858	892	15	1,248
	18 years and over...	2,076	1,469	587	3	6	11	19	1,461	587	9	
Bent Creek CDP		1,487	1,462	7	3	10	5	11	1,456	7	13	556
	18 years and over...	1,111	1,092	4	3	7	5	10	1,087	4	13	
Bessemer City city		4,698	4,104	570	9	4	11	19	4,097	569	13	1,864
	18 years and over...	3,492	3,071	405	7	4	5	9	3,067	405	11	
Bethel town		1,842	807	1,032	-	-	3	1	807	1,031	3	743
	18 years and over...	1,317	622	695	-	-	-	1	622	694	-	
Bethlehem CDP		3,186	3,163	10	4	8	1	13	3,151	10	12	1,310
	18 years and over...	2,384	2,370	4	2	7	1	10	2,361	4	9	
Boulaville town		933	755	176	-	-	2	8	752	173	-	453
	18 years and over...	736	620	115	-	-	1	4	617	115	-	
Biltmore Forest town		1,327	1,324	-	-	3	-	-	1,324	-	3	607
	18 years and over...	1,033	1,032	-	-	1	-	-	1,032	-	1	
Biscoe town		1,484	808	549	-	-	127	126	806	549	3	544
	18 years and over...	1,024	625	315	-	-	84	84	625	315	-	
Black Creek town		615	574	37	-	1	3	3	573	37	2	250
	18 years and over...	468	440	26	-	1	1	-	440	26	2	
Black Mountain town		5,418	4,909	440	7	56	6	28	4,895	439	56	2,519
	18 years and over...	4,346	3,966	344	5	27	4	21	3,955	343	27	
Bladenboro town		1,821	1,525	292	-	1	3	10	1,517	292	2	821
	18 years and over...	1,357	1,209	146	-	1	1	4	1,205	146	2	
Blowing Rock town		1,257	1,244	9	1	3	-	8	1,236	9	4	1,427
	18 years and over...	1,046	1,036	9	1	-	-	3	1,033	9	1	
Boger City CDP		1,373	1,289	24	8	8	44	54	1,282	24	13	596
	18 years and over...	1,080	1,031	13	4	5	27	33	1,027	13	7	
Boiling Spring Lakes city		1,650	1,600	31	12	5	2	10	1,597	27	16	824
	18 years and over...	1,281	1,247	19	9	5	1	6	1,244	17	14	
Boiling Springs town		2,445	2,086	340	6	6	7	12	2,082	339	12	713
	18 years and over...	2,015	1,741	255	6	6	7	12	1,737	254	12	
Bolivia town		228	211	14	3	-	-	1	210	14	3	100
	18 years and over...	167	155	9	3	-	-	-	155	9	3	
Bolton town		531	171	339	21	-	-	-	171	339	21	229
	18 years and over...	396	145	236	15	-	-	-	145	236	15	
Bonnie Doone CDP		3,893	1,566	2,021	67	77	162	311	1,477	1,962	143	2,061
	18 years and over...	2,729	1,223	1,300	47	55	104	198	1,161	1,268	102	
Boone town		12,915	12,169	602	24	100	20	86	12,102	601	126	4,534
	18 years and over...	11,986	11,298	555	22	91	20	78	11,239	554	115	
Boonville town		1,009	952	51	1	5	-	-	952	51	6	422
	18 years and over...	758	712	40	1	5	-	-	712	40	6	
Bostic town		371	344	27	-	-	-	1	344	26	-	151
	18 years and over...	268	244	24	-	-	-	1	244	23	-	
Brevard city		5,388	4,552	749	10	61	16	48	4,525	745	73	2,362
	18 years and over...	4,417	3,833	511	8	51	14	44	3,808	507	58	
Bridgeton town		453	433	16	3	1	-	9	424	16	4	242
	18 years and over...	366	350	13	3	-	-	4	346	13	3	
Broadway town		973	897	76	-	-	-	3	894	76	-	393
	18 years and over...	713	663	50	-	-	-	3	660	50	-	
Brogden CDP		3,246	1,371	1,823	9	24	19	43	1,353	1,821	23	1,154
	18 years and over...	2,197	969	1,190	9	18	11	29	956	1,189	23	
Brookford town		451	446	4	1	-	-	-	446	4	1	205
	18 years and over...	360	355	4	1	-	-	-	355	4	1	
Brunswick town		302	106	196	-	-	-	2	106	194	-	117
	18 years and over...	208	84	124	-	-	-	2	84	122	-	
Bryson City town		1,145	1,064	4	64	12	1	6	1,062	4	73	619
	18 years and over...	942	884	2	48	8	-	4	883	2	53	
Buies Creek CDP		2,085	1,903	132	7	33	10	29	1,890	131	35	521
	18 years and over...	1,895	1,745	107	5	28	10	24	1,734	106	31	
Bum town		364	241	116	6	1	-	-	241	116	7	177
	18 years and over...	281	183	95	3		-	-	183	95	3	
Burgaw town		1,807	1,140	640	6	6	15	24	1,130	639	14	202
	18 years and over...	1,415	921	476	6	4	8	14	914	476	11	
Burlington city		39,498	30,152	8,909	78	308	51	234	29,986	8,886	392	17,636
	18 years and over...	31,018	24,468	6,260	56	203	31	151	24,357	6,251	259	
Burnsville town		1,482	1,446	33	3	-	-	10	1,436	33	3	747
	18 years and over...	1,209	1,183	23	3	-	-	7	1,176	23	3	
Butner CDP		4,679	2,704	1,949	8	9	9	21	2,691	1,948	19	1,244
	18 years and over...	3,777	2,268	1,492	6	7	4	12	2,261	1,491	13	
Cajah's Mountain town		2,429	2,350	72	2	1	4	5	2,350	71	3	873
	18 years and over...	1,972	1,895	70	2	1	4	5	1,895	69	3	
Calabash town		1,210	1,202	8	-	-	-	4	1,198	8	-	786
	18 years and over...	1,142	1,139	3	-	-	-	4	1,135	3	-	

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	Race							Not of Hispanic origin			
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Cow town	71	69	2	-	-	-	-	69	2		32
18 years and over...	56	54	2	-	-	-	-	54	2		
Concord city	27,347	21,495	5,623	63	150	16	150	21,378	5,606	213	11,616
18 years and over...	21,269	17,161	3,930	52	113	13	104	17,082	3,920	163	
Conetoe town	292	109	183	-	-	-	-	109	183	-	117
18 years and over...	209	89	120	-	-	-	-	89	120	-	
Connelly Springs town	1,349	1,302	19	5	23	-	2	1,300	19	28	577
18 years and over...	1,007	976	18	4	9	-	1	975	18	13	
Conover city	5,465	4,806	532	9	101	17	89	4,738	528	110	2,241
18 years and over...	4,214	3,783	347	8	63	13	55	3,745	343	71	
Conway town	759	506	253	-	-	-	1	506	252	-	343
18 years and over...	562	400	162	-	-	-	1	400	161	-	
Cooleemee town	971	921	32	15	-	3	3	921	32	15	444
18 years and over...	777	747	22	7	-	1	1	747	22	7	
Cornelius town	2,581	2,020	525	9	26	1	19	2,007	525	30	1,079
18 years and over...	1,932	1,548	362	5	17	-	13	1,537	362	20	
Cove City town	497	264	233	-	-	-	-	264	233	-	193
18 years and over...	381	219	162	-	-	-	-	219	162	-	
Cramerton town	2,371	2,283	67	8	12	1	10	2,275	67	19	1,007
18 years and over...	1,802	1,735	51	6	9	1	8	1,729	51	14	
Creedmoor city	1,504	1,048	435	2	17	2	1	1,048	435	20	684
18 years and over...	1,171	836	323	2	10	-	-	836	323	12	
Creswell town	361	192	168	-	-	-	9	192	160	-	149
18 years and over...	253	148	105	-	-	-	5	147	101	-	
Cricket CDP	2,015	1,988	20	3		4	15	1,978	20	2	903
18 years and over...	1,574	1,559	10	3	-	2	10	1,552	10	2	
Crossnore town	271	264	7	-	-	-	2	262	7	-	137
18 years and over...	184	182	2	-	-	-	1	181	2	-	
Cullowhee CDP	4,029	3,729	206	30	58	6	28	3,709	206	86	784
18 years and over...	3,830	3,534	199	24	57	6	28	3,514	199	79	
Dallas town	3,012	2,367	625	13	4	3	15	2,358	624	15	1,272
18 years and over...	2,263	1,834	414	9	4	2	9	1,828	414	12	
Danbury town	119	108	8	-	3	-	-	108	8	3	50
18 years and over...	96	86	7	-	3	-	-	86	7	3	
Davidson town	4,046	3,334	639	16	50	7	48	3,302	633	63	1,332
18 years and over...	3,518	2,969	487	9	46	7	34	2,945	484	55	
Dellview town	10	8	-	-	2	-	-	8	-	2	3
18 years and over...	8	7	-	-	1	-	-	7	-	1	
Denton town	1,292	1,292	-	-	-	-	-	1,292	-	-	567
18 years and over...	989	989	-	-	-	-	-	989	-	-	
Dillsboro town	95	93	-	2	-	-	-	93	-	2	63
18 years and over...	81	79	-	2	-	-	-	79	-	2	
Dobbins Heights town	1,144	156	977	8	1	2	5	156	974	9	592
18 years and over...	830	119	706	4	-	1	3	119	704	4	
Dobson town	1,195	1,122	46	1	1	25	24	1,119	46	6	499
18 years and over...	962	904	39	1	-	18	17	903	39	3	
Dortches town	840	623	216	1	-	-	-	623	216	1	325
18 years and over...	619	463	155	1	-	-	-	463	155	1	
Dover town	451	257	194	-	-	-	1	257	193	-	189
18 years and over...	336	197	139	-	-	-	1	197	138	-	
Drexel town	1,746	1,676	47	8	13	2	12	1,671	41	22	727
18 years and over...	1,381	1,337	29	8	6	1	5	1,336	26	14	
Dublin town	246	235	9	2	-	-	-	235	9	2	113
18 years and over...	196	187	7	2	-	-	-	187	7	2	
Dunn city	8,336	4,768	3,435	61	44	28	77	4,746	3,409	104	3,638
18 years and over...	6,165	3,836	2,249	38	25	17	55	3,819	2,229	62	
Durham city	136,611	70,640	62,449	334	2,672	516	1,610	69,773	62,193	3,335	60,607
18 years and over...	106,578	58,815	45,007	248	2,109	399	1,262	58,110	44,847	2,359	
Earl town	230	208	22	-	-	-	-	208	22		104
18 years and over...	169	155	14	-	-	-	-	155	14	-	
East Arcadia town	468	12	455	1	-	-	-	12	455	1	174
18 years and over...	290	6	283	1	-	-	-	6	283	1	
East Bend town	619	604	14	-	1	-	5	600	13	1	271
18 years and over...	463	454	8	-	1	-	2	452	8	1	
East Flat Rock CDP	3,218	3,096	59	35	9	19	51	3,065	59	43	1,577
18 years and over...	2,484	2,404	44	18	5	13	34	2,382	44	24	
East Laurinburg town	302	282	7	13	-	-	6	277	7	12	126
18 years and over...	238	228	2	8	-	-	4	225	2	7	
Eastover CDP	1,243	1,019	170	38	11	5	15	1,010	170	48	573
18 years and over...	972	807	129	23	8	5	11	801	128	31	
East Rockingham CDP	4,158	3,732	331	76	14	5	36	3,714	319	89	1,813
18 years and over...	3,082	2,840	178	54	7	3	24	2,828	169	61	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

	Race							Not of Hispanic origin			
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other racest	Hispanic origin (of any race)1	White	Black	Other racest	Housing units
Fountain town	445	268	172	-	-	5	8	266	171	-	216
18 years and over	337	218	116	-	-	3	6	216	115		
Four Oaks town	1,308	1,114	173	3	6	12	22	1,109	173	4	598
18 years and over	982	857	114	3	4	8	14	851	114	3	
Foxfire village	334	332	-	-	2	-	4	328	-	2	308
18 years and over	308	306	-	-	2	-	4	302	-	2	
Franklin town	2,870	2,735	98	14	19	7	32	2,711	98	32	1,682
18 years and over	2,261	2,255	74	13	16	3	24	2,235	74	28	
Franklinton town	1,615	935	671	2	6	1	1	935	671	8	755
18 years and over	1,255	763	485	1	5	1	1	763	485	6	
Franklinville town	666	627	12	2	1	24	27	623	12	4	259
18 years and over	504	469	10	2	1	22	24	467	10	3	
Fremont town	1,710	789	916	3	-	2	5	787	915	3	725
18 years and over	1,300	619	678	2	-	1	4	617	677	2	
Fuquay-Varina town	4,562	3,425	1,075	17	11	34	100	3,361	1,073	28	1,959
18 years and over	3,449	2,640	764	11	9	25	70	2,597	762	20	
Gamewell town	3,357	3,194	144	3	5	11	15	3,190	144	8	1,359
18 years and over	2,543	2,423	101	3	5	11	14	2,420	101	8	
Garland town	746	430	304	4	-	8	13	427	302	4	302
18 years and over	563	349	207	2	-	5	8	346	207	2	
Garner town	14,967	12,168	2,633	39	94	33	118	12,102	2,613	134	5,675
18 years and over	11,183	9,241	1,822	34	69	17	71	9,201	1,810	101	
Garysburg town	1,057	30	1,024	2	-	1	8	30	1,017	2	428
18 years and over	716	29	684	2	-	1	6	29	679	2	
Gaston town	1,003	808	192	3	-	-	1	807	192	3	451
18 years and over	750	633	114	3	-	-	1	632	114	3	
Gastonia city	54,732	40,501	13,617	103	384	127	294	40,346	13,568	524	22,196
18 years and over	40,881	31,695	8,784	75	247	80	205	31,592	8,751	333	
Gatesville town	308	238	66	-	2	2	2	238	66	2	148
18 years and over	236	189	45	-	1	1	1	189	45	1	
Gibson town	532	263	216	53	-	-	1	262	216	53	214
18 years and over	370	212	124	34	-	-	1	211	124	34	
Gibsonville town	3,441	2,795	626	10	9	1	16	2,787	619	19	1,443
18 years and over	2,597	2,177	406	8	5	1	10	2,171	403	13	
Glen Alpine town	563	544	1	-	18	-	1	543	1	18	248
18 years and over	446	439	1	-	6	-	-	439	1	6	
Glen Raven CDP	2,616	2,026	561	19	7	3	19	2,010	561	26	1,080
18 years and over	2,063	1,608	433	16	5	1	10	1,599	433	21	
Godwin town	77	61	16	-	-	-	-	61	16	-	39
18 years and over	56	47	9	-	-	-	-	47	9	-	
Goldsboro city	40,709	20,490	19,314	130	539	236	599	20,185	19,247	668	14,345
18 years and over	30,366	16,603	13,145	102	360	156	409	16,405	13,101	451	
Goldston town	299	271	26	1	1	-	1	271	26	1	141
18 years and over	230	210	18	1	1	-	1	210	18	1	
Gorman CDP	1,090	993	95	-	-	2	2	993	95	-	442
18 years and over	863	792	70	-	-	1	1	792	70	-	
Graham city	10,426	8,659	1,673	30	40	24	97	8,588	1,667	74	4,517
18 years and over	8,216	6,954	1,194	24	27	17	67	6,909	1,190	50	
Grandfather village	34	34	-	-	-	-	-	34	-	-	28
18 years and over	27	27	-	-	-	-	-	27	-	-	
Granite Falls town	3,253	3,146	88	4	3	12	17	3,141	88	7	1,366
18 years and over	2,524	2,431	74	4	3	12	14	2,429	74	7	
Granite Quarry town	1,646	1,509	117	3	17	-	8	1,501	117	20	688
18 years and over	1,213	1,109	89	3	12	-	3	1,106	89	15	
Greenevers town	512	27	481	-	-	4	9	27	476	-	205
18 years and over	335	23	310	-	-	2	3	23	309	-	
Greensboro city	183,521	117,237	62,305	852	2,633	494	1,765	116,225	62,017	3,514	80,411
18 years and over	144,273	95,552	45,955	635	1,804	327	1,272	94,809	45,766	2,426	
Greenville city	44,972	28,867	15,337	105	524	139	379	28,654	15,312	657	16,054
18 years and over	36,115	25,007	10,517	86	394	111	305	24,835	10,501	474	
Grifton town	2,393	1,491	886	3	9	4	11	1,487	883	12	982
18 years and over	1,834	1,214	608	3	5	3	9	1,210	607	8	
Grimesland town	469	320	149	-	-	-	5	315	149		265
18 years and over	359	257	102	-	-	-	2	255	102		
Grover town	516	498	15	1	2	-	3	495	15	3	233
18 years and over	398	387	8	1	2	-	3	384	8	3	
Half Moon CDP	6,306	4,702	1,242	24	167	171	301	4,584	1,211	210	2,156
18 years and over	3,984	3,042	716	19	123	84	158	2,984	702	140	
Halifax town	377	221	105	1			-	221	105	1	138
18 years and over	268	176	91	1			-	176	91	1	
Hamilton town	544	310	234	-	-	-	2	308	234	-	215
18 years and over	403	245	158	-	-	-	1	244	158	-	

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	Race							Not of Hispanic origin			
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Jacksonville city	30,013	20,303	8,007	144	902	657	1,571	19,599	7,845	594	11,810
18 years and over...	21,237	14,954	5,170	98	598	417	977	14,512	5,087	661	
James City CDP	4,279	3,459	783	8	16	13	35	3,441	777	26	1,823
18 years and over...	3,245	2,666	550	8	12	9	15	2,662	547	21	
Jamestown town	2,600	2,327	204	1	64	4	21	2,310	204	65	1,051
18 years and over...	1,965	1,765	153	1	45	1	11	1,755	153	46	
[illegible] town	612	333	279	-	-	-	-	333	279	-	283
18 years and over...	422	263	159		-		-	263	159		
Jefferson town	1,300	1,263	22	5	8	2	4	1,261	22	13	521
18 years and over...	1,069	1,057	22	3	6	1	3	1,055	22	9	
Jonesville town	1,549	1,316	222	1	-	10	10	1,316	222	1	730
18 years and over...	1,174	1,010	159	1	-	4	4	1,010	159	1	
Kannapolis city	29,696	24,149	5,342	38	71	96	187	24,073	5,327	109	12,717
18 years and over...	22,923	19,267	3,515	26	49	66	123	19,223	3,503	74	
Kelford town...	204	99	105	-	-	-	-	99	105	-	103
18 years and over...	144	73	71	-	-	-	-	73	71	-	
Kenansville town	856	532	317	-	2	5	9	532	313	2	328
18 years and over...	716	454	255	-	2	5	9	454	251	2	
Kenly town...	1,549	932	601	11	4	1	2	931	601	15	717
18 years and over...	1,137	739	385	8	4	1	2	738	385	12	
Kernersville town	10,836	10,071	606	20	63	76	161	9,996	596	83	5,069
18 years and over...	8,366	7,833	432	14	44	43	95	7,786	428	57	
Kill Devil Hills town	4,238	4,153	21	11	31	22	51	4,124	21	42	4,809
18 years and over...	3,352	3,289	16	10	18	19	39	3,269	16	28	
King City	4,059	3,998	25	8	24	4	20	3,983	25	31	1,562
18 years and over...	3,046	3,001	18	6	18	3	16	2,989	18	23	
Kings Mountain City	8,763	6,812	1,791	17	137	6	43	6,798	1,785	137	3,689
18 years and over...	6,590	5,386	1,107	12	80	5	27	5,375	1,106	82	
Kingstown town	956	15	941	-	-	-	3	15	938	-	275
18 years and over...	644	13	631	-	-	-	2	13	629	-	
Kinston city	25,295	10,512	14,615	34	104	30	120	10,478	14,559	138	10,876
18 years and over...	18,751	8,764	9,872	28	69	18	79	8,742	9,834	96	
Kittrell town	228	171	57	-	-	-	-	171	57	-	90
18 years and over...	178	134	45	-	-	-	-	134	45	-	
Kitty Hawk town	1,937	1,915	2	3	11	6	30	1,891	2	14	2,105
18 years and over...	1,504	1,491	2	1	6	4	16	1,479	2	7	
Knightdale town	1,884	1,692	170	-	12	10	28	1,678	166	12	785
18 years and over...	1,351	1,226	107	-	8	10	21	1,217	105	8	
Kure Beach town	619	617	-	1	1	-	2	615	-	2	937
18 years and over...	522	520	-	1	1	-	1	519	-	2	
La Grange town...	2,805	1,198	1,594	1	7	5	14	1,195	1,550	6	1,220
18 years and over...	2,049	952	1,085	1	6	5	10	950	1,083	6	
Lake Junaluska CDP	2,482	2,445	16	10	10	1	8	2,438	16	20	1,612
18 years and over...	2,056	2,028	11	8	8	1	5	2,024	11	16	
Lake Lure town...	691	671	17	3	4	-	4	667	17	3	1,155
18 years and over...	626	609	14	3	-	4	4	605	14	3	
Lake Waccamaw town...	854	762	164	27	-	1	1	762	164	27	482
18 years and over...	738	610	118	9	-	1	1	610	118	9	
Landis town	2,333	2,269	54	3	6	1	12	2,258	54	9	1,055
18 years and over...	1,880	1,827	47	3	2	1	11	1,817	47	5	
Lansing town	171	171	-	-	-	-	-	171	-	-	92
18 years and over...	142	142	-	-	-	-	-	142	-	-	
Lasker town	139	138	1	-	-	-	-	138	1	-	76
18 years and over...	112	111	1	-	-	-	-	111	1	-	
Latimore town	183	166	15	-	-	2	2	166	15	-	78
18 years and over...	140	131	7	-	-	2	2	131	7		
Laurel Park town	1,322	1,312	1	3	5	1	3	1,309	1	9	827
18 years and over...	1,145	1,139	1	2	2	1	1	1,138	1	5	
Laurinburg City	11,643	5,837	5,239	504	48	25	78	5,801	5,216	546	4,637
18 years and over...	8,416	4,745	3,387	330	37	17	54	4,728	3,272	302	
Lawndale town	573	444	119	-	10	-	3	441	119	10	254
18 years and over...	468	376	86	-	6	-	3	373	86	6	
Leggett town	108	69	39	-	-	-	-	69	39		37
18 years and over...	87	60	27	-	-	-	-	60	27		
Leland town...	1,801	1,611	186	3	1	-	6	1,611	180	4	750
18 years and over...	1,305	1,181	120	3	1	-	5	1,181	115	4	
Lenoir City	14,192	11,864	2,240	26	40	22	76	11,819	2,232	65	6,338
18 years and over	10,984	9,417	1,516	17	28	6	35	9,395	1,512	42	
Lewiston Woodville town	788	257	528	3	-	-	2	255	528	3	324
18 years and over...	515	198	315	2	-	-	1	197	315	2	
Lewisville CDP	3,206	3,085	96	3	20	2	21	3,073	96	16	1,337
18 years and over...	2,394	2,303	75	2	13	1	18	2,292	75	9	

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		Race						Hispanic origin (of any race)	Not of Hispanic origin			Housing units
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race		White	Black	Other race	
Mattinas town		13,651	13,003	467	37	132	12	121	12,896	462	172	5,330
	18 years and over...	9,655	9,222	317	29	79	8	92	9,140	315	108	
Maxton town		2,373	828	1,367	168	7	3	5	828	1,366	174	888
	18 years and over...	1,592	640	847	99	5	1	1	640	847	104	
Mayodan town		2,471	2,233	222	3	12	1	11	2,224	221	15	1,[illegible]
	18 years and over...	2,016	1,858	147	2	9	-	8	1,851	146	11	
Maysville town		892	450	436	1	1	4	8	447	435	1	353
	18 years and over...	634	346	283	1	1	3	5	344	283	2	
Mebane city		4,754	3,756	952	7	24	15	48	3,722	951	33	2,017
	18 years and over...	3,566	2,877	665	4	14	6	27	2,857	664	18	
Music town		310	98	211	-	-	1	2	97	211	-	123
	18 years and over...	238	76	161	-	-	1	2	75	161	-	
Micro town		417	396	21	-	-	-	-	396	21	-	193
	18 years and over...	334	318	16	-	-	-	-	318	16	-	
Middleburg town		131	56	75	-	-	-	-	56	75	-	52
	18 years and over...	96	48	48	-	-	-	-	48	48	-	
Middlesex town		730	524	184	1	-	21	27	517	184	2	315
	18 years and over...	545	404	122	1	-	18	22	399	122	2	
Millers Creek CDP		1,787	1,780	1	3	2	1	2	1,779	1	5	735
	18 years and over...	1,348	1,343	1	2	1	1	2	1,342	1	3	
Milton town		185	109	74	-	2	-	-	109	74	2	97
	18 years and over...	162	90	70	-	2	-	-	90	70	2	
Minnesott Beach town		266	264	2	-	-	-	2	262	2	-	231
	18 years and over...	239	237	2	-	-	-	2	235	2	-	
Mint Hill town		11,567	11,212	246	46	58	5	77	11,141	246	103	4,093
	18 years and over...	8,584	8,336	172	36	36	4	50	8,291	172	71	
Mocksville town		3,399	2,676	701	12	9	1	10	2,669	699	21	1,514
	18 years and over...	2,641	2,138	490	7	5	1	9	2,131	489	12	
Monroe city		16,127	9,397	6,483	55	95	97	215	9,311	6,448	153	6,347
	18 years and over...	11,605	7,443	3,984	42	59	77	161	7,372	3,971	101	
Montreat town		693	649	29	2	12	1	1	649	29	14	516
	18 years and over...	635	591	29	2	12	1	1	591	29	14	
Moores boro city		294	228	66	-	-	-	-	228	66	-	144
	18 years and over...	228	183	45	-	-	-	-	183	45	-	
Mooresville town		9,317	7,088	2,139	25	44	21	45	7,067	2,137	68	3,808
	18 years and over...	7,018	5,527	1,431	17	32	11	33	5,508	1,429	48	
Moravian Falls CDP		1,736	1,595	95	1	15	30	37	1,588	95	16	802
	18 years and over...	1,362	1,254	70	1	11	26	30	1,250	70	17	
Morehead City town		6,046	4,877	1,066	35	52	16	56	4,850	1,061	79	3,206
	18 years and over...	4,697	3,931	693	24	39	10	31	3,917	690	59	
Morganton city		15,085	12,520	2,319	21	208	17	58	12,480	2,315	232	6,558
	18 years and over...	12,132	10,301	1,685	18	118	10	45	10,270	1,683	134	
Morrisville town		1,022	840	176	-	4	2	12	830	176	4	503
	18 years and over...	813	668	141	-	2	2	11	659	141	2	
Morven town		590	180	408	-	-	2	5	179	405	1	255
	18 years and over...	411	151	258	-	-	2	5	150	255	1	
Mountain Home CDP		1,898	1,872	11	4	5	6	17	1,861	11	9	868
	18 years and over...	1,456	1,443	5	2	3	3	6	1,440	5	5	
Mountain View CDP		3,697	3,511	146	6	33	1	11	3,501	146	33	1,311
	18 years and over...	2,556	2,440	91	5	19	1	10	2,431	91	24	
Mount Airy city		7,156	6,469	638	9	11	29	60	6,445	630	21	3,417
	18 years and over...	5,694	5,236	423	7	10	18	44	5,218	415	17	
Mount Gilead town		1,336	754	577	5	-	-	5	751	575	5	523
	18 years and over...	1,006	624	377	5	-	-	2	622	377	5	
Mount Holly city		7,710	7,006	645	19	37	3	31	6,979	645	55	3,264
	18 years and over...	5,969	5,485	441	14	26	3	25	5,463	441	40	
Mount Olive town		4,582	2,156	2,405	5	10	6	18	2,151	2,398	15	1,553
	18 years and over...	3,462	1,782	1,662	5	9	4	15	1,777	1,656	14	
Mount Pleasant town		1,027	921	102	4	-	-	-	921	102	4	447
	18 years and over...	806	727	77	2	-	-	-	727	77	2	
Mulberry CDP		2,339	2,316	22	-	-	1	11	2,305	22	1	911
	18 years and over...	1,810	1,801	9	-	-	-	8	1,793	9	-	
Murfreesboro town		2,580	1,594	914	7	59	6	14	1,586	914	66	[illegible]
	18 years and over...	2,121	1,376	683	4	54	4	11	1,369	683	58	
Murphy town		1,575	1,455	81	21	14	4	16	1,442	81	36	803
	18 years and over...	1,233	1,140	61	17	12	3	11	1,132	61	29	
Myrtle Grove CDP		4,275	4,155	100	3	17	-	13	4,143	99	20	1,828
	18 years and over...	3,325	3,230	79	3	13	-	13	3,218	78	16	
Nags Head town		1,838	1,773	48	-	14	3	10	1,766	48	14	3,117
	18 years and over...	1,534	1,481	42	-	8	3	10	1,474	42	8	
Nashville town		3,617	2,044	1,561	8	2	2	12	2,040	1,554	11	1,333
	18 years and over...	2,745	1,589	1,147	6	2	1	11	1,585	1,141	8	

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	Race							Not of Hispanic origin			
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other racest	Hispanic origin (of any race)†	White	Black	Other racest	Housing units
Pine Knoll Shores town	1,360	1,351	-	1	7	1	3	1,349		1	1,542
18 years and over...	1,208	1,200	-	1	6	1	3	1,198		1	
Pine Level town	1,217	1,132	84	1	-	-	3	1,129	84	1	555
18 years and over...	958	891	66	1	-	-	3	888	66	1	
Pinetops town	1,514	728	785	-	1	-	6	727	780	1	587
18 years and over...	1,109	567	542	-	-	-	3	566	540	-	
Pineville town	2,970	2,812	115	12	15	16	67	2,763	112	28	1,455
18 years and over...	2,413	2,299	82	8	14	10	46	2,267	79	21	
Piney Green CDP	8,999	6,362	2,031	57	283	266	534	6,163	1,973	335	3,561
18 years and over...	6,192	4,480	1,284	44	206	178	332	4,360	1,257	243	
Pink Hill town	547	408	135	1	1	2	2	408	135	2	244
18 years and over...	392	311	79	1	1	-	-	311	79	2	
Pittsboro town	1,436	1,001	412	7	6	10	17	995	411	13	638
18 years and over...	1,148	816	319	3	3	7	11	813	318	6	
Pleasant Garden CDP	2,228	1,922	290	12	1	3	11	1,914	290	13	871
18 years and over...	1,694	1,478	203	9	1	3	9	1,472	203	10	
Pleasant Hill CDP	1,114	1,105	-	-	-	9	23	1,091	-	-	502
18 years and over...	913	908	-	-	-	5	18	895	-	-	
Plymouth town	4,328	1,861	2,437	-	22	8	22	1,848	2,435	23	1,793
18 years and over...	3,040	1,493	1,530	-	13	4	12	1,486	1,528	14	
Polkton town	662	363	297	2	-	-	-	363	297	2	260
18 years and over...	463	265	197	1	-	-	-	265	197	1	
Polkville city	1,514	1,419	93	-	1	1	6	1,414	93	1	650
18 years and over...	1,147	1,086	59	-	1	1	1	1,086	59	1	
Pollocksville town	299	239	58	-	-	2	2	239	58	-	147
18 years and over...	240	195	44	-	-	1	1	195	44	-	
Pope AFB CDP	2,857	2,044	659	18	76	60	144	1,984	642	87	472
18 years and over...	2,042	1,459	464	15	54	50	99	1,425	456	62	
Porter Tent CDP	3,872	3,381	420	27	25	19	36	3,365	416	55	1,470
18 years and over...	2,832	2,495	292	16	16	13	28	2,483	289	32	
Powellsville town	103	53	50	-	-	-	-	53	50	-	49
18 years and over...	80	42	38	-	-	-	-	42	38	-	
Princeton town	1,181	826	348	4	-	3	8	819	348	6	537
18 years and over...	900	652	245	2	-	1	7	646	245	2	
Princeville town	1,652	51	1,601	-	-	-	2	51	1,599	-	656
18 years and over...	1,104	37	1,067	-	-	-	1	37	1,066	-	
Proctorville town	168	95	57	8	-	8	8	85	57	8	70
18 years and over...	138	86	38	6	-	8	8	86	38	6	
Pumpkin Center CDP	2,857	2,311	348	24	100	74	130	2,268	344	115	955
18 years and over...	1,957	1,608	215	17	72	45	77	1,584	212	84	
Raeford city	3,469	1,974	1,355	109	24	7	38	1,955	1,346	130	1,330
18 years and over...	2,505	1,570	856	63	13	3	16	1,563	851	75	
Raleigh city	207,951	143,862	57,354	584	5,127	1,024	2,940	142,237	57,010	5,764	92,643
18 years and over...	167,138	119,590	42,512	493	3,810	733	2,226	118,349	42,255	4,338	
Ramseur town	1,186	1,120	47	2	9	8	11	1,117	47	11	550
18 years and over...	919	875	31	1	6	6	6	875	31	7	
Randleman city	2,612	2,504	82	20	5	1	16	2,491	80	25	1,170
18 years and over...	1,961	1,897	46	14	3	1	13	1,887	44	17	
Ranlo town	1,650	1,537	90	12	8	3	11	1,529	90	20	663
18 years and over...	1,253	1,169	69	6	6	3	9	1,163	69	12	
Raynham town	106	53	11	42	-	-	-	53	11	42	47
18 years and over...	79	46	6	27	-	-	-	46	6	27	
Red Oak town	280	242	36	2	-	-	1	241	36	2	114
18 years and over...	225	195	29	1	-	-	1	194	29	1	
Red Springs town	3,799	1,553	1,965	267	13	1	14	1,543	1,964	278	1,549
18 years and over...	2,726	1,285	1,266	166	8	1	11	1,277	1,265	173	
Reidsville city	12,183	7,353	4,745	15	40	30	74	7,326	4,724	59	5,369
18 years and over...	9,454	5,992	3,412	14	24	12	44	5,977	3,396	37	
Rennert town	217	1	111	93	-	-	-	14	111	92	87
18 years and over...	141	14	69	58	-	-	-	14	69	58	
Rhodhiss town	638	637	1	-	-	-	1	636	1	-	250
18 years and over...	483	482	1	-	-	-	1	481	1		
Richfield town	535	456	57	3	19	-	-	456	57	22	233
18 years and over...	375	329	36	1	9	-	-	329	36	10	
Richlands town	996	768	223	1	1	3	11	760	223	2	431
18 years and over...	729	568	159	1	-	1	5	564	159	1	
Rich Square town	1,058	577	465	7	5	4	12	577	457	12	443
18 years and over...	852	490	352	6	2	2	9	490	345	8	
River Bend town	2,408	2,287	103	2	13	8	23	2,267	103	15	1,173
18 years and over...	2,042	1,981	65	2	9	5	17	1,969	65	11	
River Road CDP	3,892	2,986	898	4	3	1	13	2,975	897	7	1,799
18 years and over...	2,874	2,317	549	4	3	1	8	2,311	548	7	

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		Race							Not of Hispanic origin			
		Total	White	Black	Am Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Seagate CDP		5,444	5,314	79	24	18	9	37	5,284	79	44	2,259
	18 years and over...	4,165	4,054	67	22	16	6	27	4,032	67	33	
Seagrove town		244	242	-	2	-	-	5	237	-	2	116
	18 years and over...	196	195	-	1	-	-	3	192	-	1	
Sedge Garden CDP		2,784	2,697	75	1	5	6	9	2,695	75	5	1,097
	18 years and over...	2,147	2,090	50	1	3	3	5	2,089	50	3	
Selma town		4,600	2,664	1,908	7	3	18	37	2,647	1,905	11	1,337
	18 years and over...	3,339	2,101	1,221	7	3	7	19	2,092	1,218	10	
Seven Devils town		117	113	4		-	-	-	113	4	-	326
	18 years and over...	98	94	4	-	-	-	-	94	4	-	
Seven Lakes CDP		2,049	1,979	68	-	1	1	10	1,975	62	2	935
	18 years and over...	1,799	1,748	50	-	1	-	6	1,745	47	1	
Seven Springs town		163	147	16	-	-	-	-	147	16	-	84
	18 years and over...	131	119	12	-	-	-	-	119	12	-	
Severn town		260	157	103	-	-	-	-	157	103	-	122
	18 years and over...	208	122	86	-	-	-	-	122	86	-	
Shallotte town		965	914	42	5	3	1	5	910	42	8	413
	18 years and over...	797	752	38	3	3	1	5	748	38	6	
Sharpsburg town		1,536	947	584	-	2	3	14	938	580	4	622
	18 years and over...	1,071	703	364	-	2	2	8	698	362	3	
Shelby city		14,669	8,366	6,234	20	34	15	69	8,328	6,215	56	6,474
	18 years and over...	11,050	6,977	4,030	15	28	10	48	6,950	4,011	41	
Sherrills Ford CDP		3,185	3,056	117	6	6	-	6	3,050	117	12	2,261
	18 years and over...	2,514	2,410	94	4	6	-	5	2,405	94	13	
Siler City town		4,808	3,393	1,293	13	8	101	184	3,322	1,276	26	2,027
	18 years and over...	3,730	2,740	895	13	5	77	142	2,685	883	20	
Silver City CDP		1,343	34	1,297	11	1	-	1	34	1,296	12	480
	18 years and over...	933	29	896	7	1	-	1	29	895	8	
Silver Lake CDP		4,071	3,802	215	27	17	10	33	3,776	215	47	1,503
	18 years and over...	2,913	2,749	128	20	11	5	26	2,728	128	31	
Simpson village		410	167	240	-	-	3	3	167	240	-	175
	18 years and over...	293	129	162	-	-	2	2	129	162	-	
Sims town		124	103	21	-	-	-	-	103	21	-	57
	18 years and over...	104	87	17	-	-	-	-	87	17	-	
Smith Creek CDP		7,461	6,764	579	36	77	5	52	6,721	575	113	2,815
	18 years and over...	5,446	4,981	378	28	54	5	42	4,945	377	82	
Smithfield town		7,540	4,730	2,654	11	50	95	153	4,677	2,647	63	3,278
	18 years and over...	5,838	3,808	1,917	6	36	61	106	3,768	1,912	42	
Snads Ferry CDP		2,031	1,826	159	9	14	23	38	1,812	159	22	1,081
	18 years and over...	1,560	1,404	127	7	8	14	24	1,395	127	14	
Snow Hill town		1,378	63	733	8	1	4	10	631	729	8	607
	18 years and over...	1,042	508	527	3	-	4	9	507	523	3	
Southern Pines town		9,129	5,906	3,155	43	18	7	60	5,871	3,137	61	4,438
	18 years and over...	7,087	4,973	2,070	31	10	3	35	4,946	2,065	41	
Southern Shores town		1,447	1,435	6	2	2	2	5	1,432	6	4	1,452
	18 years and over...	1,165	1,154	5	2	2	2	5	1,151	5	4	
South Gastonia CDP		5,487	4,981	471	13	15	7	20	4,970	471	26	2,131
	18 years and over...	4,123	3,777	320	9	10	7	13	3,772	320	18	
South Henderson CDP		1,374	698	674	-	-	2	13	691	670	-	563
	18 years and over...	998	521	476	-	-	1	7	516	475	-	
Southport city		2,369	1,742	619	4	1	3	12	1,733	619	5	1,166
	18 years and over...	1,884	1,404	475	1	1	3	8	1,399	475	2	
South Rosemary CDP		1,955	1,083	868	2	1	1	3	1,081	868	3	850
	18 years and over...	1,472	878	591	1	1	1	2	877	591	2	
South Weldon CDP		1,640	311	1,324	2	3	-	1	311	1,323	5	591
	18 years and over...	1,051	249	798	2	2	-	1	249	797	4	
Sparta town		1,857	1,897	43	4	1	12	16	1,894	42	5	915
	18 years and over...	1,574	1,519	39	4	-	12	14	1,518	38	4	
Speed town		88	45	43	-	-	-	-	45	43	-	34
	18 years and over...	65	34	31	-	-	-	-	34	31	-	
Spencer town		3,219	2,467	725	13	8	6	26	2,453	719	21	1,384
	18 years and over...	2,478	2,039	425	9	4	1	12	2,032	421	13	
Spencer Mountain town		135	135	-	-	-	-	-	135	-	-	43
	18 years and over...	92	92	-	-	-	-	-	92	-	-	
Spindale town		4,040	3,083	934	6	13	4	14	3,075	928	23	1,735
	18 years and over...	3,161	2,458	687	5	11	-	12	2,450	683	16	
Spring Hope town		1,221	675	537	4	-	5	6	674	537	4	618
	18 years and over	980	577	394	4	-	5	5	577	394	4	
Spring Lake town		7,574	3,044	3,787	64	324	301	567	2,862	3,712	283	3,999
	18 years and over	4,862	2,165	2,373	47	217	160	337	2,051	2,289	285	
Spring Hope town		2,010	2,001	3	-	1	5	11	1,996	3	-	1,010
	18 years and over...	1,549	1,544	2	-	1	2	7	1,540	2	-	

Note The population counts set forth herein are subject to possible correction for undercount or overcount. The U.S. Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991

	Race: Total	Race: White	Race: Black	Race: Am. Indian, Eskimo, and Aleut	Race: Asian and Pacific Islander	Race: Other races	Hispanic origin (of any race)	Not of Hispanic origin: White	Not of Hispanic origin: Black	Not of Hispanic origin: Other races	Housing units
Troy town	3,404	2,177	1,173	43	3	9	83	2,107	1,168	46	1,191
18 years and over...	2,700	1,752	894	43	3	8	55	1,710	890	45	
Tryon town	1,680	1,269	406	2	-	3	9	1,261	406	4	654
18 years and over...	1,460	1,171	287	1	-	1	8	1,164	287	1	
Turkey town	234	196	36	2	-	-	5	191	36	2	102
18 years and over...	177	153	23	1	-	-	1	152	23	1	
Valdese town	3,914	3,870	30	6	28	30	56	3,784	30	34	1,735
18 years and over...	3,080	3,042	21	5	14	28	44	2,996	21	19	
Valley Hill CDP	1,802	1,765	6	9	18	4	38	1,730	6	28	886
18 years and over...	1,423	1,397	6	6	12	2	25	1,373	6	19	
Vanceboro town	946	736	204	4	-	2	5	733	204	4	417
18 years and over...	652	543	104	3	-	2	4	541	104	3	
Vandemere town	299	157	142	-	-	-	-	157	142	-	146
18 years and over...	240	122	118	-	-	-	-	122	118	-	
Vander CDP	1,179	886	271	18	1	3	10	881	269	19	470
18 years and over...	896	679	203	11	1	2	8	674	202	12	
Varnamtown town	404	403	-	1	-	-	1	402	-	1	208
18 years and over...	324	323	-	1	-	-	1	322	-	1	
Vass town	670	569	88	13	-	-	3	566	88	13	288
18 years and over...	497	431	58	8	-	-	3	428	58	8	
Vaco town	320	253	67	-	-	-	2	251	67	-	137
18 years and over...	232	181	49	-	-	-	2	181	49	-	
Vado town	238	18	46	3	2	-	1	186	46	5	113
18 years and over...	182	143	34	3	2	-	1	142	34	5	
Vadesboro town	3,645	1,926	1,698	12	8	1	10	1,918	1,697	20	1,552
18 years and over...	2,696	1,580	1,100	10	5	1	8	1,574	1,099	15	
Vagram town	480	284	180	16	-	-	13	273	178	16	208
18 years and over...	365	218	136	11	-	-	9	209	136	11	
Wake Forest town	5,769	4,338	1,360	9	50	12	38	4,315	1,353	63	2,299
18 years and over...	4,266	3,260	957	8	34	7	29	3,242	952	43	
Walkertown town	1,200	1,112	71	-	4	13	18	1,107	70	5	539
18 years and over...	974	909	56	-	1	8	10	907	56	1	
Wallace town	2,939	2,134	786	10	4	5	19	2,123	783	14	1,251
18 years and over...	2,187	1,668	507	6	4	2	11	1,660	506	10	
Walnut Cove town	1,088	821	259	2	3	3	10	815	259	4	461
18 years and over...	887	676	205	2	3	1	4	674	205	4	
Walnut Creek village	623	616	3	-	4	-	4	612	3	4	221
18 years and over...	467	460	3	-	4	-	4	456	3	4	
Walstonburg town	188	171	16	-	1	-	-	171	16	1	97
18 years and over...	153	140	12	-	1	-	-	140	12	1	
Wanchese CDP	1,380	1,366	1	4	5	4	15	1,355	1	9	583
18 years and over...	966	955	1	4	4	2	9	948	1	8	
Warrenton town	949	597	346	-	1	5	9	593	346	1	470
18 years and over...	775	503	266	-	1	5	7	501	266	1	
Warsaw town	2,859	1,286	1,510	14	12	27	46	1,282	1,500	21	1,199
18 years and over...	2,070	1,065	970	9	10	16	23	1,063	968	16	
Washington City	8,075	4,865	4,158	5	21	26	74	4,836	4,131	34	3,873
18 years and over...	6,634	3,895	2,707	5	13	14	41	3,874	2,695	24	
Washington Park town	403	399	4	-	-	-	1	398	4	-	193
18 years and over...	337	335	2	-	-	-	1	334	2	-	
Watha town	99	97	2	-	-	-	-	97	2	-	41
18 years and over...	79	77	2	-	-	-	-	77	2	-	
Waynesville town	1,294	971	322	1	-	-	2	970	321	1	453
18 years and over...	882	661	220	1	-	-	1	660	220	1	
Waynesville town	6,758	6,414	278	37	19	10	43	6,380	278	57	3,355
18 years and over...	5,398	5,144	208	29	13	4	28	5,120	208	42	
Weaverville town	2,107	2,057	40	9	-	1	6	2,051	40	10	828
18 years and over...	1,637	1,609	25	3	-	-	6	1,603	25	3	
Webster town	410	398	2	2	7	3	7	393	2	8	185
18 years and over...	308	301	-	1	4	2	5	298	-	5	
Weldon town	3,803	3,651	108	14	26	4	27	3,631	108	37	1,252
18 years and over...	2,617	2,512	73	13	17	2	16	2,499	73	29	
Welcome CDP	3,377	3,207	146	10	9	5	8	3,205	145	19	1,357
18 years and over...	2,561	2,455	89	8	6	3	5	2,454	88	14	
Weldon town	1,392	608	779	-	4	1	18	600	770	4	666
18 years and over...	1,051	526	521	-	3	1	12	521	515	3	
Wendell town	2,822	2,493	315	2	9	3	10	2,486	315	11	1,141
18 years and over...	2,050	1,839	198	2	8	3	7	1,835	198	10	
West Canton CDP	1,119	1,104	10	5	-	-	3	1,102	9	5	484
18 years and over...	892	881	7	4	-	-	2	879	7	4	
West Jefferson town	1,002	984	7	4	7	-	-	984	7	11	548
18 years and over...	791	780	3	3	5	-	-	780	3	8	

Note: The population counts set forth herein are subject to possible correction for undercount or overcount. The U.S. Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

Introduction

This is a special computer listing of Public Law 94-171 redistricting data. Contact Customer Services (301-763-4100) for information on the availability of Tables 1-4. The population counts set forth herein are subject to possible correction for undercount or overcount. The U.S. Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

P.L. 94-171 Program

The objective of this program is to meet the requirements of Public Law 94-171. This law, enacted in 1975, requires the Census Bureau to provide redistricting data in a geographic format requested by State governments in operations that within a year following Census Day (by April 1, 1991), the Census Bureau must send to the Governor and the legislature of each State the population data it will need to redraw districts for its State legislature.

To meet the legal requirement, the Census Bureau established a voluntary program to allow States to receive data for voting districts (e.g., election precincts, city wards) in addition to standard census geographic areas such as counties, cities, census tracts, and blocks. These files contain data for voting districts for those counties for which a State outlined voting district boundaries around a set of census blocks on census maps, in accordance with the guidelines of this program.

Area Classifications

AMERICAN INDIAN AND ALASKA NATIVE AREA

Alaska Native Village Statistical Area

Alaska Native villages (ANV's) constitute tribes, bands, clans, groups, villages, communities, or associations in Alaska that are recognized pursuant to the Alaska Native Claims Settlement Act of 1972, Public Law 92-203. Because ANV's do not have legally designated boundaries, the Census Bureau has established Alaska Native village statistical areas (ANVSA's) for statistical purposes. For the 1990 census, the Census Bureau cooperated with officials of the nonprofit corporation within each participating Alaska Native Regional Corporation (ANRC), as well as other knowledgeable officials, to delineate boundaries that encompass the settled area associated with each ANV. ANVSA's are located within ANRC's and do not cross ANRC boundaries. ANVSA's for the 1990 census replace the ANV's that the Census Bureau recognized for the 1980 census.

Each ANVSA is assigned a four-digit census code ranging from 6001 through 8989. Each ANVSA also is assigned a five-digit FIPS code. Both the census and FIPS codes are assigned in alphabetical order of ANVSA's.

American Indian Reservation and Trust Land

American Indian Reservation--Federal American Indian reservations are areas with boundaries established by treaty, statute, and/or executive or court order, and recognized by the Federal Government as territory in which American Indian tribes have jurisdiction. State reservations are lands held in trust by State governments for the use and benefit of a given tribe. The reservations and their boundaries were identified for the 1990 census by the Bureau of Indian Affairs (BIA), Department of Interior (for Federal reservations), and State governments (for State reservations). The names of American Indian reservations recognized by State governments, but not by the Federal Government, are followed by "(State)." Areas composed of reservation lands that are administered jointly and/or are claimed by two reservations, as identified by the BIA, are called "joint areas," and are treated as separate American Indian reservations for census purposes.

Federal reservations may cross State boundaries, and Federal and State reservations may cross county, county subdivision, and place boundaries. For reservations that cross State boundaries, only the portion of the reservations in a given State are shown in the data products for that State; the entire reservations are shown in data products for the United States.

Each American Indian reservation is assigned a four-digit census code ranging from 0001 through 4989. These census codes are assigned in alphabetical order of American Indian reservations nationwide, except that joint areas appear at the end of the code range. Each American Indian reservation also is assigned a five-digit FIPS code; because the FIPS codes are assigned in alphabetical sequence of American Indian [illegible] State, the FIPS code is different in each State for reservations in more than one State.

Trust Land--Trust lands are properly associated with a particular American Indian reservation or tribe, held in trust by the Federal Government. Trust lands may be held in trust either for a tribe (tribal trust land) or for an individual member of a tribe (individual trust land). Trust lands recognized for the 1990 census comprise all tribal trust lands and inhabited individual trust lands located outside of a reservation boundary. As with other American Indian areas, trust lands may be located in more than one State. Only the trust lands in a given State are shown in the data products for that State; all trust lands associated with a reservation or tribe are shown in data products for the United States. The Census Bureau first reported data for tribal trust lands for the 1980 census.

Trust lands are assigned a four-digit census code and a five-digit FIPS code, the same as that for the reservation with which they are associated. Trust lands not associated with a reservation are presented by tribal name, interspersed alphabetically among the reservations.

Tribal Designated Statistical Area (TDSA)

Tribal designated statistical areas (TDSA's) are areas, delineated outside Oklahoma by federally- and State-recognized tribes without a land base or associated trust lands, to provide statistical areas for which the Census Bureau tabulates data. TDSA's represent areas generally containing the American Indian population over which federally-recognized tribes have jurisdiction and areas in which State tribes provide benefits and services to their members. The names of TDSA's delineated by State-recognized tribes are followed by "(State)." The Census Bureau did not recognize TDSA's before the 1990 census.

Each TDSA is assigned a four-digit census code ranging from 9001 through 9589. The census codes are assigned in alphabetical order of TDSA's nationwide. Each TDSA also is assigned a five-digit FIPS code in alphabetical order within State.

Tribal Jurisdiction Statistical Area (TJSA)

Tribal jurisdiction statistical areas (TJSA's) are areas, delineated by federally-recognized tribes in Oklahoma without a reservation, for which the Census Bureau tabulates data. TJSA's represent areas generally containing the American Indian population over which one or more tribal governments have jurisdiction; if tribal officials delineated adjacent TJSA's so that they include some duplicate territory, the overlap area is called a "joint use area," which is treated as a separate TJSA for census purposes.

TJSA's replace the "Historic Areas of Oklahoma (excluding urbanized areas)" shown in 1980 census data products. The Historic Areas of Oklahoma comprised the territory located within reservations that had legally established boundaries from 1900 to 1907; these reservations were dissolved during the 2- to 3-year period preceding the statehood of Oklahoma in 1907. The Historic Areas of Oklahoma (excluding urbanized areas) were identified only for the 1980 census.

Each TJSA is assigned a four-digit census code ranging from 5001 through 5989. The census codes are assigned in alphabetical order of TJSA's, except that joint areas appear at the end of the code range. Each TJSA also is assigned a five-digit FIPS code in alphabetical order within Oklahoma.

COUNTY

The primary political divisions of most States are termed "counties." In Louisiana, these divisions are known as "parishes." In Alaska, which has no counties, the county equivalents are the organized "boroughs" and the "census areas" that are delineated for statistical purposes by the State of Alaska and the Census Bureau. In four States (Maryland, Missouri, Nevada, and Virginia), there are one or more cities that are independent of any county organization and thus constitute primary divisions of their States. These cities are known as "independent cities" and are treated as equivalent to counties for statistical purposes. That part of Yellowstone National Park in Montana is treated as a county equivalent. The District of Columbia has no primary divisions, and the entire area is considered equivalent to a county for statistical purposes.

Each county and county equivalent is assigned a three-digit FIPS code that is unique within State. These codes are assigned in alphabetical order of county or county equivalent within State, except for the

New England States, New York, and Wisconsin, and the boroughs in New York are recognized as minor civil divisions for census purposes; the boroughs in Alaska are county equivalents.

STATE

States are the primary governmental divisions of the United States. The District of Columbia is treated as a statistical equivalent of a State for census purposes.

DEFINITIONS OF SUBJECT CHARACTERISTICS

POPULATION CHARACTERISTICS

AGE

The data on age were derived from answers to questionnaire item 5, which was asked of all persons. The age classification is based on the age of the person in completed years as of April 1, 1990. The age response in question 5a was normally used to represent a person's age. However, when the age response was unacceptable or unavailable, a person's age was derived from an acceptable year of birth response in question 5b.

Data on age are used to determine the applicability of other questions for a person and to classify other characteristics in census tabulations. Age data are needed to interpret most social and economic characteristics used to plan and examine many programs and policies.

HISPANIC ORIGIN

The data on Spanish/Hispanic origin were derived from answers to questionnaire item 7, which was asked of all persons. Persons of Hispanic origin are those who classified themselves in one of the specific Hispanic origin categories listed on the questionnaire--"Mexican," "Puerto Rican," or "Cuban"--as well as those who indicated that they were of "other Spanish/Hispanic" origin. Persons of "Other Spanish/Hispanic" origin are those whose origins are from Spain, the Spanish-speaking countries of Central or South America, or the Dominican Republic, or they are persons of Hispanic origin identifying themselves generally as Spanish, Spanish-American, Hispanic, Hispano, Latino, and so on. Write-in responses to the "Other Spanish/Hispanic" category were coded only for sample data.

Origin can be viewed as the ancestry, nationality group, lineage, or country of birth of the person or the person's parents or ancestors before their arrival in the United States. Persons of Hispanic origin may be of any race.

Some tabulations are shown by the Hispanic origin of the householder. In all cases where households, families, or occupied housing units are classified by Hispanic origin, the Hispanic origin of the householder is used.

During direct interviews conducted by enumerators, if a person could not provide a single origin response, he or she was asked to select, based on self-identification, the group which best described his or her origin or descent. If a person could not provide a single group, the origin of the person's mother was used. If a single group could not be provided for the person's mother, the first origin reported by the person was used.

If any household member failed to respond to the Spanish/Hispanic origin question, a response was assigned by the computer according to the reported entries of other household members by using specific rules of precedence of household relationship. In the processing of sample questionnaires, responses to other questions on the questionnaire, such as ancestry and place of birth, were used to assign an origin before any reference was made to the origin reported by other household members. If an origin was not entered for any household member, an origin was assigned from another household according to the race of the householder.

The 1990 data on Hispanic origin are generally comparable with those for the 1980 census. However, there are some differences in the format of the Hispanic origin question between the two censuses. For 1990, the word "descent" was deleted from the 1980 wording. In addition, the term "Mexican-Amer." used in 1980 was shortened further to "Mexican-Am." to reduce misreporting (of "American") in this category detected in the 1980 census. Finally, the 1990 question allowed those who reported as "other Spanish/Hispanic" to write [illegible]

Misreporting in the "Mexican-Amer." category of the 1980 census item on Spanish/Hispanic origin may affect the comparability of 1980 and 1990 census data for persons of Hispanic origin for certain areas of the country. An evaluation of the 1980 census item on Spanish/Hispanic origin indicated that there was misreporting in the Mexican origin category by White and Black persons in certain areas. The study results showed evidence that the misreporting occurred in the South (excluding Texas), the Northeast (excluding the New York City area), and a few States in the Midwest Region. Also, results based on available data suggest that the impact of possible misreporting of Mexican origin in the 1980 census was severe in those portions of the above-mentioned regions where the Hispanic origin population was generally sparse. However, national 1980 census data on the Mexican origin population or total Hispanic origin population at the national level was not seriously affected by the reporting problem. (For a more detailed discussion of the evaluation of the 1980 census Spanish/Hispanic origin item, see the 1980 census Supplementary Reports.)

The 1990 and 1980 census data on the Hispanic population are not directly comparable with 1970 Spanish origin data because of a number of factors: (1) overall improvements in the 1980 and 1990 censuses, (2) better coverage of the population, (3) improved question designs, and (4) an effective public relations campaign by the Census Bureau with the assistance of national and community ethnic groups.

Specific changes in question design between the 1980 and 1970 censuses included the placement of the category "No, not Spanish/Hispanic" as the first category in that question. (The corresponding category appeared last in the 1970 question.) Also, the 1970 category "Central or South American" was deleted because in 1970 some respondents misinterpreted the category; furthermore, the designations "Mexican-American" and "Chicano" were added to the Spanish/Hispanic origin question in 1980. In the 1970 census, the question on Spanish origin was asked of only a 5-percent sample of the population.

RACE

The data on race were derived from answers to questionnaire item 4, which was asked of all persons. The concept of race as used by the Census Bureau reflects self-identification; it does not denote any clear-cut scientific definition of biological stock. The data for race represent self-classification by people according to the race with which they most closely identify. Furthermore, it is recognized that the categories of the race item include both racial and national origin or socio-cultural groups.

During direct interviews conducted by enumerators, if a person could not provide a single response to the race question, he or she was asked to select, based on self-identification, the group which best described his or her racial identity. If a person could not provide a single race response, the race of the mother was used. If a single race response could not be provided for the person's mother, the first race reported by the person was used. In all cases where occupied housing units, households, or families are classified by race, the race of the householder was used.

The racial classification used by the Census Bureau generally adheres to the guidelines in Federal Statistical Directive No. 15, issued by the Office of Management and Budget, which provides standards on ethnic and racial categories for statistical reporting to be used by all Federal agencies. The racial categories used in the 1990 census data products are provided below.

White--Includes persons who indicated their race as "White" or reported entries such as Canadian, German, Italian, Lebanese, Near Easterner, Arab, or Polish.

Black--Includes persons who indicated their race as "Black or Negro" or reported entries such as African American, Afro-American, Black Puerto Rican, Jamaican, Nigerian, West Indian, or Haitian.

American Indian, Eskimo, or Aleut--Includes persons who classified themselves as such in one of the specific race categories identified below.

American Indian--Includes persons who indicated their race as "American Indian," entered the name of an Indian tribe, or reported such entries as Canadian Indian, French-American Indian, or Spanish-American Indian.

REFERENCE 18

NUS CORPORATION AND SUBSIDIARIES **TELECON NOTE**

CONTROL NO.	DATE: 3/27/90	TIME: 1300

DISTRIBUTION: File Under Union Camp Smithfield Saw

BETWEEN: Don Baker Habitat Conservation Manager	OF: Wildlife Resources Commission-NC	PHONE: (919) 733-6406 733-7638

AND: Alvin Williams

Alvin Williams

DISCUSSION:

I asked Mr. Baker to identify what type of recreational activity occurs along the Neuse River, Little River and Middle Creek in Johnston County North Carolina. He replied saying that there is heavy recreational fresh water fishing that occurs along all three areas. He also stated that there is duck hunting in some areas along the Neuse River.

REFERENCE 19

ENDANGERED AND THREATENED SPECIES

U.S. FISH AND WILDLIFE SERVICE

REGION 4 - ATLANTA

Federally Listed Species by State

NORTH CAROLINA

(E=Endangered; T=Threatened; CH=Critical Habitat determined)

Mammals	General Distribution
Bat, gray (*Myotis grisescens*) - E	Extreme Southwest
Bat, Indiana (*Myotis sodalis*) - E	West
Bat, Virginia big-eared (*Plecotus townsendii virginianus*) - E	Avery County
Cougar, eastern (*Felis concolor cougar*) - E	Entire state
Manatee, West Indian (*Trichechus manatus*) - E	Coastal waters
Shrew, Dismal Swamp southeastern (*Sorex longirostris fisheri*) - T	Dismal Swamp; Camden, Gates Pasquotank and Perquimans Counties
Squirrel, Carolina northern flying (*Glaucomys sabrinus coloratus*) - E	Western mountains (Yancy County)
Whale, finback (*Balaenoptera physalus*) - E	Coastal waters
Whale, humpback (*Megaptera novaeangliae*) - E	Coastal waters
Whale, right (*Balaena glacialis*) - E	Coastal waters
Whale, sei (*Balaenoptera borealis*) - E	Coastal waters
Whale, sperm (*Physeter catodon*) - E	Coastal waters

Birds	
Eagle, bald (*Haliaeetus leucocephalus*) - E	Entire state
Falcon, American peregrine (*Falco peregrinus anatum*) - E	Western mountains
Falcon, Arctic peregrine (*Falco peregrinus tundrius*) - T	Entire State
Plover, piping (*Charadrius melodus*) - T	Coast
Stork, wood (*Mycteria americana*) - E	Coast
Warbler, Bachman's (*Vermivora bachmanii*) - E	East
Warbler, Kirtland's (*Dendroica kirtlandii*) - E	Northwest, Central, Southeast
Woodpecker, ivory-billed (*Campephilus principalis*) - E	Southeast
Woodpecker, red-cockaded (*Picoides* (=*Dendrocopos*) *borealis*) - E	East

Reptiles

Alligator, American (*Alligator mississippiensis*) - T (S/A)*	Coastal plain
Turtle, Kemp's (Atlantic) ridley (*Lepidochelys kempii*) - E	Coastal waters
Turtle, green (*Chelonia mydas*) - T	Coastal waters
Turtle, hawksbill (*Eretmochelys imbricata*) - E	Coastal waters
Turtle, leatherback (*Dermochelys coriacea*) - E	Coastal waters
Turtle, loggerhead (*Caretta caretta*) - T	Coastal waters

Fishes

Chub, spotfin (*Hybopsis monacha*) - T,CH	Little Tennessee River, Swain and Macon Counties
Shiner, Cape Fear (*Notropis mekistocholas* - E,CH	Randolph, Moore, Lee, and Chatham Counties
Silverside, Waccamaw (*Menidia extensa*) - T	Lake Waccamaw and Upper Waccamaw R., Columbus County
Sturgeon, shortnose (*Acipenser brevirostrum*) - E	Coastal rivers

Mollusks

Mussel, Tar River spiny (*Elliptio* (*Canthyria*) *steinstansana*) - E	Tar River, Edgecombe County; Sandy Creek, Franklin County; Swift Creek, Nash County
Snail, noonday (*Mesodon clarki nantahala*) - T	Swain County

Plants

Hudsonia montana (mountain golden heather) - T,CH	Burke and McDowell Counties
Isotria medeoloides (small whorled pogonia) - E	Macon and Henderson Counties

*Alligators are biologically neither endangered nor threatened. For law enforcement purposes they are classified as "Threatened due to Similarity of Appearance." Alligator hunting is regulated in accordance with State law.

Liatris helleri (Heller's blazing star) - T	Ashe, Avery, Caldwell, Burke Counties
Lindera melissifolia (pondberry) - E	Bladen County
Lysimachia asperulaefolia (rough-leaved loosestrife) - E	Carteret, Scotland, Cumberland/Bladen, Brunswick, Pender, and Hoke Counties
Oxypolis canbyi (Canby's dropwort) - E	Scotland County
Sagittaria fasciculata (bunched arrowhead) - E	Henderson County
Sarracenia oreophila (green pitcher plant) - E	Clay County
Solidago spithamaea (Blue Ridge goldenrod) - T	Avery and Mitchell Counties

REFERENCE 20

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

ENVIRONMENTAL SERVICES DIVISION
ATHENS, GEORGIA 30613

TO WHOM IT MAY CONCERN

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If you have received a copy on disk, please be advised that it is in WordPerfect® 5.1 format. You will notice that the following figures are not on the disk:

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Should you have any comments or suggestions concerning the SOPQAM, please contact either Michael R. Carter (404-546-3117) or Bill Bokey (404-546-3300).

Sincerely yours,

John T. Marlar

John T. Marlar, Chief
Environmental Compliance Branch

ENVIRONMENTAL COMPLIANCE BRANCH

STANDARD OPERATING PROCEDURES

AND

QUALITY ASSURANCE MANUAL

FEBRUARY 1, 1991

U. S. Environmental Protection Agency
Region IV
Environmental Services Division
College Station Road
Athens, Georgia 30613

FOREWORD

This manual contains the standard operating and field quality assurance procedures used by Environmental Compliance Branch employees during field operations. The specific procedures outlined are based on the experience of Branch personnel over the years or are specifically referenced at the end of each chapter. The specific quality control procedures outlined in the manual are provided as required by the Agency's Mandatory Quality Assurance Policy.

This manual shall be provided to each Branch employee engaged in field operations. Each employee is expected to read and be familiar with each section of the manual. This manual will serve as a source-book for training new employees as well as a reference for current employees. The manual is meant to be a dynamic document. It will be periodically reviewed and updated. When changes are made in the manual, a memo will be sent to each Branch employee. Each employee will be responsible for keeping his or her manual current. To assist in this updating, a log is included inside the front cover for tracking revisions of individual sections.

The SOP and specific quality assurance procedures outlined in this manual (SOPQAM) are to be incorporated by reference into all study plans issued by Branch personnel. Any deviation from this SOP or specific quality assurance procedures as outlined in this manual must be thoroughly documented and cleared (if possible) with the appropriate Unit Chief and/or Section Chief. Any deviation from this SOPQAM shall also be documented in all study plans and reports resulting from that project.

DISCLAIMER

This SOPQAM has been prepared for use by the Environmental Compliance Branch, Environmental Services Division, Region IV, United States Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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1.0 STANDARD OPERATING POLICIES AND PROCEDURES

1.1 INTRODUCTION

This section presents the standard operating policies and procedures of the Environmental Compliance Branch (ECB) as well as a description of Branch activities. The basic objectives of this section are to present:

- the Branch functional statement and organization;
- how requests for field investigations and technical assistance are received, processed, and implemented;
- the basic flow of project activities, including the assignment of personnel to projects, preparation of study plans, report preparation, and peer review;
- basic rules for employee conduct and legal requirements for entry procedures during field investigations;
- Branch procedures for handling basic administrative functions such as travel, overtime, purchase requisitions, and typing requests;
- Branch procedures for obtaining analytical support;
- the Branch quality assurance plan; and
- the Branch basic safety program.

1.2 BRANCH ORGANIZATION

1.2.1 General

The Branch is organized into two sections: the Hazardous Waste Section and the Air and Water Compliance Section. The Hazardous Waste Section is composed of the RCRA Unit and the Superfund Unit. The Air and Water Compliance Section is composed of the Water Compliance Unit and the Air Compliance Unit. The staffing plan for these sections is presented in Section 1.2.2. The functional statements for the Branch and each Section are presented in the following section. The Branch structure is shown in Figure 1.2.1.

1.2.1.1 Environmental Compliance Branch -- Responsible for planning, coordinating, executing, and evaluating investigations of toxic and hazardous substances; pesticides; waste, air and wastewater management problems; water treatment facilities; UIC facilities and groundwater related problems; and related environmental studies within the Region. Provides technical assistance and multimedia overview to other federal agencies, states, local agencies, the private sector, and EPA contractors in municipal and industrial operations, field investigative procedures, and toxic and hazardous wastes investigations. Maintains expertise in air monitoring methodology. Develops and presents direct training courses. Reviews and comments on remedial investigations/feasibility study work plans, remedial investigation reports, RCRA facility investigations, Record of Decision documents, NPDES permits, UIC permits, State/local agency QA/SOP Plans, and federally licensed construction projects and provides requested field investigatory support of these programs.

1.2.1.2 Hazardous Waste Section -- Responsible for planning, directing, and conducting assessments and investigations for program and enforcement purposes (civil and criminal) related to hazardous substances, including: RCRA related sampling and non-sampling facility inspections (pre- and post-permit issuance), solid waste dumps and landfills, and Superfund remedial and pre-remedial investigations such as at abandoned hazardous waste sites and related multimedia environmental and technical assistance studies. Responds to requests for assistance with oil and hazardous material spill investigations, and related multimedia environmental and technical assistance studies. When required, provides support and technical assistance for TSCA and FIFRA inspections and investigations.

In conjunction with the Analytical Support Branch, manages the Regional Sample Control Center (RSCC) for the national Contract Laboratory Program (CLP) and provides logistical support and scheduling for all Superfund related field investigations conducted by the Section and program contractors. Provides overview (field and document related) and quality assurance of Superfund contractors in conjunction with the Waste Management Division.

Provides technical assistance, training, and multimedia and routine overview to other federal agencies, state agencies, local agencies, and EPA contractors in conducting multimedia hazardous waste inspections, toxic waste monitoring, and RCRA inspections.

Provides related input to permitting, enforcement, and other associated regional programs.

1.2.1.2.1 RCRA Unit -- The RCRA Unit has the primary responsibility for all Hazardous Waste Section RCRA activities, including the conduct of RCRA compliance inspections, sampling and non-sampling field investigations, technical support, technical assistance, and testimony for RCRA related facility and/or site related investigations in support of civil and/or criminal enforcement actions; overview of the state RCRA field program activities including on-site overview of state RCRA inspections as well as field program mid-year and end-of-year reviews; review of state RCRA grants and related documents; development of standard operating procedures and inspection protocols for RCRA field activities; as well as technical assistance and training for local, state, EPA program, and other federal personnel in the field aspects of RCRA investigations. The RCRA Unit has the primary responsibility for coordinating the training activities conducted by the Section and training received by Section personnel. When required, provides the primary Section support for TSCA and FIFRA inspections and investigations.

1.2.1.2.2 Superfund Unit -- The Superfund Unit has the primary responsibility for all Hazardous Waste Section Superfund activities including the conduct of abandoned hazardous waste site inspections and investigations, both sampling and geophysical; field investigations, technical assistance, and testimony in support of Superfund civil and criminal enforcement actions; responds to requests from the Waste Management Division for assistance in monitoring oil and hazardous material spill situations, as well as assistance in investigating potential immediate removal Superfund sites; and operation of the Section's portion of the RSCC. In conjunction with the Waste Management Division, schedules all Superfund investigations in the Region conducted by Section and EPA contractor personnel; conducts on-site field quality assurance overview of contractor field investigations and overviews contract related investigation documents (study plans, RI/FS work and site operation plans, study reports, etc.); overviews state hazardous waste programs that are Superfund related; participates in and develops specific Superfund related training and field standard operating procedures as well as participates in training courses for local, state, EPA programs, other federal field personnel, and contractors; and provides technical support for Superfund investigations and inspections to state and other federal programs. The Superfund Unit has the primary responsibility for the Branch's field health and safety program.

1.2.1.3 Air and Water Compliance Section -- Responsible for planning, coordinating, and executing investigations of municipal and industrial wastewater treatment facilities, and investigations in support of the Regional UIC and drinking water programs. Provides technical assistance and overview to states, local agencies, and other federal agencies in municipal and industrial wastewater operations, and air monitoring studies. Develops and presents direct training courses; reviews and comments on NPDES permits, and federally licensed construction permits; and provides expert testimony.

1.2.1.3.1 Water Compliance Unit -- Responsible for planning, directing, and conducting assessments and investigations including data interpretation and

investigative reports related to municipal and industrial wastewater treatment facilities.

Responsible for studies relating to facility operations, including their impact upon receiving waters as well as the persistence and fate of their contaminants in the aquatic environment and ground water. Provides related input to permitting, enforcement, and other associated regional programs.

Overviews and provides technical assistance and troubleshooting to state, local, and other federal agencies and the private sector concerning municipal operations in order to correct operational problems at existing facilities.

Conducts in-depth diagnostic evaluations of wastewater treatment facilities to provide technical details for enforcement actions, consent decrees, etc., in support of the Water Management Division.

Monitors and overviews NPDES delegated states as well as conducts independent studies of municipal and industrial facilities including CSIs, CEIs, PAIs, etc. Reviews and suggests corrections for self-monitoring techniques at municipal and industrial facilities and provides input to enforcement actions.

Provides technical assistance, training, and overview to state, local, and other federal agencies concerning municipal and industrial facility investigative techniques, operational control techniques, and data interpretation.

At the request of the Water Management Division, responsible for conducting field investigations of water treatment facilities and field investigations in support of the UIC, Drinking Water, UST and the Regional ground water monitoring program including associated water quality investigations.

1.2.1.3.2 Air Compliance Unit -- Responsible for conducting state and local agency Performance Audits; Quality Assurance Plan (QA/SOP) reviews and approvals; conducting National Air Monitoring (NAMS), State and Local Air Monitoring (SLAMS), and Special Purpose Monitoring (SPM), and National Performance Audit Program (NPAP) participation including the distribution of particulate filters; conducting data validations; tracking and submitting Precision and Accuracy (PARS) data submittals; conducting an annual state/local agency training workshop; and conducting special studies.

Responsible for maintaining the Region's expertise in air toxics monitoring methodology, which includes conducting, planning, and arranging air toxics studies. Provides technical assistance to federal, state, and local agencies on air monitoring and analytical methods for both toxics and criteria air pollutants.

Conducts air monitoring in support of CERCLA and RCRA site ranking studies, and performs air sampling for specific pollutants in response to emergency response requests from the Waste Management Division. Reviews hazardous waste site clean-up and remedial action plans for air toxics monitoring activities and overviews contractor air monitoring activities.

Maintains an air monitoring laboratory equipped with sophisticated air monitoring instrumentation, air toxics screening instrumentation, air toxics sampling equipment, calibration equipment, computerized data acquisition equipment, and a NBS Standard Reference Photometer in condition ready to produce valid air quality data. Some air monitoring equipment is maintained for use by state and local agencies for special studies or emergencies.

Provides assistance to the Air, Pesticides and Toxics Management Division by arranging, planning and conducting regional studies; reviewing state and local agency workplans; and conducting National Ambient Air System (NAAS) Audits.

Verifies that state/local Hi-Vol orifices meet regulatory specifications and certifies ozone photometers and calibration systems.

1.2.2 Line of Authority

The purpose of this section is to establish the line of authority, in the Branch and in each Section, in the event of the absence of the Branch or respective Section Chiefs.

Branch:

John Marlar
Mike Carter
Bill Bokey
Steve Hall
Ron Barrow
Herb Barden
Bill Cosgrove

Hazardous Waste Section:

Bill Bokey
Steve Hall
Bill Cosgrove
Rod Davis
Bruce Ferguson
Dan Thoman
Charles Till
Don Hunter
Jim Gray
Fred Sloan
Sharon Matthews
Pat Boyle
John Trudell
Roger Carlton
John Vail
Terry Thomas
Laura Childs

Air and Water Compliance Section:

Mike Carter
Ron Barrow
Herb Barden
Danny France
Joe Compton
Louis Salguero
Jerry Burger
Mike Bowden
Chuck Padgett
Tim Slagle
Jeff Lovell

FIGURE 1.2.1
STAFFING CHART
U. S. ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL SERVICES DIVISION
ENVIRONMENTAL COMPLIANCE BRANCH
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613
FTS Access - 250

BRANCH CHIEF
John Marlar (404) 546-3117

HAZARDOUS WASTE SECTION
Bill Bokey - Chief (404) 546-3300 (3351)
Cathy Murphy - Secretary
Sandy McClain - Clerk Typist

AIR AND WATER COMPLIANCE SECTION
Michael R. Carter - Chief (404) 546-3317
Linda Kidd - Secretary

SUPERFUND UNIT
Steve Hall, Chief
Roger Carlton
Gray
Don Hunter
Fred Sloan
Dan Thoman
Charles Till
John Vail
ESAT Field Staff

RCRA UNIT
Bill Cosgrove, Chief
Pat Boyle
Rod Davis
Bruce Ferguson
Sharon Matthews
Terry Thomas
John Trudell
Laura Childs
Pat Thomas - Warehouse
Chuck Zimmerman - Warehouse
Milton Henderson - Warehouse
ESAT Warehouse Staff

WATER COMPLIANCE UNIT
Ron Barrow, Chief
Mike Bowden
Joe Compton
Louis Salguero
John Williams
Jeff Lovell

AIR COMPLIANCE UNIT
Herb Barden, Chief
Jerry Burger
Jim
Danny France
Richard Guillot
Margaret Hale
Chuck Padgett
Tim Slagle

1.3 PROJECT ACTIVITY FLOW

The Branch receives requests for field investigations and technical assistance activities from a variety of sources including federal, state, and local agencies; EPA Headquarters (including NEIC's Office of Criminal Investigations), EPA regional operating divisions (primarily the Water Management Division and the Waste Management Division); U.S. Department of Justice; as well as the private sector.

All requests for non-routine field studies or technical assistance activities shall be directed to the Director, Environmental Services Division with a copy to the appropriate Section Chief. Any request that is forwarded in any other manner shall be immediately routed to the Director's office. Requests for field studies that are received by Branch staff by telephone shall be discussed with the appropriate Unit Chief who will notify the Section Chief and/or the Branch Chief. All such requests shall be followed up by a memo or letter from the requestor. Non-supervisory Branch personnel are not to commit the Branch or the Division to field studies without the approval of the Division Director and Branch Chief (or appropriate Section Chief in his/her absence). All emergency requests for field studies shall be handled expeditiously, but all such requests shall be followed up by a written memo or letter from the requestor. All requests for routine field studies or technical assistance activities (i.e., those activities committed to in the annual work plan) shall be directed to the appropriate Section Chief who will assign the activity to the appropriate Unit.

The receipt of an investigation or technical assistance request shall be acknowledged as soon as possible. This is normally the responsibility of the Division Director, the Branch Chief, or the appropriate Section Chief. If the request is accepted, the requestor will be so notified, and the Branch Chief shall assign it to the appropriate Section. The Section Chief shall then assign the request to the appropriate Unit Chief who will log the request into the computerized project tracking system. The Unit Chief, in consultation with the Section Chief, shall select a tentative study date and assign a project leader or field investigator as appropriate.

The assigned project leader or field investigator shall discuss the technical merits of each project with his/her Unit Chief. The objectives and scope of each investigation or technical assistance project will be mutually agreed upon during this session. The project leader or field investigator will then contact the requestor and obtain necessary background information to formulate a study plan. A reconnaissance trip may be necessary in some cases. Trips to the EPA regional office or state and local regulatory agency offices may also be required. When the project leader has collected all of the relevant material, he/she shall prepare a study plan and, if appropriate, discuss the resource requirement of the project with his/her Unit Chief. When required, additional staff from other Units will be assigned by the Section Chief or Branch Chief. In studies involving more than one Branch, appropriate staff will be assigned by the Branch Chiefs or Division Director/Deputy Division Director. Concurrently, the Unit Chief and/or project leader shall discuss the analytical requirements with appropriate Analytical Support Branch

personnel. Draft study plans and final study plans shall be prepared as outlined in Section 1.5 and shall be reviewed in accordance with the Regional peer review policy.

After the study plan has been prepared, the project leader/field investigator shall prepare a request for travel orders and overtime/compensatory time and submit them to the appropriate Section Secretary. This request should be submitted at least 10 working days in advance of routine studies. Concurrently, the project leader shall coordinate equipment and vehicle needs with the Branch warehouse staff coordinator and procure any needed special equipment.

After the field study has been conducted, the project leader/field investigator shall prepare an outline or draft of the study report for review and concurrence of the appropriate Unit Chief (not required for routine inspections). If samples were collected during the study or investigation, the Analytical Support Branch will submit data to the appropriate Section Chief. The Section Chief will distribute the analytical data, through the appropriate Unit Chief, as soon as possible to the project leader/field investigator. The project leader shall prepare a draft of the final report (not required for routine inspections) for review by the Unit Chief and Section Chief. Once the report has been cleared by the appropriate Unit Chief and Section Chief, it shall then be reviewed in accordance with the Regional peer review policy. The review comments shall be considered and incorporated where appropriate. A final report shall then be prepared and distributed as outlined in Section 1.6. Routine inspection reports shall be prepared in final form for review by the Unit Chief and the Section Chief or his/her designee and shall be promptly transmitted (Section 2).

After the final report has been transmitted, the project leader/field investigator shall collect all relevant material including the report, etc., as outlined in Section 3, place it in the project file, and submit it to the appropriate Section Secretary for filing. Completion of the project shall be entered by the appropriate Section Chief or Unit Chief into the appropriate computerized project log.

1.4 PROJECT LEADER RESPONSIBILITIES

The project leader has overall responsibility for seeing that field operations are carried out expeditiously and that the project objectives are met. Specifically, these responsibilities include:

- study plan preparation and coordination;
- logistical arrangements including the submission of travel and purchase order requests;
- overall technical supervision of assigned project personnel during field operations and assurance that standard field operating procedures are followed (any deviations shall be documented in the field log book as well as in the final report);
- overall responsibility for project field safety;
- overall responsibility for making study plan modifications in the field as required;
- certifying and keeping accurate records of all overtime, compensatory time, and hazardous duty time earned by project personnel in the field;
- project data interpretation and final report preparation; and
- coordinating any necessary project follow-up activities such as attending show-cause hearings, presenting testimony, etc.

1.5 STUDY PLANS

Study plans shall be prepared and issued for all investigations, inspections, and field studies conducted by Branch personnel. The responsibility for preparing study plans rests with the assigned project leader or field investigator. Study plans shall be issued at least 10 working days in advance of the study for routine inspections and investigations and at agreed upon time frames (agreed upon with the requestor) for more complex studies. The only exceptions are those investigations and inspections that are conducted in response to emergency episodes and spills. No specific requirements for study plans for emergency episodes or spills shall be made. However, if time permits, a study plan should be prepared.

Study plans for routine inspections such as compliance sampling (CSI), case development investigation evaluations (CDIE), performance audit inspections (PAI), etc., shall consist of a notification that the inspection will be conducted, who will conduct it, the inspection dates, the number and types of samples to be collected (if appropriate), analyses required (if appropriate) and a statement that the procedures outlined in this SOPQAM will be followed. These study plans shall be prepared as one or two page memorandums. These standard study plans shall be distributed to appropriate Regional staff as well as the appropriate state regulatory agency (if appropriate). Where required, safety plans should be prepared for routine investigations (Appendix K).

Study plans for non-routine investigations and field studies need to be more detailed. In general, these study plans should contain the following elements:

- Introduction -- a brief history and statement of the problem to be investigated.
- Objectives -- a statement as to what the investigation is to accomplish and how the information is to be used.
- Scope -- a definition of the limits of the study.
- Time Schedule -- a statement outlining when the study will be conducted, analytical results will be available, the draft report will be written, and the final report will be available.
- Study Procedure -- the specific plan to collect the required information (not field methodology).
- Methodology -- specific field techniques to be employed. A statement that the techniques in this SOPQAM will be employed shall be included. The use of any techniques not included in this SOPQAM shall be justified.
- Analytical Requirements -- a complete listing of all samples to be collected, required analyses, and which laboratory(s) will analyze the samples.

- Logistics -- a complete listing of the manpower requirements and specific functions of all project personnel, special equipment and vehicles to be used, use of mobile laboratories, how samples are to be transported to the laboratory, etc.

- Safety Plan -- where required, a safety contingency plan will be included (Appendix K).

Draft study plans for the non-routine investigations shall be prepared and reviewed in accordance with the Regional peer review policy. Information copies of the draft study plan should be sent to all relevant program staff and to the Analytical Support Branch staff. If significant changes are made to the draft study plan, it shall be rewritten and reviewed again in accordance with the Regional Peer Review Policy. A final study plan will be prepared and transmitted to appropriate Regional, OCI, and/or Headquarters staff as well as appropriate state regulatory agency staff utilizing a transmittal memorandum.

1.6 STUDY REPORTS

Almost all investigations, inspections, and field studies conducted by Branch personnel will result in the issuance of a technical report. The project leader/field investigator is responsible for the preparation of the report.

Routine inspection reports such as CSI's, CDIE's, PAI's, etc., shall include the completion of any appropriate standard forms along with a transmittal memo detailing the significant findings of the inspection. Specific requirements for routine inspection reports are given in Section 2. The reports shall be distributed to appropriate Regional or Headquarters personnel utilizing a transmittal memorandum. Reports distributed to state or local personnel will be by use of an official EPA letter.

No firm format is given for non-routine technical reports. The following report outline shall be used as a guide and modified as necessary. Generally, report formats should include:

- Introduction -- should include a statement of the problem, who requested the study, when the study was conducted, who conducted the study, the objectives of the study, and any necessary acknowledgements.
- Study Area -- a description of the area studied.
- Study Findings -- a brief summary of study findings, results, and any relevant conclusions.
- Recommendations -- any recommendations resulting from study findings.
- Study Methodology -- field and analytical methods employed during the study.
- Appendices -- a listing of all relevant data collected during the study.

As a general rule, reports prepared for enforcement purposes, or reports prepared in anticipation of possible enforcement actions, should contain only factual information. These reports shall not contain conclusions, recommendations, or personal opinions. Conclusions, recommendations, and personal opinions for these investigations may be included in a separate memorandum with the concurrence of the Branch or appropriate Section Chief. When this is done, the transmittal memorandum should be stamped "Confidential - This document is prepared in anticipation of enforcement litigation. It is not subject to discovery."

The draft study report shall be reviewed in accordance with the Regional peer review policy. Although the Regional peer review policy excludes enforcement related reports, the Regional Quality Assurance Officer shall be sent a copy of all draft enforcement related reports for peer review with the exception of criminal investigative reports. The final report shall be distributed to appropriate Regional or Headquarters personnel utilizing a transmittal memo.

1.7 EMPLOYEE CONDUCT

1.7.1 General

EPA employees are required to perform their duties in a professional and responsible manner, refraining from any use of official position for private gain. Branch employees are also required to collect and report the facts of an investigation or inspection completely, accurately, and objectively. They must conduct themselves at all times in accordance with the Environmental Protection Agency Regulation on Employee Responsibilities and Conduct (1) and shall adhere to the Code of Ethics for Government Service. The following paragraphs review some topics in the regulations especially applicable to the work of Branch employees.

Employees shall avoid conflicts of interest through outside employment or other private interests. A conflict of interest may exist whenever an EPA employee has a personal or private interest in a matter which is related to his/her official duties and responsibilities. It is important to avoid even the appearance of a conflict of interest because the appearance of a conflict damages the integrity of the Agency and its employees in the eyes of the public. All employees must, therefore, avoid situations which are, or give the appearance of, conflicts of interest when dealing with others in or outside the government.

Good public relations and common sense dictate that employees dress appropriately for the activity in which they are engaged.

It is important that cooperation be obtained and good working relations established when working with the public. This can best be accomplished by using diplomacy, tact, and persuasion. Employees should not speak of any person (including other regulatory agency or facility personnel) in a derogatory manner, and should use discretion when asked to give a professional opinion on specific products. All information acquired during an employee's duties is for official use only.

An employee is forbidden to solicit or accept any gift, gratuity, entertainment, favors, loans, or any other thing of monetary value from any person, corporation, or group which has a contractual or financial relationship with EPA; which has interests that may be substantially affected by such employee's official actions; or which conducts operations regulated by EPA.

1.7.2 Entering A Facility

1.7.2.1 Authority -- Various federal environmental statutes grant EPA enforcement personnel authority to enter and inspect facilities. The authority granted in each statute is similar to that stated below in Section 308 of the Clean Water Act:

> "(a)(B) the Administrator or his authorized representative, upon presentation of his credentials (i) shall have a right of entry to, upon, or through any premises in which an effluent source is located or in which any records required to be maintained. . .are located, and

(ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method required. . . , and sample any effluents which the owner or operator of such source is required to sample. . ."

For the specific requirements on conducting inspections and collecting data pursuant to a particular Act, see: Section 308 of the Clean Water Act; Section 9 of the Federal Insecticide, Fungicide, and Rodenticide Act; Section 3007 of the Resource Conservation and Recovery Act; Section 8 of the Toxic Substances Control Act; Section 1445 of the Safe Drinking Water Act; Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund); and Titles I, III, and IV of the Clean Air Act.

1.7.2.2 Unreasonable Search and Seizure -- EPA authority under the various Acts is subject to the "unreasonable search and seizure" provisions of the Fourth Amendment to the Constitution. The prohibition is not against all searches and seizures, but only those which are unreasonable or to which valid consent, if required, has not been given. Consent, in this context, means the intentional foregoing of right to privacy which is not the result of either fear, ignorance, or trickery.

To comply with the Acts and avoid any "unreasonable search" and procedural problems, a facility should be entered in the following manner:

1. The facility premises should be entered through the main gate or through the entrance designated by the source if in response to an inspection notification letter (a 308 letter for example).

2. The employee shall introduce herself/himself in a dignified, courteous manner to a responsible plant official. A responsible plant official may be the owner, operator, officer, or agent in charge for the facility, including the plant environmental engineer. Identification credentials shall always be shown.

3. If only a guard is present at the entrance, the employee shall present her/his credentials and suggest that the guard call his superior on the phone. If the inspector knows the name of the responsible official he/she is to see, he/she shall request the guard to call him/her directly.

4. If the company provides a general sign-in sheet, it is acceptable to sign it. Branch employees shall not sign a release of liability (waiver) when entering a facility under the authority of Federal law.

5. If entry is refused, the employee shall not contest the issue with the facility representative, but will immediately do the following:

   - obtain name and position of individual denying entry to the facility, and record the date and time;

   - cite the appropriate EPA-administered legislation, ask

if he/she heard and understood the reason for your presence, and record the answer and any reasons given for denial of entry; and

- leave the premises immediately.

After leaving the facility, the employee shall, at the earliest possible time, inform their immediate supervisor and the Office of Regional Counsel, by telephone of the events which took place and seek guidance on how to proceed.

1.7.3 Requesting Information

The various laws and statutes under which EPA operates address the protection of trade secrets and confidential information. As a general policy, Branch staff should not accept confidential information unless it is necessary for carrying out Agency functions under a particular Act. As a matter of Branch policy, request for confidential information can only be signed by a responsible party in one of the operating Divisions or by an attorney in the Office of Regional Counsel.

In compliance with EPA regulations, an EPA request for company information, pursuant to statutory authority, will contain a statement allowing the facility to designate all or part of the information requested by the Agency as confidential by marking it according to: Code of Federal Regulations, Title 40, Part 2, Section 203.41; or Federal Register, 41 FR 36902. In addition to citing the appropriate regulations, the request for confidential information will state that:

(1) The business may, if it desires, assert a business confidentiality claim covering part or all of the information in the manner described by [the applicable regulation], and that information covered by such a claim will be disclosed by EPA only to the extent, and by means of the procedures, set forth in [the applicable regulations]; and that

(2) If no such claim accompanies the information when it is received by EPA, it may be made available to the public by EPA without further notice to the business.

If the collection of confidential information is required to carry out the responsibility of the Branch, personnel should consult carefully with the appropriate operating Division staff and the Office of Regional Counsel attorneys. In general, when such information is needed by Branch personnel, the request should state that this information will be transmitted directly to the Office of Regional Counsel.

In general, Branch personnel shall not accept confidential information when conducting a plant evaluation, inspection, or reconnaissance. When Branch personnel must collect or observe confidential information, a separate logbook shall be maintained. When confidential information is entered into an inspector's logbook, the entire logbook and each page containing confidential information shall be marked "CONFIDENTIALITY CLAIM." Upon return to the EPA Region

IV, ESD facility, all such information shall be maintained in a locked filing cabinet and the Office of Regional Counsel shall be notified for ultimate disposition of the material.

1.7.4 Disclosure of Official Information

It is EPA policy to make information about EPA and its work available, freely and equally, to all individuals, groups, and organizations. This policy, however, does not extend to confidential information or to investigatory information and evidence relating to the suspicion of a violation of federal environmental laws.

Any Branch employee who receives a request, written or oral, for inspection or disclosure of EPA investigatory records, whether made under judicial discovery procedures or the Freedom of Information Act, shall immediately advise the Division's Freedom of Information (FOI) Act Coordinator and/or the Regional FOI Coordinator of the request. Such records shall not be released without the specific concurrence of the Regional FOI coordinator. RCRA, Superfund, and TSCA program offices will make all third party distribution of data and investigative reports.

1.8 BASIC ADMINISTRATIVE FUNCTIONS

1.8.1 Timekeeping

Each Section Secretary is that particular Section's timekeeper. The timekeeper shall be kept informed of all leave taken as well as the overtime and compensatory time earned and taken by each employee. Branch employees shall obtain approval from their respective Unit, Section, or Branch Chief before taking annual leave. A leave request form (SF-71) must be completed when more than 40 hours of annual leave is taken or whenever any leave is taken and the employee anticipates being unavailable to initial his/her timecard. All Branch employees shall utilize the appropriate Section roster, located on the bulletin board in their respective Section Secretary's office, to post leave taken. If an employee is too sick to report for duty, the employee shall notify the respective Section Secretary by telephone as soon as possible. The appropriate Section Secretary, as well as the employee's immediate supervisor, shall always be kept informed of all travel plans (even those made to the regional office). The appropriate Section Secretary is responsible for notifying the Division Director's Secretary in writing of any scheduled travel by COB on Thursday prior to the following week's travel. Emergency or unscheduled travel will be reported via telephone to the Division Director's Secretary by the appropriate Section Secretary once the travel is known. All employee's time must be charged to appropriate specific account numbers. This is accomplished by having each Branch employee utilize the form shown in Figure 1.8.1 to account for all work hours. This form shall be filled out by each Branch employee to the nearest whole hour. For the Activity Code in Figure 1.8.1, each employee shall use the most relevant Activity Code from Table 1.8.1. The form shall be submitted to the appropriate Section Timekeeper no later than close of business on the first Monday of each pay period. All leave, compensatory time, and overtime, whether earned or taken, must be turned in to the appropriate Section Timekeeper by 0900 on the second Thursday of each pay period. These times/days may vary on holidays. A notice will be posted in each Section Secretary's office if leave should be turned in earlier.

Each employee with either a fixed Superfund account number or any employee who works on any Superfund activity during a pay period shall also complete the EPA Payroll Distribution Timesheet (Figure 1.8.2). This form shall be filled out to the nearest hour for regular hours worked and to the nearest quarter hour for overtime. The report shall be signed and dated by each employee prior to turning it in to their Section Timekeeper on the first day of each pay period. The Timekeeper gives the supervisor the form to review, sign, and date. By noon on the second day of each pay period, the Supervisor returns the form to the Section Timekeeper.

All requests for compensatory time and overtime must be submitted in advance of projects and approved before it can be earned. Overtime/compensatory time requests should be submitted to the appropriate Section Secretary on the bottom of the Request for Travel Order Form (Figure 1.8.3). These requests should be submitted at least two weeks in advance of projects, and shall be initialed by the employee's immediate supervisor. The appropriate Section Secretary shall complete the Request for Authorization of Overtime Work (EPA Form 2560-7) for approval by the Division Director.

All overtime and compensatory time earned shall be submitted to the appropriate Section Timekeeper utilizing the form shown in Figure 1.8.4. This form should be signed by the project leader/field investigator, initialed by the appropriate Unit Chief, and signed by the appropriate Section Chief. When field operations are conducted during the second week of the pay period, the project leader or field investigator shall call the appropriate Section Timekeeper by 0900 on Thursday and report any overtime and compensatory time earned by project personnel.

Blanket authorization for hazardous duty pay is approved on an annual basis for Hazardous Waste Section personnel. The Overtime/Compensatory Time/ Hazardous Duty Pay Approval Form (Figure 1.8.4) must be completed for all approved personnel earning hazardous duty pay. The form shall be completed upon return from the field investigation for approval by the Chief, Hazardous Waste Section. The justification for hazardous duty pay shall be signed by the Project Officer, the Section Safety Officer, and the Chief of the Hazardous Waste Section.

1.8.2 Purchase Requisitions

All purchase requests shall be submitted on EPA Form 1980-8 (Procurement Request/Requisition). This form shall be routed through the appropriate Unit Chief to the Section Chief. All purchase requests shall contain a specific written justification on a separate sheet of paper attached to EPA Form 1980-8 as to why the purchase is necessary (if the request is for Superfund, it should be so noted below the written justification). This form and written justification shall also be used when purchases are made utilizing petty cash.

1.8.3 Travel Authorization Requests

All travel requests shall be made on the Request for Travel Orders Form (Figure 1.8.3), initialed by the immediate supervisor, and (if possible) shall be submitted to the appropriate Section Secretary at least 10 working days in advance of the scheduled travel.

1.8.4 Word Processing Procedures

To minimize risks of multiple copies, all reports and memos will be finalized through the clerical staff. The clerical staff will be responsible for proper formatting, editing, and final distribution of each document. Once a document has been submitted for finalization, no further editing should occur to the document unless it is on the "official working copy" which has been submitted to the clerical staff.

1.8.5 Report and Correspondence Distribution

After report distribution memos and correspondence have been signed, these items will be returned to the appropriate Section Secretary or Clerk-Typist for distribution. In general, other Branch employees will not make distribution of such items. Memos or correspondence for the Division Director (or higher level authority) must be initialed by the originator, the Unit Chief, the Section Chief, and the Branch Chief prior to submittal to the Division Director's

Secretary. The appropriate Section Secretary will carry all correspondence for the Division Director's signature directly to the Division Director's Secretary.

1.8.6 Vehicle Use and Check-Out

The keys for Branch sedans are kept in the Air and Water Compliance Section Secretary's office in a locked box, and the keys for Branch field vehicles are kept in the Hazardous Waste Section Secretaries's office in a locked box. All vehicles shall be checked out by Branch personnel utilizing the check-out sheet located in the appropriate Section Secretary's office. Any needed repairs shall be noted on the check-out sheet along with the ending vehicle mileage at the conclusion of a trip when the keys are returned. The gas tank for all vehicles shall be at least three quarters full when returned to the Athens facility.

1.8.7 Field Equipment Check-Out

Branch field personnel shall use the current field equipment load-out form (Figure 1.8.5) to specify the field equipment needed for specific field studies. All requested information (including account number, project number, and activity code for which the investigation is charged) shall be completed prior to submittal to the warehouse staff. The load-out form should be submitted to the warehouse staff at least five working days prior to the time the equipment is needed (except in an emergency).

1.8.8 CERCLA/RCRA Site Map Requests

Requests for hardcopy production of site maps and other graphic output to be produced by the Hazardous Waste Section AutoCAD/Mapping workstation should be completed using the form shown in Figure 1.8.6 or equivalent. Requests for non-CERCLA/RCRA work as well as requests by non-HWS Section personnel require approval by the HWS Chief.

1.8.9 Requests for Analytical Data Summary Tables

The Hazardous Waste Section has developed computer programs that produce tables summarizing ESD/ASB and CLP laboratory analytical data results. Since these programs require direct access to the ESD/ASB computer databases and appropriate accounts and access rights on the laboratory's computer, requests should be made to the HWS using the form shown in Figure 1.8.7 or equivalent.

FIGURE 1.8.3
REQUESTS FOR TRAVEL ORDERS

Names_____

_____

Dates of Travel_____

Site Name(s)_____

Site Location(s)_____

Site Account Number(s)_____

Purpose of Trip_____

_____

****

LODGING

City/County_____Hotel_____

Cost_____Actual Expenses_____

****

DO YOU NEED FLIGHT RESERVATIONS? Yes ( ) No ( )

Beginning Date_____LV_____Time_____Flight #_____

AR_____Time_____

Returning Date_____LV_____Time_____Flight #_____

AR_____Time_____

****

DO YOU NEED A RENTAL CAR? Yes ( ) No ( )

Confirmation #_____Agency_____

Rate_____Size_____

****

REQUEST FOR OVERTIME/COMP TIME

No. of Hrs_____

_____

Submitted By:_____

Approved By:_____Unit Chief

_____Section Chief

FIGURE 1.8.4

OVERTIME/COMPENSATORY TIME/HAZARDOUS DUTY PAY APPROVAL FORM

USE ONE FORM FOR EACH PROJECT

PROJECT NAME:_____ PROJECT NUMBER:_____

ACCOUNT NUMBER_____ PROGRAM ELEMENT:_____

NAME	DATE	OVERTIME	COMP TIME	HD PAY

PROJECT LEADER:_____ APPROVAL/DATE _____

CHIEF, HWS_____ APPROVAL/DATE_____

_____

HAZARDOUS DUTY PAY JUSTIFICATION

_____

_____

_____

SAFETY OFFICER: _____APPROVAL/DATE_____

CHIEF, HWS:_____APPROVAL/DATE_____

FIGURE 1.8.5
HAZARDOUS WASTE SECTION
LOAD OUT SHEET

Project Leader_____EXT._____
Study(s)_____ST._____
Account No(s)_____RCRA? CERCLA?

Activity Code_____ Loadout Date
Project No. _____ __/__/____
Vehicles(s) _____
_____

SOIL/SEDIMENT/WASTE

__S. S. Shovels

__Hand Augers 4" heads
__Extensions
__Pins (jar)
__Handles

__(L) S.S. Spoons
__(S)

__(L) Glass Pans
__(S)

__Scoops
__Scoop Brackets
__Conduit Pipe

__(L) S.S. Ponar Dredge
__(S)
__3/8" Rope (ft)

Miscellaneous
__Glass Tube
__Bacon Bomb
__Coliwasa Tubes
__S.S. Push Head (ea)
__Shelby Tube/pushhead(ea)

WATER
__Well Sounder #_____
__2" Teflon® Bailers
__Bailer Rope (spool)
__Phase Detector #_____
__Graduated Cylinder

GLOVES
__Surgical (latex) (Box)
__Neoprene Rubber (Box)
__Butyl Rubber (ea)
__PVC (ea)
__Cotton Work (ea)
__Silver Shields

WELL INSTALLATION
__Lil' Beaver®
__Auger Points
__Auger Flights
__2" Sand Points
__2" Well Casings

PUMPS

__Peristaltic Pump(s)#____
__Silastic Tubing (coil)
__Teflon® Tubing (25'roll)
__Vacuum Inserts (jar)
__M. Flex Cables (set)

__Fultz® Pump(s)#_____
#_____#_____
__Extra Fultz Heads (S/L)
__Power pack
__24v Cables (set)
__Charging Units (ea)
__24v Generator

__Goulds Pump #_____
__Extension Cord
__110v Generator
__Hose (ft)
__3/8" Rope (ft)
__Tripod

__Geo Guard #_____
__Geo Guard Control Box
__Geo Guard Compressor

__Well Wizard #_____
__3011 Controller (elect.)
__3111 Controller (gas)
__Air Connector
__12v Connector

BATTERIES
__12 volt
__ _____

SURVEYING EQUIPMENT
__Transit #_____
__Level #_____
__Rod #_____
__Altimeter
__Steel Tape (ea)
__Fiberglass Tape (ea)
__Aerial Targets (ea)
__Flagging (ea)
__Cloth Tape (ea)
__Tacks
__Wood Stakes (ea)
__Sledge Hammer (ea)
__Hammer (ea)
__Orange Vests
__Plumb Bob

TOPCON

__Topcon#_____
__Prisms
__Prism Tripods
__Thermometer
__Barometer
__Field Book

GEOPHYSICAL
__Magnetometer #__
__Metal Det. (L),(S)#
__EM-31#_____
__EM-34 #_____
__Wadi

LIQUID CONTAINERS

Liquid
__1Gal.(Ext/Pest)
__1L Poly Met/Cyanide
__40-ml VOAs-3/sample
____Chlorinated
____Non-Chlorinated
__500ml Glass(Phenol)

Soil/Sed/Sludge
__8oz Ext/Pest/Cyan
__2oz VOAs

Miscellaneous
__1 Gal Plastic
__4oz white-cap jars
__500-ml Polyeth.
__1/2 Gal Plastic
__1 L. W/M Clr. Glass

Concentrated Waste
__8oz Glass (jar)

REAGENTS

__HNO_3 (500ml)
__NaOH (bottle)
__H^2SO_4 (500ml)
__Thiosulfate
__Zinc Acetate
__KCL
__Ascorbic Acid

FIGURE 1.8.5 (CON'T)

FIELD ANALYSES

___pH Paper
___pH Meter (old)____
___pH Meter (new)____
___pH Buffer (set)
___Storemore jars
___Cond. Meter#_____
___D.O. Meter#_____
#_____
#_____

ICE CHESTS (L,S, 6pck)
___ ___ ___ ___ ___ ___
___Plastic Crates (L,S)

Plastic Bags
___Large
___Medium
___Small
___Whirl-Paks®

TAPE
___Fiber (ea)
___Duct (ea)
___Electrical (ea)
___Masking (ea)

SAMPLE SHIPPING
___Vermiculite (Bag)
___Dust Masks (Box)

Sample Cans w/ Clips
___Gallon (ea)
___Quart (ea)

Shipping Boxes/ Styrofoam Inserts
___1 Quart (ea)
___4 Quart (ea)
___1 Gallon (ea)

SAFETY EQUIPMENT

	XL	L	M	S
___Tyvek	___	___	___	___

___Green One Piece Suit
___Yellow Splash Suit (ea)
___Disposable Booties (pr)
___Tent (ea)
___Drink Cooler (ea)
___Chair(s) (ea)
___Tables (ea)
___Cooling Vests
___Brass Tools (set)
___Rangers (set)
___Extra Air Tanks (ea)
___Ultra Twin Canist.(set)
___Cascade System
___Boundary Tape-Excl Zone
___Boundary Tape-Supp Zone
___Boundary Tape-Cont Zone
___Eye Wash System
___Cooling Vest & Batteries

SAFETY MONITORING

___Air Monitoring Box#____
___OVA#_____
___Tip II #_____#_____

FIELD CLEANING
___Wash Tubs (ea)
___Pump Sprayer (ea)
___Distilled Water (gal)
___Organic Free Water (gal)
___Milli-Q Water System
___Isopropanol (gal)
___Liquinox (bott)
___Graduated Bucket (ea)
___Brushes (ea)
___Aluminum Foil (box)
___Garbage Bags (ea)
___Oil Wipes (ea)
___Saw Horses (pr)
___Plastic Sheets (box)

PROJECT LEADER

___Tags (bundle)
___Custody Seals (box)
___Custody Sheets
___Sample Receipt
___Travel Orders
___Hotel RSVP
___Topo/Quad/Photo
___Hand Radios
___Hand Rad. Charger
___Safety Bag(s)
___Camera
___Film
___Instruction Manuals
___Notebook(s)
___Traffic Reports
___Air Bill(s)
___Hazardous Manifest

MISCELLANEOUS
___Extension Cord
___Trailer (large)
___Trailer (small)
___Trailer (H) Hearse)
___Bungi Cord (ea)
___Gas Can (ea)
___Boat
___Life Vest(s) (ea)
___Oar(s) (ea)
___Waders (pr)
___Flashlight (ea)
___Machete (ea)
___Whizz Witch
___Jumper Cables (set)
___Safety Harness (ea)
___Fluorescent Paint
___12v Floodlights
___Tool Box (ea)
___Paper Towels (pks)
___Garden Hose
___Gator Aid (pks)

#CHECK PAGE ONE
__*__Reagents
__*__Lit' Beaver®
__*__24v Generator
__*__110v Generator
__*__PUMPS

Special Requests _____

Released By: _____ Date: _____ Returned To: _____ Date: _____
Released To: _____ Date: _____ Returned To: _____ Date: _____

FIGURE 1.8.6
AUTOCAD REQUEST FORM

REQUESTOR'S NAME:_____

TYPE OF REQUEST: CERCLA_____ RCRA_____ OTHER_____

DATE OF REQUEST:_____ DATE REQUIRED:_____

PROJECT NUMBER:_____ ACCOUNT NUMBER:_____

PROGRAM ELEMENT:_____ FIGURE NUMBER:_____

NAME OF OLD DRAWING TO USE AS TEMPLATE:_____
(IF APPLICABLE)

HAZARDOUS WASTE SECTION CHIEF SIGNATURE:_____
(REQUIRED FOR ALL NON-CERCLA/RCRA OR NON-HWS REQUESTS)

COMMENTS:

_____

_____

_____

_____

_____

_____

_____

_____

_____

COMPLETED BY:_____ DATE:_____

FIGURE 1.8.7

DATA TABLE .. DEFINITION ENTRY SHEET

FIRST and LAST INITIALS: __ __

PROJECT NUMBER: ____ - _____

TABLE ID: (1 or 2 char): __ __

(computer will assign the DBNAME based on info at left, WRITE IT DOWN!)

DBNAME = __ __ __ __ __ __ __ __

YOUR LAST NAME: _____

DATE TO RUN: __ __ / __ __ /__ __
M M D D Y Y

INCLUDE NONDETECTABLES (Y or N)? ___ ("Y"es will give all "U" values)

SORT COMPOUNDS ALPHABETICALLY? (Y or N)? ___ ("N"o is the default)

****

* ANALYSES TO PULL (Answer Y or N):

ALL __ VOAORG __ EXTORG __ PEST/PCB __ METALS __ SPECIFIED (CN) __

****

* (You may enter up to 5 titles, up to 40 characters each) EXAMPLE:

TABLE TITLE #1: _____ TABLE 1

TABLE TITLE #2: _____ ANALYTICAL DATA SUMMARY

TABLE TITLE #3: _____ BOZO'S TOXIC WASTE, INC

TABLE TITLE #4: _____ FUME CITY, NEW JERSEY

TABLE TITLE #5: _____ JANUARY, 1988

****

	SAMP 1	SAMP 2	SAMP 3	SAMP 4	SAMP 5	SAMP 6	SAMP 7	SAMP 8
SAD #1:	_____	_____	_____	_____	_____	_____	_____	_____
SAD #2: (optional)	_____	_____	_____	_____	_____	_____	_____	_____
STATION: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____
DESCRIP: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____
DESCRIP: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____

	SAMP 9	SAMP 10	SAMP 11	SAMP 12	SAMP 13	SAMP 14	SAMP 15	SAMP 16
SAD #1:	_____	_____	_____	_____	_____	_____	_____	_____
SAD #2: (optional)	_____	_____	_____	_____	_____	_____	_____	_____
STATION: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____
DESCRIP: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____
DESCRIP: (8 char)	_____	_____	_____	_____	_____	_____	_____	_____

Program Element	Activity
	General Administrative
010	Administrative - Personnel, Performance, Travel, Etc.
012	Timekeeping
013	Training Attended
014	Safety Training
015	Training Plan Development
016	Property Inventory
017	Procurement
018	Clerical
020	Equipment Maintenance
021	Vehicle Maintenance
023	Equipment Repair
	Leave
051	Annual
052	Sick
053	Holiday
054	Administrative
055	Hazardous Weather
056	Jury
057	LWOP
058	Compensatory Time (Taken)
	Management/Supervision
100	General
101	Review of National Guidance
102	Work Plan Development/Review
103	Regional Program Reviews
104	Regional Program Planning
106	Literature Review
107	Workload Model Review/Input
108	End of Year Review (Personnel)
109	Mid-Year/End-Of-Year Review (Personnel)
110	SPMS/STAR Report/Preparation
111	Study/Project Plan Review
112	Peer Review Reports
113	Report Preparation
120	Office/Lab Cleanup/Move
121	Employee Physical
122	Attendance at Conference, Seminars, Conventions, Etc.
123	Staff Meetings
124	Health and Safety Meetings
125	FOI Requests
126	Committee Meetings
127	Program Meetings
128	General Meetings
133	Congressional Response/Inquiry

AIR MONITORING (A2304P009)

Program Element	Activity
	Technical Assistance
201	Develop State/Local Agency Capabilities
202	TA to EPA Program Personnel
203	TA to State/Local Agency Personnel
204	TA to HQ Personnel
205	TA to Other Federal Agency Personnel
206	On-site TA
207	General TA
208	Assistance to State/Local Agencies - Acid Rain
209	Assistance to State/Local Agencies - Air Toxics
211	Training Conducted
282	Trends Analysis
551	QA/SOP Plan Reviews including Branch SOPQAM Revisions
	Evaluations
251	Project/Study Plan Review and Preparation
252	State/Local Agency Lab Evaluations
254	Site Evaluations
255	NAMS (New Sites)
256	NAMS (Existing Sites)
257	SLAMS (New Sites)
258	SLAMS (Existing Sites)
261	NAMS Documentation
262	SLAMS Documentation
263	QAMS Audit
264	EMSL Audit
265	NAAS System Audits
266	Pre-audit Preparation
267	Audit Report Preparation
268	Performance Audits
	Precision & Accuracy and Data Submittals/Retrievals
259	P&A Reports
260	P&A Evaluations
287	SAROAD Retrieval/System Support
	Air Toxics Monitoring/Special Studies
269	Air Toxics Monitoring Studies - Ambient
270	Air Toxics Monitoring Studies - Superfund
283	Air Monitoring Policy Manual
	Criteria Monitoring
284	Orifice Calibration/Certification
285	Ozone Calibrator/Monitor Certification
286	CO Saturation Monitoring
287	PM_{10} Saturation Monitoring
	Network Design/Redesign
271	Ozone Network Redesign
272	CO Network Redesign
273	TSP, SO_2, & Pb Network Redesign
	Special Enforcement Activity
271	Criminal Investigations
272	Civil Investigations
273	Admin. Enf. Actions

WATER QUALITY ENFORCEMENT (AFE04P000)

Program Element	Activity
	Technical Assistance
202	TA to EPA Program Personnel
203	TA to State Agency Personnel
204	TA to HQ Personnel
205	TA to Federal Agency Personnel
207	On-site TA
211	Training Conducted
551	QA/SOPQAM Activities/Updates
101	Review of National Guidance
	Inspections
301	PAI - Major Municipal
302	PAI - Minor Municipal
303	PAI - Major Industrial
304	PAI - Minor Industrial
305	PAI - Federal Facility
306	CSI - Major Municipal
307	CSI - Minor Municipal
308	CSI - Major Industrial
309	CSI - Minor Industrial
310	CSI - Toxics
311	CSI - Federal Facility
312	CEI - Major Municipal
313	CEI - Minor Municipal
314	CEI - Major Industrial
315	CEI - Minor Industrial
316	CEI - Federal Facilities
318	RI - Major Municipal
319	RI - Minor Municipal
320	RI - Major Industrial
321	RI - Minor Industrial
322	RI - Federal Facilities
323	LSI - Major Municipal
324	LSI - Minor Municipal
325	LSI - Major Industrial
326	LSI - Minor Industrial
327	LSI - Federal Facilities
328	DE - Major Municipal
329	DE - Minor Municipal
330	DE - Major Industrial
331	DE - Minor Industrial
336	DE - Federal Facilities
400	DE (MWPP)
401	DE (Tech Transfer)
341	Biomonitoring
337	Toxicity Study
357	Toxic Sludge

Program Element	Activity
	State Overview
250	General
	Special Enf. Activities
409	Show Cause Hearings
402	Consent Decree
403	AO
404	Attorney Consultation
372	Criminal Investigations
373	Civil Investigations
	Pretreatment Inspections
360	Pretreatment Compl Insp.
361	Pretreatment Check
362	Pretreatment Audit
	Underground Injection
368	UIC
	Special Water Quality Studies
347	Water Qual Monitoring
348	Toxicity Studies
363	Support Permit Activities
364	NPDES Enforcement
	Wetlands/Oceans
338	Field Investigation
	Miscellaneous
279	EIS Review

Program Element	Activity
	Technical Assistance
101	Review of National Guidance
105	Review of Water Monitoring Strategy
211	Training Conducted
280	Review of Annual Workplans
551	QA/SOPQAM Review/Update
	Program Evaluation
103	Regional Program Review
280	State Program Review
	Technical Assistance to States
201	Developing State Capabilities
207	General TA
210	Multimedia Geographical Area Assessments
	Water Quality Technical Assessments
202	Review of Regional Documents
203	Review of State Prepared Documents/Reports
250	Emerging Problems
274	Success Stories/PR
282	Trend Analysis
	Technical Assistance to HQ
366	Field Investigations
204	Other Assistance
	Technical Assistance to Region
366	Field Investigations
	Special Monitoring for States
366	Field Investigations
	Estuarine/Marine Program
103	Program Review
207	Technical Assistance
251	Overview of Work Plans and Work Products

HAZARDOUS WASTE MANAGEMENT (A8004P009)

Program Element	Activity
	Technical Assistance
101	Review of Program Guidance (Not Enforcement Related)
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
207	Technical Review of Waste Analysis Plans
	State Program Reviews, Training, Technical Assistance
201	Review of State Grant Package
280	Review of State Program Plan
281	Mid-Year or End-of-Year Program Reviews
203	Technical Assistance for State or Local Agencies
211	Training Presented to State or Local Agencies
	Program Planning, Training, Technical Assistance
104	Program Planning
211	Training Presented to EPA Program Personnel
202	Technical Assistance for EPA Program Personnel
211	Training Presented to Other Federal Agency Personnel
205	Technical Assistance for Other Federal Agency Personnel

HAZARDOUS WASTE ENFORCEMENT (AGD04P009)

Program Element	Activity
	Technical Assistance
101	Review of National Enforcement Guidance
211	Training Conducted
551	QA Activities Including SOPQAM Revision
202	Technical Assistance to Program Staff - Civil/Criminal/Admin.
203	Technical Assistance to State Personnel
206	On-Site Technical Assistance
289	State/Contractor Field Overview
295	Document Review
	Investigations and Inspections
350	Comprehensive Groundwater Monitoring Evaluations - TSD - Major
352	Comprehensive Groundwater Monitoring Evaluations - Federal Fac.
353	Comprehensive Groundwater Monitoring Evaluations - State Facility
354	Case Development Investigations/Evaluations - TSD - Major
356	Case Development Investigations/Evaluations - Federal Facility
357	Case Development Investigations/Evaluations - State Facility
	Field Support
372	Field Investigative Support for Civil Enforcement Actions
373	Field Investigative Support for Criminal Enforcement Actions
366	Field Investigative Support for Administrative Enforcement Actions
	Litigation Support
407	Litigation Support for Civil Enforcement Actions
408	Litigation Support for Criminal Enforcement Actions
403	Litigation support for Administrative Enforcement Actions
	State Program Oversight/Technical Assistance
280	State Program Review

HAZARDOUS SUBSTANCE SPILL AND SITE RESPONSE (TFA04P700)

Program Element	Activity
	Technical Assistance
101	Review of National Guidance (Not Enforcement Related)
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
	Sample Control Center
538	Operation of the Sample Control Center (RSCC)
369	Scheduling ESD Field Inspections
	Contractor Overview
295	Review of EPA Fund-Lead RI/FS Contractor Documents
289	On-Site Overview of Fund-Lead RI/FS Contractor Field Activity
296	Review of EPA Enforcement Lead RI/FS PRP Contractor Document
290	Review of EPA Enforcement Lead RI/FS PRP Contractor Field Activity
297	Review of State or State Contractor Prepared RI/FS Documents
292	On-Site Overview of State or State Contractor RI/FS Field Activity
298	Review of State Enf. Lead PRP Contractor Prepared RI/FS Doc.
291	Review of State Enf. Lead PRP Contractor RI/FS Field Activity
295	Review of FIT Study Plans
293	Review of FIT Reports
294	On-Site Overview of FIT Field Activity
	State Overview Activity
278	On-Site OV of State or State Contractor Screening Site Inspections (SSI)
281	Mid-Year Evaluation of State Superfund Grant Program
	Technical Assistance and Training
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Agency Personnel
211	Training Presented

Program Element	Activity
	Technical Assistance
101	Review of National Enforcement Guidance
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
	Field Investigations in Support of Enforcement Activities
373	Field Investigations in Support of Civil Enforcement Actions
372	Field Investigations in Support of Criminal Enforcement Actions
366	Field Investigations in Support of Adm Enforcement Actions
374	Field Investigations in Support of State Enforcement Actions
	Litigation Support or Technical Assistance for Enf. Actions
407	Litigation or Technical Support for EPA Civil Enf. Actions
410	Support for EPA Superfund Cost Recovery Program
408	Litigation or Technical Support for EPA Criminal Enf. Actions
403	Litigation or Technical Support for EPA Adm. Enf. Actions
406	Litigation or Technical Support for State Enf. Actions
	Contractor Overview
296	Review of EPA Enf. Lead Contractor Prepared RI/FS Documents
290	On-Site Overview of EPA Enf. Lead PRP RI/FS Field Activity
297	Review of State Agency Enf. Lead PRP Contractor Prepared RI/FS Doc
291	On-Site OV of State Agency Lead PRP Contractor RI/FS Field Act.
294	On-Site OV of EPA Enforcement Contractor Field Activity

TABLE 1.8.1 (CONTINUED)

DREDGE AND FILL (AGM04P009)

Program Element	Activity
	Program Assistance
207	Desk-Top Environmental Assessment
206	On-Site Technical Advice
413	Expert Witness/Consultant for Litigation/Settlement
366	Field Investigation
279	EIS Review

DRINKING WATER (A7004P009)

Program Element	Activity
366	Field Investigation
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Agency Personnel
204	Technical Assistance to HQ

UNDERGROUND STORAGE TANKS (A4E05GOSL)

Program Element	Activity
101	Review of National Guidance
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Personnel
366	Field Investigation

1.9 BRANCH PROCEDURES FOR OBTAINING ANALYTICAL SUPPORT

1.9.1 General

Analytical support for Branch field investigations is available from a number of sources including in-house analytical support from the Analytical Support Branch (ASB), other EPA laboratories, the National Contract Laboratory Program (CLP), or other private contract laboratories. Procedures to be followed for obtaining this support are contained in the following paragraphs.

1.9.2 Specific Procedures

All arrangements for analytical support are ultimately channeled to the Analytical Support Branch (ASB). All requests for in-house (ASB) analytical support, or for contract laboratory support other than from the National Contract Laboratory Program (CLP), are handled directly by the ASB. Requests for CLP support (Superfund) are normally directed to the Regional Sample Control Center (RSCC - i.e., Chief, Hazardous Waste Section).

In either case, the ASB Sample Custodian assigns project numbers for all projects as they are received. Requests for analytical support should be submitted as far in advance as possible to insure that the support can be obtained and the analytical capacities of the analytical laboratories are not exceeded. The ASB will not accept samples without a project number, except in an emergency.

The Sample Custodian requires the following information to assign a project number:

- project name/facility name;
- location of project/facility (city and state);
- type of study, activity, and program element;
- date of study and sample shipping dates;
- number of samples by media;
- analyses required by media and analysis type; and
- the analytical turn-around time required.

Branch personnel should not routinely request quick turn-around for analyses unless it is absolutely required.

Blind spike and blank samples for inclusion with CLP sample shipments or for other purposes are obtained from the ASB (see Section 4.6).

1.9.3 Definitions

1.9.3.1 National Contract Laboratory Program (CLP) -- The CLP generally supports the Superfund Program. The program can be used for regional laboratory support by contacting either the Regional Sample Control Center (RSCC, Chief, Hazardous Waste Section) or the Technical Project Officer (TPO, Chief, Organic Chemistry Section). All aspects of the CLP including the proper completion of CLP forms and shipping procedures are given in the Users Guide to the Contract Laboratory Program (2).

1.9.3.2 Routine Analytical Service (RAS) -- Analysis conducted by the CLP which includes volatile organic compounds, semivolatile organic compounds, pesticides, metals, and cyanide. These individual parameters are listed on the Target Compound List (TCL) and the Target Analyte List (TAL).

1.9.3.3 Target Compound List and Target Analyte List -- The list of organic (TCL) and inorganic (TAL) parameters normally analyzed for by both the ASB and the CLP. These compounds/analytes are included in the Users Guide to the Contract Laboratory Program (2).

1.9.3.4 Special Analytical Services (SAS) -- Analyses that can be conducted by the CLP other than those included in the TCL/TAL. These need to be requested through the ASB as soon as possible since protocols for analyses have to be developed for the CLP.

1.9.3.5 Detection Limits -- The optimum detection limits for organic and inorganic constituents in water and soil/sediments by both the ASB and the CLP are listed in Tables 1.9.1 and 1.9.2. Optimum detection limits for organic and inorganic compounds for other media, i.e., concentrated waste, aquatic organisms, etc., can be obtained from the ASB on request. The detection limits for other standardized analytical procedures are contained in the Analytical Support Branch, Operation and Quality Control Manual (3).

1.9.3.6 Regional Sample Control Center (RSCC) -- The RSCC coordinates all aspects of the scheduling of Superfund investigations and analytical support (ASB and CLP) that involve sampling activities. The RSCC is accessed through the Chief, Hazardous Waste Section. The information required to obtain analytical support is the same as outlined in Section 1.9.2. Normally, analytical support for samples to be collected by EPA contractors is coordinated with the RSCC for Superfund projects through the Environmental Services Assistance Team (ESAT), Sample Control Coordinator located in the Waste Management Division (WD). Support for Environmental Services Division Superfund activities is coordinated by the Hazardous Waste Section's, Superfund Unit Chief.

In addition to coordinating the scheduling of Superfund sampling activities, the RSCC is responsible for estimating the needed regional CLP support for the National Superfund Program.

The RSCC is also responsible for obtaining sample containers for Branch Superfund and RCRA activities conducted by Branch personnel.

1.9.4 Distribution of Analytical Data

1.9.4.1 ASB Laboratory Reports -- Normally, two copies of the results of analysis will be sent to the Chief, Hazardous Waste Section for all Superfund and RCRA projects and to the Chief, Air and Water Compliance Section for all municipal and industrial investigations. Analytical data will be reported as it is completed. When all project data have been submitted, the ASB will notify the data requestor that the analyses are complete and request that disposal of the unused portion of samples be approved.

1.9.4.2 CLP Laboratory Reports -- Normally, two copies of the results of analyses for Branch projects will be distributed as outlined in Section 1.9.4.1.

TABLE 1.9.1
OPTIMUM DETECTION LIMITS
ORGANIC COMPOUNDS
WATER AND SOIL/SEDIMENT SAMPLES
(BASED ON CLEAN SAMPLES)

Concentration Description	Reported As	ASB Detection Limits	CLP Detection Limits
		Purgeables	**Purgeables**
Low Water	NA	5-20 ug/l	10 ug/l
Low Soil/Sediment	Dry Weight	10-20 ug/kg	10 ug/kg
Medium Water	NA	5-21 ug/l	10 ug/l
Medium Soil/Sediment	Dry Weight	10,000-50,000 ug/kg	1200 ug/kg
		Extractables	**Extractables**
Low Water	NA	10-20 ug/l	10-50 ug/kg
Low Soil/Sediment	Dry Weight	2,000-4,000 ug/kg	1,700-3,000 ug/kg
Medium Water	NA	10-20 ug/l	10-50 ug/l
Medium Soil/Sediment	Dry Weight	10,000-20,000 ug/kg	10,000-50,000 ug/kg
		Pesticides (PCB's)	**Pesticides (PCB's)**
Low Water	NA	0.05-5.0 ug/l (1.0-3.0 ug/l)	0.05-5.0 ug/l (1.0-2.0 ug/l)
Soil/Sediment	Dry Weight	50-5,000 ug/l (500-1500 ug/kg)	1.7-170 ug/l (33-67 ug/kg)
Medium Water	NA	0.05-5.0 ug/l (1.0-3.0 ug/l)	0.05-5.0 ug/l (1.0-2.0 ug/l)
Medium Soil/Sediment	Dry Weight	50-25,000 ug/kg (2500-7500 ug/kg)	1.7-170 ug/l (33-67 ug/kg)

1 - Detection limits may increase because of varying sample size and/or interferences requiring dilutions

Note: Soil/Sediment Extracting Methods, Medium Level Versus low Level: The primary difference in the methods is the size of sample used for extraction. The low level method uses 30 gm (wet weight) of sample, whereas the medium level method uses 2-3 gm (wet weight) of sample. The negative aspects of the medium level method are (1) the quantitation limit is higher and (2) the smaller sample size is less representative of the sample. The positive aspect is the much simpler and faster sample extraction time. It takes less than an hour to extract a medium level sample and four hours to prepare a low level sample while the difference in quantitation limit is only a factor of five (1000 ug/kg for low level extractable organics and 5000 ug/kg for medium level). This is very significant with the increasing work load and also considering the lack of information on whether this factor of five increase in quantitation limit is necessary.

TABLE 1.9.2
OPTIMUM DETECTION LIMITS
INORGANIC CONSTITUENTS
WATER AND SOIL/SEDIMENT SAMPLES

	Water (ug/l)		Soil (Dry Weight) (mg/kg)	
	ASB	CLP	ASB	CLP
Silver	10	10	1	5
Arsenic	30	10	3	5
Barium	20	200	2	100
Beryllium	10	5	1	2.5
Cadmium	10	5	1	2.5
Cobalt	20	50	2	25
Chromium	10	10	1	5
Copper	10	25	1	12.5
Molybdenum	20	--	2	--
Nickel	20	40	2	20
Lead	30	5	3	2.5
Antimony	30	60	3	30
Selenium	40	5	4	2.5
Tin	100	40	10	20
Strontium	10	--	1	--
Tellurium	40	--	4	--
Titanium	10	--	1	--
Thallium	--	10	--	5
Vanadium	10	50	1	25
Yttrium	10	--	1	--
Zinc	10	20	1	10
Mercury	0.2	0.2	0.05	0.05
Aluminum	100	200	10	100
Manganese	25	15	2.5	7.5
Calcium	1000	5000	100	2500
Magnesium	100	5000	10	2500
Iron	100	100	10	50
Sodium	1000	5000	100	2500
Potassium	--	5000	--	2500

NOTE: -- Indicates that the constituent is not analyzed for.

1.10 QUALITY ASSURANCE PLAN

1.10.1 General

The procedures outlined in this manual are the basis of the Branch Quality Assurance Plan. Where appropriate, each section within this SOPQAM addresses the specific quality control aspects of the subjects covered by that section. The Branch Chief shall designate the Branch Quality Assurance Coordinator for the Branch. The current Quality Assurance Coordinator is the Chief, Hazardous Waste Section. The Quality Assurance Coordinator is responsible for: seeing that the specific quality control procedures as outlined in this SOPQAM are followed, and for tracking and recording the results of specific quality control (QC) programs (such as that outlined in Section 4 - Sampling Procedures). The Branch Quality Assurance Coordinator is responsible for the field analysis QC program, periodically checking the equipment logbooks, and notifying the appropriate Section Chiefs, Unit Chiefs, and Branch Chief of any observed problems.

The Branch and Section Chiefs are responsible for seeing that Branch personnel receive adequate training in order to provide the required quality control for Branch operations. In addition, the Section Chiefs and/or Unit Chiefs may periodically observe the professional and paraprofessional employees, in their respective sections, under actual field operating conditions to insure that the Standard Operating Procedures, as outlined in this manual, are being followed.

1.10.2 Corrective Actions

Corrective actions will be taken any time when deemed necessary. Problems with field quality control may result from contamination of field blanks or contamination of field equipment and supplies either from the vendor, during the cleaning/loadout process, or during field operations. Corrective actions must be taken immediately when data or field procedures are of questionable quality. These corrections may range from modifying certain procedures to reconducting an entire field investigation. The Regional QA Officer (QAO) shall be notified (through the Branch and appropriate Section Chief) of any suspected problems. A Corrective Action Plan shall be developed in cooperation with the QAO.

1.10.3 Peer Review

All non-routine reports and study plans generated by the Branch shall be peer reviewed in accordance with Region IV Order R2200.1 - Review and Clearance of Materials for Public Distribution. The appropriate Section secretary shall be responsible for distribution of documents for peer review after the Peer Review Clearance Form has been signed by the Division Director. All comments from reviewers shall be considered by the project leader. If the document receives a nonconcurrence, the Branch and appropriate Section Chief shall be immediately notified. Appropriate changes/corrections shall be made and the entire document shall be resubmitted for peer review.

1.11 SAFETY PROGRAM

The Branch safety program includes the following regulations and policies in addition to safety practices specified in Appendix N of this SOPQAM:

- Safety and Health Manual, United States Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia, 1990 (4).

  This manual covers safety practices and rules governing activities at the EPA facilities in Athens, Georgia. Included in its contents are accident reporting procedures, procedures for natural and manmade emergencies, safety guidelines for offices and laboratories, and special rules for storage of equipment and wastes.

- Field Health and Safety Manual, USEPA, Region IV, 1990 (5).

  This manual covers safety involved in all field activities performed in Region IV. It includes regional policy regarding training requirements, medical monitoring, and personal protection.

- 29 CFR, Part 1910, Hazardous Waste Operations and Emergency Response; Final Rule, March 1989 (6).

  This is the title for the Department of Labor, Occupational Safety and Health Administration (OSHA) regulations governing workers at hazardous waste sites. It covers requirements for training, equipment, and practices involved in specific hazardous waste activities.

1.12 REFERENCES

1. Ethics In A Nutshell...Ethical Conduct for EPA Employees...in Brief, US-EPA, Office of Inspector General, Washington, D.C., March 1988 (or 40 CFR, Part 3, Chapter 1, Subchapter A, pp. 71-95, July 1, 1989).

2. EPA Users Guide to the Contract Laboratory Program, Us-EPA, Office of Emergency and Remedial Response, Washington, D. C. 20460, December 1988.

3. Analytical Support Branch Operation and Quality Control Manual, Region IV, US-EPA, ESD, September 1990 (and subsequent revisions).

4. Safety and Health Manual, United States Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia, 1990.

5. Field Health and Safety Manual, United States Environmental Protection Agency, Region IV, 1990.

6. 29 CFR, Part 1910, Hazardous Waste Operations and Emergency Response; Final Rule, March 1989.

Facility/Site Name_____

Address_____

Project No._____ EPA ID No._____

Facility Contact_____ Phone No.(_____)-_____

Overview Personnel_____ Date_____

State/Contractor Project Leader_____

Affiliation_____ Phone No.(_____)-_____

Address_____

_____

Sampling Personnel_____

_____

Other Personnel & Affiliation_____

_____

_____

Type of study?_____

Study plan issued?_____ Date issued?_____

Study plan reviewed by ESD? Yes_____ No_____ Acceptable? Yes_____ No_____

Was study plan followed? Yes_____ No_____

Comments_____

Was a safety plan prepared for the study? Yes_____ No_____

Was the safety plan adequate? Yes_____ No_____

Comments_____

Was the safety plan followed? Yes_____ No_____

Comments_____

Additional Comments or Information_____

_____

Checklist sections completed for this overview: 1_____2_____3_____4_____5_____6_____
KEY: 1 General Procedures; 2 Ground Water Sampling; 3 Soil, Sediment Sampling
4 Surface Water Sampling; 5 Waste Sampling; 6 Monitoring Well Installation

SECTION 1 - GENERAL PROCEDURES - SAFETY, RECORDS, QA/QC, CUSTODY, ETC.

1) Type samples collected?_____

2) Were sampling locations properly selected? Yes_____ No_____

Comments_____

3) Were sampling locations adequately documented in a bound field log book using indelible ink? Yes_____ No_____

Comments_____

4) Were photos taken and a photolog maintained? Yes_____ No_____

5) What field instruments were used during this study?_____

_____

_____

6) Were field instruments properly calibrated and calibrations recorded in a bound field log book? Yes_____ No_____

Comments_____

7) Was sampling equipment properly wrapped and protected from possible contamination prior to sample collection? Yes_____ No_____

Comments_____

8) Was sampling equipment constructed of Teflon®, glass, or stainless steel?

_____

9) Were samples collected in proper order? (least suspected contamination to most contaminated?) Yes_____ No_____

Comments_____

10) Were clean disposable latex or vinyl gloves worn during sampling? Yes_____ No_____

Comments_____

11) Were gloves changed for each sample station? Yes_____ No_____

Comments_____

12) Was any equipment field cleaned? Yes_____ No_____

13) Type of equipment cleaned?_____

14) Were proper field cleaning procedures used? Yes_____ No_____

Comments_____

15) Were equipment rinse blanks collected after field cleaning?
Yes_____ No_____

Comments_____

16) Were proper sample containers used for samples? Yes_____ No_____

Comments_____

17) Were split samples offered to the facility owner or his representative?
Yes_____ No_____

Comments_____

18) Was a receipt for samples form given to facility representative?
Yes_____ No_____

19) Were any duplicate samples collected? Yes_____ No_____

Comments_____

20) Were samples properly field preserved? Yes_____ No_____

Comments_____

21) Were preservative blanks utilized? Yes_____ No_____

Comments_____

22) Were field and/or trip blanks utilized? Yes_____ No_____

Comments_____

23) Were samples adequately identified with labels or tags? Yes_____ No_____

Comments_____

24) Were samples sealed with custody seals after collection? Yes_____ No_____

Comments_____

25) What security measures were taken to insure custody of the samples after collection?

_____

26) Were chain-of-custody and receipt for samples forms properly completed?
Yes_____ No_____

Comments_____

27) Were any samples shipped to a laboratory? Yes_____ No_____

28) If yes to No. 27, were samples properly packed? Yes_____ No_____

Comments_____

29) If shipped to a CLP lab, were Traffic Report Forms properly completed?
Yes_____ No_____

Comments_____

30) What safety monitoring equipment, protection, and procedures were used prior to and during sampling?_____

_____

31) Was safety monitoring equipment properly calibrated and calibrations recorded in a bound field log book? Yes_____ No_____

Comments_____

SECTION 2 - SAMPLING - GROUND WATER WELLS

1) Type of wells sampled? (monitoring, potable, industrial,etc.)_____

_____

2) Were wells locked and protected? Yes_____ No_____

Comments_____

3) Were identification marks and measurement points affixed to the wells? Yes_____ No_____

Comments_____

4) What were the sizes and construction materials of the well casings?

_____

5) Were the boreholes sealed with a concrete pad to prevent surface infiltration? Yes_____ No_____

Comments_____

6) Was there a dedicated pump in the well? Yes_____ No_____

7) Was clean plastic sheeting placed around the wells to prevent contamination of sampling equipment and containers? Yes_____ No_____

8) Were total depths and depths to water determined before purging? Yes_____ No_____

9) What device was used to determine depths?_____

10) Were measurements made to the nearest 0.01 ft? Yes_____ No_____

11) Was the measuring device properly cleaned between wells? Yes_____ No_____

Comments_____

12) Was the standing water volume in each well determined? Yes_____ No_____

13) How was the volume determined?_____

14) Was a sufficient volume purged prior to sampling? Yes_____ No_____

Comments_____

15) How many volumes?_____

16) How was the purged volume measured?_____

8) Were total depths and depths to water determined before purging?
Yes_____ No_____

9) What device was used to determine depths?_____

10) Were measurements made to the nearest 0.01 ft? Yes_____ No_____

11) Was the measuring device properly cleaned between wells?
Yes_____ No_____

Comments_____

12) Was the standing water volume in each well determined?
Yes_____ No_____

13) How was the volume determined?_____

14) Was a sufficient volume purged prior to sampling? Yes_____ No_____

Comments_____

15) How many volumes?_____

16) How was the purged volume measured?_____

17) What was the method of purging?_____

_____

18) Were pH, conductivity, and temperature measurements taken and recorded at least once during each well volume purged? Yes_____ No_____

Comments_____

19) Were pH, conductivity, and temperature readings stable prior to sampling? Yes_____ No_____

Comments_____

20) How many wells were sampled?_____Upgradient?_____Downgradient?_____

21) How were the samples collected? Bailer_____Pump_____Other_____

Comments_____

22) If pump was used, what type?_____

23) If a pump was used, was it properly cleaned before and/or between wells?
Yes_____ No_____

Comments_____

24) What were the cleaning procedures?_____

_____

25) Did bailers have Teflon® coated wire leaders to prevent rope from coming into contact with water? Yes_____ No_____

26) Were bailers open or closed top?_____

27) Was a clean bailer and new rope used at each well? Yes_____ No_____

Comments_____

28) Were samples properly transferred from the sampling device to the sample containers? (i.e., purgeable sample first - not aerated, etc.) Yes_____ No_____

Comments_____

29) Was pH of preserved samples checked to insure proper preservation? Yes_____ No_____

Comments_____

30) Were samples iced immediately after collection? Yes_____ No_____

31) For what analyses were the samples collected?_____

_____

32) If samples were split, what were the sample/station numbers for these?

_____

_____

Other comments or observations_____

_____

_____

_____

SECTION 3 - SAMPLING - SOIL, SEDIMENT, SLUDGE, ETC. (Non-containerized)

1) Type of samples collected?_____

2) General description of samples?_____

_____

3) How many samples were collected?_____

4) Were background and/or control samples collected? Yes_____ No_____

Comments_____

5) Were representative samples collected? Yes_____ No_____

Comments_____

6) Were grab or composite samples collected?_____

7) Were composite samples areal or vertical?_____

8) How many aliquots were taken for the composite sample?_____

9) What procedures and equipment were used to collect samples?_____

_____

_____

10) Were samples thoroughly mixed prior to putting them into the sample containers? Yes_____ No_____

Comments_____

11) Were samples properly placed into sample containers? Yes_____ No_____

Comments_____

12) Were samples iced immediately after collection? Yes_____ No_____

13) For what analyses were the samples collected?_____

14) If samples were split, what were the sample/station numbers for these?

_____

15) Was a drilling rig, back hoe, etc., used to collect soil samples? _____

16) Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site? Yes_____ No_____

Comments _____

17) What was the condition of the drilling and sampling equipment when it arrived on site? _____

_____

18) Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment? Yes_____ No_____

Comments _____

19) Was clean equipment properly wrapped and stored in a clean area? Yes_____ No_____

Comments _____

20) Was the drilling rig(s) properly cleaned between well borings? Yes_____ No_____

Comments _____

21) Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP? Yes_____ No_____

Comments _____

22) Other comments or observations _____

_____

_____

SECTION 4 - SAMPLING - SURFACE WATER (Pond, Stream, River, Leachate, Etc.)

1) Type of samples collected?_____

2) General description of samples?_____

3) How many samples were collected?_____

4) Were background and/or control samples collected? Yes_____ No_____

Comments_____

5) Were grab or composite samples collected?_____

6) How many aliquots were taken for the composite sample?_____

7) What procedures and equipment were used to collect the samples?

_____

_____

8) Were samples collected directly into sample containers? Yes_____ No_____

Comments_____

9) Did the sampler wade in the stream to collect the samples? Yes_____ No_____

Comments_____

10) Were the samples collected upstream from the sampler? Yes_____ No_____

Comments_____

11) Did the sampler insure that roiled sediments were not collected along with the water samples? Yes_____ No_____

Comments_____

12) Were representative samples collected? Yes_____ No_____

Comments_____

13) Was the pH of preserved samples checked to insure proper preservation? Yes_____ No_____

Comments_____

14) Were samples iced immediately after collection? Yes_____ No_____

15) For what analyses were the samples collected?_____

_____

16) If samples were split, what were the sample/station numbers for these?

_____

_____

Other comments or observations_____

SECTION 5 - OTHER SAMPLING - DRUMS, TANKS, BARRELS, ETC. (Containerized)

1) Type of samples collected? (Oil, sludge, waste?)_____

2) Description of containers or sources sampled?_____

3) How many samples were collected?_____

4) What type of equipment was used to collect the samples?_____

5) What procedures were used to collect the samples?_____

6) For what analyses were the samples collected?_____

7) If samples were split, what were the sample/station numbers for these?

8) Were any special safety measures taken during collection of the samples?

9) What level of safety protection was required for collection of the samples?

Other comments or observations_____

SECTION 6 - MONITORING WELL INSTALLATION

General

1) Were the wells installed in the proper locations in accordance with the study plan and/or project operations plan (POP)? Yes_____ No_____

Comments_____

2) Were the wells installed starting in the least contaminated area and proceeding to the most contaminated area? Yes_____ No_____

Comments_____

3) Were proper safety protocols employed during the well installations? Yes_____ No_____

Comments_____

4) Were samples of the drilling mud, water, bentonite pellets, filter pack materials, etc., collected for quality control analyses? Yes_____ No_____

Comments_____

Equipment Decontamination

5) Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site? Yes_____ No_____

Comments_____

6) What was the condition of the drilling and sampling equipment when it arrived on site?_____

_____

7) Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment? Yes_____ No_____

Comments_____

8) Was clean equipment properly wrapped and stored in a clean area? Yes_____ No_____

Comments_____

9) Was the drilling rig(s) properly cleaned between well borings? Yes_____ No_____

Comments_____

10) Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP? Yes_____ No_____

Comments_____

Drilling

11) What type of drilling method(s) was used to install the wells? _____

_____

12) Was this drilling method(s) the same as proposed in the study plan and/or POP? Yes_____ No_____

Comments_____

13) Were soil samples collected for logging and analyses as the wells were installed? Yes_____ No_____

14) If yes to 13, at what intervals and by what method?_____

_____

15) If air rotary was used:
Was an in-line organic air filter employed? Yes_____ No_____
Was a cyclone velocity dissipator used? Yes_____ No_____

Comments_____

16) What diameter borehole(s) were installed?_____

17) Were surface outer casings used? Yes_____ No_____

18) If yes to 17, what size and to what depth?_____

_____

19) Were the wells double cased? Yes_____ No_____

20) If yes to 19, explain procedure._____

_____

Well Installation

21) What type of well casing(s) and screen(s) were used?_____

_____

22) What diameter were the well casing(s)?_____screen(s)?_____

23) Was there a minimum two inch annulus around the casing (between casing and borehole wall or inside augers)? Yes_____ No_____

Comments_____

24) What was the length of the well screen(s)?_____

25) What was the slot size of the well screen(s)?_____

26) Was the well screen(s) commercially manufactured? Yes_____ No_____

If yes, by whom?_____

27) Was the bottom of the well screen(s) plugged or capped? Yes_____ No_____

Comments_____

28) Were sand and/or gravel (filter) packs installed? Yes_____ No_____

Comments_____

29) Specify type of materials in 28 [(play sand, Ottawa sand, etc.) and grain size (20/30, 20/40, etc.)], if known._____

_____

30) Was a sieve analysis conducted to determine well screen slot size and filter pack grain size? Yes_____ No_____

Comments_____

31) Were the wells installed to the proper depths? Yes_____ No_____

Comments_____

32) Were well screens placed at the proper intervals? Yes_____ No_____

Comments_____

33) Were the filter packs placed a minimum of two feet above the well screens? Yes_____ No_____

Comments_____

34) Was the tremie tube method used to place the filter packs? Yes_____No_____

Comments_____

35) Were seals placed above the filter packs? Yes_____ No_____

36) If yes to 35, what material was used for the seals?_____

37) Was the vertical thickness of the seals a minimum of two feet? Yes_____ No_____

Comments_____

38) If bentonite pellets were used for the seals above the filter packs, were they allowed to hydrate a minimum of 8 hours? Yes_____ No_____

Comments_____

39) Did contractor/driller have documentation from manufacturer stating recommended hydration time? Yes_____ No_____

Comments_____

40) Was the tremie tube method used to place the bentonite pellets? Yes_____ No_____

Comments_____

41) Was the annulus grouted from the seal to within two feet of the ground surface, or below the frost line? Yes_____ No_____

Comments_____

42) Was the tremie tube method used to place the grout in the annulus? Yes_____ No_____

43) If no to 42, what method was used?_____

44) What type of grout was used to seal the annulus (neat cement, cement/bentonite, cement/sand, etc.)?

_____

45) What grout mix ratio was used? (should be stated in the POP)_____

_____

46) What was the density of the grout? (lb./gal., etc.)_____

47) If bentonite grout was used, was the density at least 9.4 lb./gal.? Yes_____ No_____

48) Was the density determined using a mud balance? Yes_____ No_____

49) Was the grout allowed to set a minimum of 24 hours before the surface pad was installed? Yes_____ No_____

Comments_____

50) Was a concrete surface pad installed with an outer protective casing and locking cap? Yes_____ No_____

Comments_____

51) How far below the ground surface did the concrete pad extend?_____

52) What were the dimensions of the concrete pads?_____

53) Did the well casings extend to a minimum of 2.5 feet above the ground surface? Yes_____ No_____

Comments_____

54) How far above the ground surface did the outer protective casings extend?

_____

55) Did the outer protective casings have weep holes? Yes_____ No_____

Comments_____

56) Were the wells properly developed? Yes_____ No_____

Comments_____

57) Describe method of development._____

_____

58) Give a general evaluation of the activities observed during the installation of the wells.

_____

_____

_____

_____

_____

51) How far below the ground surface did the concrete pad extend?_____

52) What were the dimensions of the concrete pads?_____

53) Did the well casings extend to a minimum of 2.5 feet above the ground surface? Yes_____ No_____

Comments_____

54) How far above the ground surface did the outer protective casings extend?

_____

55) Did the outer protective casings have weep holes? Yes_____ No_____

Comments_____

56) Were the wells properly developed? Yes_____ No_____

Comments_____

57) Describe method of development._____

_____

58) Give a general evaluation of the activities observed during the installation of the wells.

_____

_____

_____

_____

_____

3.0 SAMPLE CONTROL, FIELD RECORDS, AND DOCUMENT CONTROL

3.1 INTRODUCTION

The objectives of this section are to present the Branch standard operating procedures for sample identification, sample control and chain-of-custody, maintenance of field records, and document control.

A sample is defined as physical evidence collected from a facility, site, or the environment. For the purposes of this section, the term "physical evidence" also includes photographs, records, or any other tangible article collected from the environment, facility, or site.

All sample identification, field records, and chain-of-custody records shall be recorded in waterproof, non-erasable ink. If errors are made in any of these documents, Branch personnel will make corrections by simply crossing a single line through the error and entering the correct information. All corrections shall be initialed and dated by the investigator. If possible, all corrections should be made by the individual making the error.

If information is entered onto sample tags, logbooks, or sample containers utilizing stick-on labels, these labels should not be capable of removal later without leaving obvious indications of the attempt. Labels should never be placed over previously recorded information Corrections to information recorded on stick-on labels should be made as stated in the previous paragraph.

3.2 SAMPLE AND EVIDENCE IDENTIFICATION

3.2.1 General

The method of sample identification utilized depends on the type of sample collected. Samples collected for in-situ field analyses are those collected for specific field analyses or measurements where the data are recorded directly in bound field logbooks or recorded directly on the Chain-of-Custody Record, with identifying information, while in the custody of the sampling team. Examples of such in-situ field measurements and analyses include pH, temperature, and conductivity. Also included in this category are those field measurements or analyses such as flow measurements, geophysical measurements, surveying measurements, etc. that are made with field instruments or analyzers, where no sample is actually collected.

3.2.2 Sample Identification

Samples, other than those collected for in-situ field measurements or analyses, are identified by using a standard sample tag (Figure 3.2.1) which is attached to the sample container. In some cases, particularly with biological samples, the sample tag may have to be included with or wrapped around the sample. The sample tags are sequentially numbered and are accountable documents after they are completed and attached to a sample or other physical evidence. The following information shall be included on the sample tag:

- ESD project number;
- field identification or sample station number;
- date and time of sample collection;
- designation of the sample as a grab or composite;
- type of sample (water, wastewater, leachate, soil, sediment, etc.) and a very brief description of the sampling location;
- the signature(s) of the sampler(s) or of the designated sampling team leader (a team leader is a field investigator assigned by the project leader to be present during the collection of a specific sample and to be responsible and knowledgeable of all activities directly related to the collection of that sample).
- whether the sample is preserved or unpreserved;
- the general types of analyses to be conducted (checked on front of tag); and
- any relevant comments (such as readily detectable or identifiable odor, color, or known toxic properties).

Samples or other physical evidence collected by Branch personnel during criminal investigations are to be identified by using the "criminal sample tag."

This tag is identical to the standard sample tag shown in Figure 3.2.1, except that it has a red border around the front and a red background on the back of the tag.

The field sample station number is assigned by the project leader or field investigator. This number is ordinarily an alpha-numeric code, designed for a particular inspection or investigation. For example, if a sample is collected from a monitoring well installed during a site screening investigation conducted at the Abercrombie Widget Company, the alpha-numeric sample number code could be AW-001W. A surface soil sample from this facility might be identified as AW-002S. Each separate monitoring location should have a different numerical designation. Frequently, water and sediment samples are collected from the same sampling station and could have the same numerical designation. For example, water and sediment samples collected from the same location in the Oconee River at Station 001 would be identified as OR-001W and OR-001S, respectively. The project leader or field investigator shall exercise due caution to insure that sample station numbers are not duplicated during studies. The exact description of all sampling stations associated with field identification or sample station numbers shall be documented in the bound field logbooks.

If a sample is split with a facility, state regulatory agency, or other party representative, sample tags or labels with identical information should be attached to each of the sample containers by the party receiving the split sample. Also, all tags for blank or duplicate samples will be marked "blank" or "duplicate," respectively. This requirement does not apply to "blind" spiked or blank samples which are to be submitted for laboratory quality control purposes. "Blind" spiked or blank samples shall not be identified as such, but will be submitted as outlined in Section 4.6.9. This identifying information shall also be recorded in the bound field logbooks and on the Chain-Of-Custody Record as outlined in Section 4.4.

3.2.3 Photograph Identification

All photographs taken by Branch personnel shall be identified on the back of the print with the following information:

- an accurate description of what the photograph shows, including the name of the facility or site and the location.
- date, time and the location that the photograph was taken;
- the orientation of the photograph (i.e., looking northeast, etc.);
- the signature of the photographer.

If the photograph was taken with a Polaroid camera, the information shall be entered on the back of each photograph as soon as it is taken. If a 35 mm camera is used, a serial type record of each frame exposed shall be kept in the bound field logbook along with the information required for each photograph. The film shall be developed with the negatives supplied uncut. The field investigator shall then enter the required information on the prints, using the serialized photographic record from the bound field logbook, to identify each

photograph. For criminal investigations, the negatives must be maintained with the bound field logbook in the project file and stored in the secured file cabinet.

3.2.4 Identification of Physical Evidence

Physical evidence, other than samples, shall be identified by utilizing a sample tag or recording the necessary information on the evidence. When samples are collected from vessels or containers which can be moved (barrels for example), the field investigator shall mark the vessel or container with the field identification or sample station number for future identification, if necessary. The vessel or container shall be marked by utilizing a sharp instrument or spray paint. The vessel or container need not be marked if it already has a unique marking or serial number; however, these numbers shall be recorded on the sample tag and in the bound field logbooks. In addition, it is suggested that photographs of any physical evidence (markings, etc.) be taken and the necessary information recorded in the field logbook.

Occasionally, it is necessary to obtain recorder and/or instrument charts from facility owned analytical equipment, flow recorders, etc., during field investigations and inspections. Field investigators should mark the charts and write the following information on these charts while they are still in the instrument or recorder (along with the field investigators initials):

- if possible, starting and ending time(s) and date(s) for the chart;
- if possible, the field investigator shall take an instantaneous measurement of the media being measured by the recorder. The instantaneous measurement shall be entered at the appropriate location on the chart. The field investigator shall enter the date and time of the measurement and then enter his/her initials;
- a description of the location being monitored and any other information required to interpret the data such as type of flow device, chart units, factors, etc.

After the chart has been removed, the field investigator shall indicate on the chart who the chart (or copy of the chart) was received from and enter the date and time, as well as the investigator's initials.

Documents such as technical reports, laboratory reports, etc., should be marked with the field investigator's signature, the date, the number of pages, and from whom they were received. Branch personnel shall not accept confidential documents, except in special circumstances such as process audits, hazardous waste site investigations, etc.

FIGURE 3.2.1
SAMPLE TAG

FRONT

BACK

3.3 CHAIN-OF-CUSTODY PROCEDURES

3.3.1 General

The possession of samples or other physical evidence shall be traceable from the time they are obtained until they are introduced as evidence in legal proceedings. This section covers only that portion of the Environmental Services Division chain-of-custody procedures that are the responsibility of Branch personnel.

3.3.2 Sample Custody

A sample or other physical evidence is in custody if:

- it is in the field investigator's or the transferee's actual possession; or
- it is in the field investigator's or the transferee's view, after being in his/her physical possession; or
- it was in the field investigator's or the transferee's physical possession and then he/she secured it to prevent tampering; or
- it is placed in a designated secure area.

3.3.3 Chain-of-Custody Record

The field Chain-Of-Custody Record (Figure 3.3.1) is used to record the custody of all samples or other physical evidence collected and maintained by Branch personnel. This form shall not be used to document the collection of split or duplicate samples where there is a legal requirement to provide a receipt for samples (see Section 3.4). The Chain-Of-Custody Record also serves as a sample logging mechanism for the Analytical Support Branch (ASB) sample custodian.

The following information must be supplied in the indicated spaces (Figure 3.3.1) in detail to complete the field Chain-Of-Custody Record.

- The ESD project number.
- The project name.
- All samplers and /or sampling team leader must sign in the designated signature block.
- The sampling station number, date, and time of sample collection, grab or composite sample designation, and a brief description of the type of sample and the sampling location must be included on each line (each line shall contain only those samples collected at a specific location).

- The sampling team leader's name should be recorded in the right or left margin of the Chain-Of-Custody Record when samples collected by more than one sampling team are included on the same form. The sampling team leader is an individual designated by the project leader to be responsible for all activities related to the collection of samples by a specific team of sampling personnel.

- The total number of sample containers must be listed in the indicated space for each sample. The total number of individual containers must also be listed for each type of analysis under the indicated media or miscellaneous columns. Note that it is impossible to have more than one media type per sample. The type of container and required analyses should be circled as indicated on the Record.

- The tag numbers for each sample and any needed remarks are to be supplied in the indicated column.

- The field investigator and subsequent transferee(s) must document the transfer of the samples listed on the Record in the spaces provided at the bottom of the Record. One of the samplers documented under the sampler(s) section must be the person that originally relinquished the samples or evidence or a designated field sample custodian who receives secured samples from sampling teams and maintains these samples under secure conditions. Both the person relinquishing the samples and the person receiving them must sign the form; the date and time that this occurred must be documented in the proper space on the Record. Usually, the last person receiving the samples or evidence should be a laboratory sample custodian or other evidence clerk.

- The remarks column at the bottom of the Record is used to record airbill numbers or registered or certified mail serial numbers.

The Chain-Of-Custody Record is a serialized document. Once the Record is completed, it becomes an accountable document and must be maintained in the project file. The suitability of any other form for chain-of-custody should be evaluated based upon its inclusion of all of the above information in a legible format.

3.3.4 Field Custody Procedures

- To simplify the Chain-Of-Custody Record and eliminate potential litigation problems, as few people as possible should handle the sample or physical evidence during the investigation or inspection.

- The field investigator is responsible for the proper handling and custody of the samples collected (Section 3.3.2) until they are properly and formally transferred to another person or facility.

- Sample tags (Figure 3.2.1) shall be completed for each sample, using waterproof, non-erasable ink as specified in Section 3.3.2.

- All samples shall be sealed immediately upon collection utilizing the EPA custody seal (EPA Form 7500-(R7-75)) shown in Figure 3.3.2. The field investigator may write the date and his/her signature on the seal. This requirement shall be waived if the field investigator keeps the samples in his/her continuous custody from the time of collection until they are delivered to the laboratory analyzing the samples.

- All samples must be documented in bound field logbooks.

- A Chain-Of-Custody Record will be completed for all samples or physical evidence collected as specified in Section 3.3.3. A separate Chain-Of-Custody Record will be utilized for each final destination or laboratory utilized during the inspection or investigation.

- If chain-of-custody is required for documents received during investigations, they should be placed in large envelopes, and the contents should be noted on the envelope. The envelope shall be sealed and an EPA custody seal placed on the envelope such that it cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for the envelope. Any time the EPA seal is broken, that fact shall be noted on the Chain-Of-Custody Record and a new seal affixed. The information on the seal shall include the field investigator's signature, as well as the date and time of sealing.

- Other physical evidence such as video tapes or other small items shall be placed in Zip-Loc® type bags or envelopes and an EPA custody seal should be affixed so that they cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for these items. Any time the seal is broken, a new seal shall be affixed. The information on the seal shall include the field investigator's signature, as well as the date and time of sealing.

- In general, Branch personnel shall not accept samples from other sources unless the sample collection procedures used are known to be acceptable, can be documented, and the sample chain-of-custody can be established. If such samples are accepted by Branch personnel, a standard sample tag containing all relevant information and the Chain-Of-Custody Record, shall be completed for each set of samples.

- EPA custody seals can be used to maintain custody on other items when necessary by using similar procedures as those outlined previously in this section.

3.3.5 Transfer of Custody and Shipment

- All physical evidence or sample sets shall be accompanied by a Chain-Of-Custody Record. When transferring the possession of samples, the individual receiving the samples shall sign, date, and note the time that he/she received the samples on the Chain-Of-Custody Record. This Chain-Of-Custody Record documents transfer of custody of samples from the field investigator to another person, to the ASB, other laboratories, or other organizational elements.

- Samples shall be properly packaged for shipment (Appendix C) and delivered or shipped to the ASB or other designated laboratory for analyses. Shipping containers shall be secured by using nylon strapping tape and EPA custody seals. The custody seals shall be placed on the container so that it cannot be opened without breaking the seals. The seal shall be signed and dated by the field investigator.

- When samples are split with a facility, state regulatory agency, or other government agency, the facility, state regulatory agency, or other government agency representative should sign the Chain-Of-Custody Record. The only exception is that a Receipt For Samples Form will be used for RCRA, TSCA, and CERCLA samples as required by the appropriate regulations (Section 3.4).

- All samples shall be accompanied by the Chain-Of-Custody Record. The original and one copy of the Record will be placed in a plastic bag inside the secured shipping container if samples are shipped. One copy of the Record will be retained by the field investigator or project leader. The original Record will be transmitted to the field investigator or project leader after samples are accepted by the laboratory. This copy will become a part of the project file.

- If sent by mail, the package shall be registered with return receipt requested. If sent by common carrier, a Government Bill of Lading (GBL) or Air Bill should be used. Receipts from post offices, copies of GBL's, and Air Bills shall be retained as part of the documentation of the chain-of-custody. The Air Bill number, GBL number, or registered mail serial number shall be recorded in the remarks section of the Chain-Of-Custody Record or in another designated area if using a form other than that shown in Figure 3.3.1.

3.4 RECEIPT FOR SAMPLES

3.4.1 General

Section 3007 of the Resource Conservation and Recovery Act (RCRA) of 1976 and Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) of 1980 require that a "receipt" for all facility samples collected during inspections and investigations be given to the owner/operator of each facility before the field investigator departs the premises. The Toxic Substances Control Act (TSCA) contains similar provisions.

3.4.2 Receipt for Samples Form

The Receipt For Samples Form (Figure 3.4.1) is to be used by Branch personnel to satisfy the receipt for samples provisions of RCRA, CERCLA, and TSCA. The form also documents that split samples were offered and accepted or rejected by the owner/operator of the facility or site being investigated. The following information must be supplied and entered on the Receipt For Samples Form.

- The ESD project number, project name, name of facility or site, and location of the facility or site must be entered at the top of the form in the indicated locations.

- The sampler(s) must sign the form in the indicated location.

- The facility/site owner/operator's acceptance or rejection of split samples must be checked in the appropriate place in the Split Samples Offered section of the form. The owner/operator should be requested to initial his acceptance or rejection by the check mark and to sign his name in this block indicating that he has been offered this choice if the offer is refused.

- Each sample collected from the facility or site must be documented in the sample record portion of the form. The sample station number, date and time of sample collection, composite or grab sample designation, whether or not split samples were collected (yes or no should be entered under the split sample column), the tag numbers of samples collected which will be removed from the site, a brief description of each sampling location, and the total number of sample containers for each sample must be given. If EPA sample tags are used for split samples, these tag numbers should be recorded under the remarks column.

- The bottom portion of the form is used to document the receipt of split samples by the owner/operator of the facility or site. One of the samplers must be requested to sign and complete the information in the "transferred by" section (date and time must be entered). The owner/ operator of the site must sign the "received by" section of the form (the owner/operator must give his title, and telephone number and give the date and time he/she signed the form). If the owner/operator refuses to sign the form, the sampler(s) should note

this fact in the owner/operator's signature block and initial this entry.

The copy of the form is to be given to the facility or site owner/operator. The Receipt for Samples Form is serialized and becomes an accountable document after it is completed. The original copy of this form must be maintained in project files.

3.5 FIELD RECORDS

Branch personnel shall use only bound field logbooks for the maintenance of field records. The standard field logbooks utilized by Branch personnel are those obtained from the General Services Administration federal supply schedule numbers 7530-00-274-5494 and 7530-00-222-3525. Other bound logbooks such as bound surveyors logbooks are acceptable so long as pages cannot be removed without tearing them out.

Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project code should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and initial indicating the conclusion of the entry or the days activity.

All aspects of sample collection and handling as well as visual observations shall be documented in the field logbooks. All sample collection equipment (where appropriate), field analytical equipment, and equipment utilized to make physical measurements shall be identified in the field logbooks as outlined in Sections 4, 5, 6, and 7 of this SOPQAM. All calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment shall also be recorded in the field logbooks. All field analyses and measurements must be traceable to the specific piece of field equipment utilized and to the field investigator collecting the sample, making the measurement, or analyses.

All entries in field logbooks shall be dated, shall be legible, and shall contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and must be maintained as part of project files.

3.6 DISPOSAL OF SAMPLES OR OTHER PHYSICAL EVIDENCE

Disposal of samples or other physical evidence obtained during Branch investigations is conducted on a case-by-case basis. Before any samples analyzed by the ASB are disposed, ASB personnel shall contact the Branch field investigator or Branch or Section Chief, in writing, requesting permission to dispose of the samples. The samples will not be disposed until the Branch field investigator or Branch or Section Chief completes the appropriate portions of the ASB memo, signs and returns the memo to the ASB, specifically giving them permission to dispose of the samples. Branch personnel should check with the EPA Program Office requesting the inspection or investigation before granting permission to dispose of samples or other physical evidence. The following general guidance is offered for the disposal of samples or other physical evidence:

- No samples, physical evidence, or any other document associated with a criminal investigation shall be disposed without written permission from EPA's Office of Criminal Investigation, the Office of Regional Counsel, or the Department of Justice.

- Quality assurance samples are routinely disposed after the analytical results are reported. ASB does not advise the Branch on the disposal of these samples.

- Samples associated with routine Branch inspections may be routinely disposed.

After samples are disposed, the ASB shall send the sample tags to the Branch field investigator. These sample tags are accountable and must be placed and maintained in the project files.

3.7 DOCUMENT CONTROL

The term document control, as it applies to Branch inspections and investigations, refers to the maintenance of inspection and investigation project files. All project files shall be maintained by the appropriate Section Secretary. All documents as outlined below shall be kept in project files. Branch personnel may keep their own files, however, all official and original documents relating to Branch inspections and investigations shall be placed in the official project files. The following documents shall be placed in the project file:

- a copy of the study plan;
- original Chain-Of-Custody Records and bound field logbooks;
- a copy of the Receipt For Sample Forms;
- all records obtained during the investigation;
- a complete copy of the analytical data and memorandums transmitting analytical data;
- sample tags from samples that have been disposed of by the ASB;
- all official correspondence received by or issued by the Branch relating to the investigation including records of telephone calls;
- one copy of the draft report (without review comments; however, peer review clearance forms shall be included);
- one copy of the final report and transmittal memorandum(s); and
- any other relevant documents related to the original investigation/inspection or follow-up activities related to the investigation/inspection.

Under no circumstances are any personal observations or irrelevant information to be filed in the official project files. The project leader or field investigator shall review the file at the conclusion of the project to insure that it is complete.

4.0 SAMPLING PROCEDURES

4.1 INTRODUCTION

This section discusses the standard practices and procedures utilized by Branch personnel during field operations to ensure the collection of representative samples. All sampling activities conducted by Branch personnel are conducted with the expectation that they will be used for enforcement purposes, unless specifically stated to the contrary in advance of the field investigation. Therefore, the use of proper sampling procedures cannot be over emphasized. The collection of representative samples depends upon:

- ensuring that the sample taken is representative of the material or medium being sampled;
- using proper sampling, sample handling, preservation, and quality control techniques;
- properly identifying the collected samples and documenting their collection in permanent field records (field log books, Chain-Of-Custody Records); and
- maintaining sample chain-of-custody.

The objectives of this section are to present:

- general considerations that must be incorporated in all sampling operations conducted by the Branch;
- Branch sampling site selection and collection procedures for an individual medium;
- Branch sampling quality assurance procedures; and
- equipment calibration and maintenance requirements for Branch sampling equipment.

4.2 GENERAL CONSIDERATIONS

The following factors and procedures shall be considered and implemented in planning and conducting all Branch sampling operations. All these factors and procedures must be considered in view of specific objectives and scope of each individual field investigation.

4.2.1 Selection of Representative Sampling Sites

Representative sampling sites are dependent on the type of investigation undertaken and are discussed under type of sample procedures for each medium later in this section.

4.2.2 Selection and Proper Preparation of Sampling Equipment

The type of sampling equipment to be used is dictated by the investigation and is discussed for each medium later in this section. Appendix B describes the standard equipment cleaning procedures.

4.2.3 Sampling Equipment Construction Material

The material that sampling equipment is constructed of can affect sample analytical results. Materials used must not contaminate the sample being collected and must be readily cleaned so that samples are not cross-contaminated. The standard materials for sampling equipment used to collect samples for trace organic compounds or metals analyses are, in order of decreasing desirability; Teflon®, glass, stainless steel, and steel.

4.2.4 Selection of Parameters to be Measured

Parameters to be measured are usually dictated by the purpose of an investigation and should be based on required monitoring conditions (NPDES or RCRA permits for example) or on the field investigator's or requestor's knowledge of the problem being investigated.

4.2.5 Required Sample Volumes

The volume of sample obtained should be sufficient to perform all required analyses with an additional amount collected to provide for quality control needs, split samples, or repeat examinations. When using a peristaltic pump, individual aliquots of a composite sample should be at least 100 milliliters in order to minimize sample solids bias.

Although the volume of sample required by contract laboratories depends on the analyses to be performed, the amount of sample required for a complete water or wastewater analysis is normally two gallons (7.6 liters) for each laboratory receiving a sample. The amount of soil/sediment required for a complete analysis is approximately 16 ounces. However, the laboratory receiving the sample should be consulted for any specific volume requirements.

The volumes of samples collected from waste sources at hazardous waste sites or samples from sources which are known to be toxic should be kept to an absolute minimum.

Sample volumes to be collected by Branch personnel for routine analyses by the Environmental Services Division (ESD), Analytical Support Branch (ASB) laboratory are in Appendix A. The sample volume required for each analysis is the volume of the standard container less ullage (empty space) required for sample mixing by laboratory personnel and safe shipment of samples to the laboratory. Branch personnel shall allow a minimum of ten percent ullage in every sample container for this purpose. The only exception is samples collected for purgeable organic analyses (VOA) or dissolved gases such as sulfides for which sample containers must be completely filled.

4.2.6 Selection and Proper Preparation of Sample Containers

The type of sample container is dictated by the analyses required. Standard sample containers used by Branch personnel are presented in Appendix A. Special sample container preparation requirements are in Appendix B.

4.2.7 Sample Preservation

Samples for some analyses must be preserved in order to maintain their integrity. Preservatives required for routine analyses of samples collected by Branch personnel are given in Appendix A. All chemical preservatives used by Branch personnel will be supplied by the ASB. All samples requiring preservation should be preserved immediately upon collection in the field. Samples that should not be preserved in the field are:

- Samples collected within a hazardous waste site that are known or thought to be highly contaminated with toxic materials. Barrel, drum, closed container, spillage, or other source samples from hazardous waste sites are not to be preserved with any chemical. These samples may be preserved by placing the sample container on ice, if necessary.

- Samples that have extremely low or high pH or samples that may generate potentially dangerous gases if they were preserved using the procedures given in Appendix A.

- Samples for metals analyses which are shipped by air shall not be preserved with nitric acid in excess of the amount specified in Appendix C.

- Samples for purgeable organic compounds analyses which are shipped by air shall not be preserved with hydrochloric acid in excess of the amount specified in Appendix C.

All samples preserved with chemicals shall be clearly identified by indicating on the sample tag that the sample is preserved. If samples normally requiring preservation were not preserved, field records shall indicate why.

4.2.8 Sample Holding Times

The elapsed time between sample collection and initiation of laboratory analyses must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for all routine samples collected by Branch personnel are shown in Appendix A.

4.2.9 Special Precautions for Trace Contaminant Sampling

Some contaminants can be detected in the parts per billion and/or parts per million range. Extreme care must be taken to prevent cross-contamination of these samples. The following precautions shall be taken when trace contaminants are of concern:

- A clean pair of new, disposable gloves will be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

- Sample containers for source samples or samples suspected of containing high concentrations of contaminants shall be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

- If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples shall never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants shall be lined with new, clean, plastic bags.

- If possible, one member of the field team should take all the notes, fill out tags, etc., while the other members collect all of the samples.

- When sampling surface waters, the water sample should always be collected before the sediment sample is collected.

- Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

- Branch personnel should use equipment constructed of Teflon®, stainless steel, or glass that has been properly precleaned (Appendix B) for collecting samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of

plastic or PVC shall not be used to collect samples for trace organic compounds analyses.

4.2.10 Sample Handling and Mixing

After collection, all sample handling should be minimized. Branch personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags, should be used when small sample containers (e.g., VOA's or bacterial samples) are placed in ice chests to prevent cross-contamination.

Once a sample has been collected, it may have to be split into separate containers for different analyses. The best way to split liquid samples is to continually stir the sample contents with a clean pipette or precleaned Teflon® rod and allow the contents to be alternately siphoned into respective sample containers using Teflon® or PVC (Tygon® type) tubing. Teflon® must be used when analyses for organic compounds or trace metals are to be conducted. Any device used for stirring, or tubing used for siphoning, must be cleaned in the same manner as other equipment (Appendix B). However, samples collected for purgeables organic compounds analyses may not be split using this procedure.

A true split of soil, sediment, or sludge samples is almost impossible to accomplish under field conditions. The higher the moisture content, the more difficult it is to split the sample.

It is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. The most common method of mixing is referred to as quartering. The soil in the sample pan is divided into quarters. Each quarter is mixed, then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material over. Soil and sediment samples collected for purgeable organic compounds analyses should not be mixed. The 2-ounce (60-ml) sample container should be filled completely; no head space should remain in the sample containers.

4.2.11 Purgeable Organic Compounds Sampling (VOA)

Water samples to be analyzed for purgeable organic compounds should be stored in 40-ml septum vials with screw cap and Teflon®-silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

The vials (40-ml) should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule,

it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the procedure. Since the VOA vials are pre-preserved, extreme caution should be exercised when the vials are used as the collection device for surface water samples in order to prevent the loss of the preservative. When collecting water samples for purgeable organic compounds, triplicate samples should always be collected from each location. Three 40-ml vials containing four drops of concentrated HCl should be filled the with sample.

4.2.12 Sample Identification

All samples will be fully documented, as outlined in Section 3, in the field records, on the field sample Chain-Of-Custody Record, and on the sample tags.

4.2.13 Procedures for Identifying Potentially Hazardous Samples

Any sample either known or thought to be hazardous should be so identified on both the sample tag and the field sample Chain-Of-Custody Record. Information explaining the hazard, i.e., corrosive, flammable, poison, etc., shall also be listed.

4.2.14 Collection of Auxiliary Data

All auxiliary data such as flow measurements, photographs of sampling sites, meteorological conditions, and other observations shall be entered onto the field records when the auxiliary data are collected. Auxiliary data relative to a particular sampling location should be collected as close to the sample collection time as possible. Specific types of auxiliary data to collect for each medium sampled are discussed later in this section.

4.2.15 Time Records

All records of time shall be kept using local time in the 2400 hour time format and shall be recorded to the nearest minute.

4.2.16 Transporting and Shipping of Samples

Samples may be hand delivered to the laboratory using government owned (or rented) vehicles or they may be shipped by common carrier. All Branch personnel must be aware that certain samples are hazardous materials and, as such, are regulated by the U. S. Department of Transportation under the Transportation Safety Act of 1974. These regulations are contained in Title 49, CFR, Parts 110-119. Shipment of dangerous goods by air cargo is also regulated by the United Nations/International Civil Aviation Organization (UN/ICAO). The Dangerous Goods Regulations promulgated by the International Air Transport Association (IATA) meet or exceed DOT and UN/ICAO requirements and should be used for shipment of dangerous goods via air cargo. Shipment of samples by EPA employees is also governed by EPA Order No. 1000.18 (1). The standard Branch procedure for

shipping environmental samples is in Appendix C. All Branch employees shall meet the intent of the Transportation Safety Act of 1974 when shipping samples by common carrier.

4.2.17 Sample Chain-of-Custody

Branch employees shall maintain sample chain-of-custody during all field investigations for all samples collected. The standard sample chain-of-custody procedures used by Branch employees are given in Section 3.3.

4.3 DEFINITIONS

4.3.1 Grab Sample

An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes. Grab samples are associated with surface water, groundwater, wastewater, waste, contaminated surfaces, soil, and sediment sampling. Grab samples are typically used to characterize the media at a particular instant in time. See Appendix A for additional guidance concerning parameters requiring a grab sample and for monitoring that indicates that grab samples must be collected.

4.3.2 Composite Samples

A sample collected over time that typically consists of a series of discrete samples which are combined or "composited". Four types of composite samples are listed below:

- Time Composite (TC): A sample comprised of a varying number of discrete samples collected at equal time intervals during the compositing period. The TC sample is typically used to sample wastewater or streams.

- Flow Proportioned Composite (FPC): A sample collected proportional to the flow rate during the compositing period by either a time-varying/constant volume (TVCV) or time-constant/varying volume (TCVV) method. The TVCV method is typically used with automatic samplers that are paced by a flow meter. The TCVV method is a manual method that individually proportions a series of discretely collected samples. The FPC is typically used when sampling wastewater.

- Areal Composite: A sample collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from grid points.

- Vertical Composite: A sample collected from individual grab samples collected from a vertical cross section. Vertical composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes and estuaries.

4.3.3 Quality Control Samples

The majority of ECB field studies require the collection of additional samples for various quality control purposes. These include the isolation of site effects (control samples), define background conditions (background sample), evaluate field/laboratory methodology (spikes and blanks, trip blanks, duplicate samples), or to assess sampling equipment (sampler blanks and equipment rinse

blanks). In addition, it may be necessary to provide split or duplicate samples to assess field sampling procedures.

Miscellaneous sampling definitions are listed below:

- Sample Aliquot: A portion of a sample that is representative of the entire sample.

- Split Sample: A sample which has been portioned into two or more containers from a single sample container or sample mixing container.

- Duplicate Sample: Two or more samples collected simultaneously into separate containers from the same source under identical conditions.

- Control Sample: A sample collected upstream or upgradient from a source or site to isolate the effects of the source or site on the particular ambient medium being sampled.

- Background Sample: A sample collected from an area, water body, or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.

- Biased Sample: A sample which is known to be non-representative of the entire site being studied. An example is samples collected during Superfund Site Screening Investigations that are intentionally biased towards suspected areas of contamination.

- Trip Blanks: Trip blanks are prepared prior to the sampling event in the actual sample container and are kept with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they reach the laboratory. ESD utilizes volatile organic trip blanks to determine if samples were contaminated during storage and transportation back to the laboratory. If samples are to be shipped, trip blanks are to be provided per shipment but not per cooler.

- Equipment Blanks: Equipment field blanks are defined as samples which are obtained by running organic-free water over/through sample collection equipment after it has been cleaned. These samples will be used to determine if cleaning procedures were adequate. (The equipment could have been cleaned in the field or prior to the field operation.)

- Pre and Post Preservative Blanks: To determine if the preservative used during field operations were contaminated, pre and post preservative blanks are prepared. On small studies, usually only a post preservative sample will be prepared. These samples are prepared by putting analyte-free/organic-free water in the container and then preserving the sample with the appropriate preservative.

- Field Blanks: Organic-free water is taken to the field in sealed containers and poured into the appropriate sample containers at pre-designated locations. This is done to determine if any contaminants present in the area may have an affect on the sample integrity. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.

4.4 DATA QUALITY OBJECTIVES

As defined in Data Quality Objectives for Remedial Response Activities (29), "Data Quality Objectives (DQO's) are qualitative and quantitative statements which specify the quality of the data required to support Agency decisions during remedial response activities". DQO's should be considered when planning any study. DQO's provide information on the limits of the data, which in turn dictate the proper uses of the data. DQO's were originally developed to guide the analytical program of Superfund (29), but the concept also has application for other field sampling efforts. Data collected in the field include samples and site information. The methods by which samples are collected may limit the uses of the subsequent analytical data. The methods by which site information, such as physical measurements, photographs, field notes, etc., are collected, may reduce their accuracy. The manner in which sampling equipment is cleaned will also affect the DQO level of the data. The various DQO levels are numbered I through V, with I being the lowest and IV the highest quality data. Level V data are collected using special or non-standard methods. Higher quality methods may be substituted for lower level work.

4.4.1 DQO Level I

Sampling equipment and sample containers must be cleaned using soap and tap water, visibly free of contamination, and free of detectable analytes using the analytical screening methods specified for the study. Use of organic vapor survey methods to determine locations or media fractions for higher level analysis is an example of DQO Level I field work. However, this technique is not appropriate for compounds that are not volatile or produce low instrument response. Data produced from such samples may not be used for other than the stated purpose.

4.4.2 DQO Level II

Field methods, decontamination procedures, and sampling equipment construction materials for DQO Level II analyses are as specified elsewhere in this document. The construction materials for sampling equipment may vary if rinse blanks analyzed using the field analytical procedures show that the substituted equipment does not contribute detectable analytes, and the materials would not reasonably be expected to contribute detectable analytes. For example, it may be acceptable to use PVC sampling equipment to collect samples that are only being analyzed for metals, or to use equipment made of chrome plated material for samples being analyzed only for organic compounds. Field cleaning procedures for sampling equipment used to collect samples that will be analyzed at this DQO level may consist of:

- Soap and potable water wash with brush (steam may also be used), followed by potable water rinse.

- Water rinse. The quality of the water is determined by the contaminants of concern and the minimum quantitation limits of the analytical methods used. For example, if an atomic absorption (AA) unit is being used to analyze water samples for lead only, and the

minimum quantitation limit is 20 ug/l, water containing up to 10 ug/l lead (one-half the minimum quantitation limit) may be used as decontamination water.

A minimum of five percent of samples collected for DQO Level II analyses should be split for DQO Level IV analysis. These samples must be representative of all samples submitted to the field laboratory.

4.3.3 DQO Level III

Field methods, decontamination procedures, and sampling equipment construction materials for DQO Level III analyses are as specified elsewhere in this document. Some modifications of these specifications are allowable in certain limited instances, as specified below.

If DQO Level III analytical services are being used in support of drilling or excavation operations, the cleaning procedures for the down-hole drilling or excavation equipment only may be cleaned as specified in Appendix E.9, with the omission of steps 3, 4, and 5. All other cleaning and decontamination procedures specified in that appendix apply.

When wells are constructed using materials that are not inert with respect to the contaminants being analyzed, data collected from those wells are DQO Level III or lower for those incompatible analytes, even if DQO Level IV analytical procedures are used.

A minimum of one equipment rinse blank per week for each week sampling equipment is field cleaned is required to be analyzed. If samples are preserved, a preservative blank must be collected and analyzed in the field at the beginning and end of the study. A blank of the rinse water must be collected and analyzed prior to beginning the study and at the end of each week sampling equipment is field cleaned.

A minimum of five percent of samples collected for DQO Level III analysis should be split for DQO Level IV analysis. These samples must be representative of all samples submitted to the field laboratory.

4.4.4 DQO Level IV

Field methods and equipment decontamination procedures described in this document are considered to be level IV methods. These are the standard methods to be used on all studies requiring DQO Level IV quality data. Any deviations from these methods must be documented in the field logbook or the approved study plan. The sampler must be aware that such deviations in the field work may reduce the DQO level of the data, with a subsequent reduction in the data uses. The field notes are always collected as specified in Section 3.5. Photographs are always logged as specified in Section 3.2.3.

4.4.5 DQO Level V

Because DQO Level V procedures are by definition non-standard, they are not discussed in detail. The project leader must be aware that special analytical procedures may require specialized field procedures and equipment. These must be specified in the approved study plan prior to beginning the study.

4.5 INVESTIGATION DERIVED WASTE

4.5.1 General

Many field investigations conducted by the Branch generate waste materials. These waste materials are known as investigation derived waste (IDW) (30). Some of these waste materials may be hazardous wastes which must be properly disposed in accordance with EPA regulations. Most, but not all, of these hazardous wastes will be associated with investigations of hazardous waste sites.

4.5.1.1 Types of IDW -- Materials which may become IDW requiring proper treatment, storage and disposal are:

- Personnel protective equipment (PPE). This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
- Disposable equipment (DE). This includes plastic ground and equipment covers, aluminum foil, conduit pipe, coliwasa samplers, Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand auguring.
- Drilling mud or water used for water rotary drilling.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as spent solvent and washwater.

4.5.1.2 Management of Non-Hazardous IDW -- Disposal of non-hazardous IDW from hazardous waste sites should be addressed in the study plan. Non-hazardous IDW such as PPE and DE may be double-bagged and brought back to the Branch warehouse for disposal in the warehouse trash containers. To reduce volume for transportation back to the warehouse, it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum. If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE and DE IDW into the facilities dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a permitted landfill local to the site. On larger studies, waste hauling services may be obtained and a dumpster located at the study site. They may also be buried on site near the contamination source, with the burial location noted in the field logbook.

Disposal of non-hazardous IDW such as drill cuttings, purge or development water, decontamination fluids, drilling muds, etc., should be specified in the approved study plan. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place the liquid IDW into the facilities treatment system. It may be feasible to spread drill cuttings around the borehole, or if the well is temporary, to replace the cuttings back into the borehole. Cuttings, purge

water, or development water may also be placed in a pit in or near the source area. Monitoring well purge or development water may also be poured onto the ground downgradient of the monitoring well. Purge water from private potable wells which are in use may be discharged to the ground surface.

4.5.1.3 Management of Hazardous IDW -- Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed of in the source area from which they originated, if doing so does not endanger human health and the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to permit arrangements for proper containerization, labelling, transportation, and disposal/treatment in accordance with USEPA regulations.

Hazardous investigation derived waste should be kept to a minimum to conserve Branch resources. Most of the routine studies conducted by the Branch should not produce any IDW that are hazardous, with the possible exception of purged groundwater. Many of the above PPE and DE wastes can be deposited in municipal dumpsters if care is taken to keep them segregated from hazardous waste contaminated materials. Disposable equipment can often be cleaned to render it non-hazardous, as can some PPE, such as splash suits. The volume of spent solvent waste produced during equipment decontamination can be reduced or eliminated by applying only the minimum amount of solvent necessary.

4.6 SPECIFIC SAMPLE COLLECTION QUALITY CONTROL PROCEDURES

4.6.1 General

This subsection provides guidelines for establishing quality control procedures for Branch sampling activities. Specific guidelines for sample site selection, selection of sampling equipment, types of samples to be collected, standard sample collection procedures, specific maintenance and calibration procedures for sampling equipment, and other considerations are presented for each medium later in this Section. Specific requirements for all sampling activities are presented in Section 4.2. Strict adherence to all of the standard operating procedures outlined in this chapter form the basis for the Branch sampling quality assurance program.

4.6.2 Experience Requirements

There is no substitute for field experience. Therefore, all professional and paraprofessional Branch employees shall have the equivalent of six months field experience before they are permitted to select sampling sites on their own initiative. This field experience shall be gained by on-the-job training using the "buddy" system. Each new Branch field employee shall accompany an experienced employee on as many different types of field studies as possible. During this training period, the new employee will be permitted to perform all facets of field investigations, including sampling, under the direction and supervision of senior Branch technical staff.

4.6.3 Traceability Requirements

All sample collection activities shall be traceable through field records to the person collecting the sample and to the specific piece of sampling equipment (where appropriate) used to collect that sample. All maintenance and calibration records for sampling equipment (where appropriate) shall be kept so that they are similarly traceable.

4.6.4 Measurement of Relative Sampling Precision

The following duplicate sampling procedures shall be used during the collection of Branch samples as a relative measure of the precision of the sample collection process. Duplicate grab and/or composite samples shall be collected during all major investigations and studies (more than 20 samples) conducted by the Branch. No more than ten percent of all samples shall be collected in duplicate. These samples shall be collected at the same time, using the same procedures, the same equipment, and in the same types of containers as the required samples. They shall also be preserved in the same manner and submitted for the same analyses as the required samples. The collection of duplicate composite samples shall require the installation of duplicate automatic sampler setups if automatic samplers are used for sample collection.

These data will be examined by the project leader to determine if any problems are evident with specific types of media samples or with the procedures used by specific Branch personnel. The project leader will advise the Branch Quality Assurance Officer who will in turn advise the Branch and appropriate

Section Chiefs of any problems encountered so that corrective action can be taken.

4.6.5 Measurement of Sample Handling Effectiveness

The effectiveness of Branch personnel sample handling techniques will be monitored by utilizing field blank samples. For routine studies these blank samples will be prepared by ASB personnel. Branch personnel shall request that these samples be provided at least one week in advance of scheduled field investigations and inspections and never (except in emergency situations) less than two days in advance of scheduled field investigations and inspections. These samples should not be picked up by Branch personnel earlier than the morning of departure for the scheduled inspection/investigation. On larger studies, where organic-free water is generated in the field, these blank samples may be made in the field. The following field blank samples are required:

- Water Sample VOA Trip Blank -- A water sample VOA trip blank is required for every study where water samples are collected for VOA analysis. Two sealed preserved (or unpreserved if appropriate) 40-ml VOA vials will be transported to the field. These field blanks will be handled and treated by Branch personnel in the same manner as the water samples collected for purgeable organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-Of-Custody Records as trip blanks.

- Soil Sample VOA Trip Blank -- A soil sample VOA trip blank is required for every study where soil samples are collected for purgeable organic compounds analysis. One 2-oz. soil VOA vial will be transported to the field. This field blank will be handled and treated by Branch personnel in the same manner as the soil samples collected for purgeable organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-Of-Custody Records as trip blanks.

The following blanks are prepared in the field:

- Inorganic Sample Preservative Blanks -- Metals and general inorganics sample containers filled with blank water will be transported to the field and preserved and submitted for the same analyses as the other inorganic samples collected. These samples will be clearly identified as preservatives blanks on sample tags and in the Chain-Of-Custody Record(s). At least one preservative blank for each type of preserved sample should be collected at the end of routine field investigations. A minimum of one preservative blank should be prepared at the beginning and end of all major Branch field investigations (20 samples or more).

- Automatic Sampler Blanks -- The procedure for collecting automatic sampler blanks is given in Section 4.5.4. In general, cleaning procedures outlined in Appendix B should be adequate to insure sample integrity. However, it is the standard practice of the

Branch to submit automatic sampler blanks for analyses when automatic samplers are used to collect samples for organic compounds analyses. Automatic sampler blanks for other standard analyses shall be submitted at least once per quarter.

The ASB will advise the Branch Quality Assurance Officer when trip blanks or preservative blanks are unacceptably contaminated. The Branch Quality Assurance Officer will immediately initiate an investigation to determine the cause of the problem. The results of this investigation will be promptly reported to the Branch and appropriate Section Chief so that corrective action can be initiated.

4.6.6 Measurement of Sample Container, Sample Equipment, and Cleaning Procedure Integrity

Specific quality control procedures are outlined in Appendix B.

4.6.7 Measurement of Field Generated Organic-Free Water

On larger studies, organic-free water may be prepared in the field. When this is done, a system blank should be collected prior to use and at the end of the study. If the study lasts more than one week, at least one sample per week shall be collected. Blank samples should be analyzed for all analytes of interest.

4.6.8 Special Quality Control Procedures for Water Samples for Extractable, Pesticide, or Herbicide Organic Compounds Analyses

Branch personnel shall submit duplicate water samples for extractable, pesticide, and/or herbicide organic compounds analyses from at least one sampling location per project and laboratory used. This sample should be collected from a location expected to be relatively free from contamination, since this sample will be used for laboratory quality control purposes. The duplicate sample should be clearly identified as "Duplicate Sample for Matrix Spike" on the sample tag, Chain-Of-Custody Record, in the field logbook, and on the Contract Laboratory Program (CLP) Traffic Report Form (if appropriate). This procedure shall be followed for all Branch projects where water samples are collected for the indicated organic compounds analyses, whether the samples are submitted to the ASB or the EPA CLP.

4.6.9 Special Quality Control Procedures for EPA Contract Laboratories

Special quality control procedures are used when samples are submitted to the EPA CLP. A series of blank and spiked samples are provided by ASB personnel that are to be submitted along with the regular samples to each contract laboratory utilized. These samples will be provided by the ASB along with the necessary CLP Traffic Report Forms for each blank and spike sample. These samples shall be submitted to the respective contract laboratories on a blind basis. Fictitious station numbers will be used on the Traffic Report Forms; the contract laboratories are not to know which samples are spikes and blanks. These samples are identified as spikes or blanks only on the copy of the Traffic Report Forms that are returned to the ASB.

These spike and blank samples are to be obtained from the ASB utilizing the procedures outlined in Section 4.4.5.

The ASB TPO (See Section 1.9.3.1) may request, on a case-by-case basis, that Branch personnel collect split samples (or duplicate samples if appropriate) for analysis by both the ASB and contract laboratories. The split samples are to be submitted to the ASB using established procedures. The contract laboratory involved shall not be notified in any way that samples were split, i.e., there should be no indication on Chain-Of-Custody Records or CLP Traffic Report Forms submitted to the contract laboratories that these samples were split with the ASB.

4.6.10 Special Quality Assurance Procedures for Dioxin (2,3,7,8-TCDD or Other Isomers)

All samples collected for dioxin (2,3,7,8-TCDD or isomers) analyses are analyzed by other EPA laboratories or through contract laboratories. The ASB does not conduct in-house analyses for dioxin. The ASB maintains a package that outlines all current quality control procedures to be used by Branch personnel when collecting samples for dioxin (2,3,7,8-TCDD or other isomers) analyses. The ASB must be consulted before any such samples are collected.

4.7 WASTEWATER SAMPLING

4.7.1 General Considerations

The variety of conditions at different sampling locations require that considerable judgment be made regarding the methodologies and procedures for collection of representative samples of wastewater. Each sampling point warrants attention commensurate with its complexity. There are, however, basic rules and precautions generally applicable to sample collection. The procedures used by the Branch are generally those outlined in the NPDES Compliance Inspection Manual (2). Additional guidance is given in the agency's handbook, Monitoring Industrial Wastewater (3). Some important considerations for obtaining a representative wastewater sample include:

- The sample should be collected where the wastewater is well mixed. Therefore, the sample should be collected near the center of the flow channel, where the turbulence is at a maximum and the possibility of solids settling is minimized. Skimming the water surface or dragging the channel bottom should be avoided; however, allowances should be made for fluctuations in water depth due to flow variations.

- In sampling from wide conduits, cross-sectional sampling should be considered. Rhodamine WT dye (See Section 7.8.2.3 for procedures) may be used as an aid in determining the most representative sampling point(s); and

- If manual compositing is employed, the individual sample bottles must be thoroughly mixed before pouring the individual aliquots into the composite container.

4.7.2 Site Selection

Where applicable, wastewater samples should be collected at the location specified in the NPDES permit (if the source has such a permit). In some instances the sampling location specified in the permit, or the location chosen by the permittee, may not be acceptable for the collection of a representative wastewater sample. In such instances, the project leader or field investigator is not limited by permit specifications from collecting a sample at a more representative location. When a conflict exists between the permittee and the regulatory agency regarding the most representative sampling location, both sites should be sampled, and the reason for the conflict should be noted in the inspection or study report and field notes. Recommendations and reasons for a change in sampling location should be given to the appropriate permitting authority.

4.7.2.1 Influent -- Influent wastewaters are preferably sampled at points of highly turbulent flow in order to ensure good mixing; however, in many instances the most desirable location is not accessible. Preferable influent wastewater sampling points include: (1) the upflow siphon following a comminutor (in absence of grit chamber); (2) the upflow distribution box following pumping from main plant wet well; (3) aerated grit chamber; (4) flume throat; or (5) pump

wet well when the pump is operating. When possible, raw wastewater samples should be collected upstream from sidestream returns.

4.7.2.2 Effluent -- Effluent samples should be collected at the site specified in the permit, or if no site is specified in the permit, at the most representative site downstream from all entering wastewater streams prior to discharge into the receiving waters. If a conflict exists between the permittee and inspector regarding the source being sampled or the location of the most representative site, follow the procedure outlined in Section 4.7.2.

4.7.2.3 Pond and Lagoon Sampling -- Generally, composite effluent wastewater samples should be collected from ponds and lagoons. Even if the ponds or lagoons have long retention times, composite sampling is necessary because of the tendency of ponds and lagoons to have flow paths that short circuit the detention time. However, if dye studies or facility data indicate a homogeneous discharge, a grab sample may be taken as representative of the waste stream.

4.7.3 Sampling Techniques - General

Sampling and flow measuring are mutually dependent for a complete evaluation of a wastewater treatment plant. The investigator must know the wastewater flow variability before a sampling program can be initiated.

The choice of a flow proportional or time composite sampling scheme depends on the variability of the wastewater flow or concentration, equipment availability, and sampling location. If an investigator knows or suspects that there is significant variability in the wastewater flow or if the investigator knows nothing about the facility, a flow proportional sample should be collected. Otherwise a time composite sample would be acceptable.

Prior to sampling, the flow measuring system (primary flow device, totalizer, and recorder) should be examined (methods described in Section 5). If the flow measuring system is unacceptable, the investigator may have to install flow measurement instrumentation (Section 5). If the flow measuring system is acceptable, samples can be collected by the appropriate method.

Time composite samples collected by the Branch are based on a constant time interval between samples. A time composite sample can be collected either manually or with an automatic sampler.

Flow proportional samples can be collected automatically with an automatic sampler and a compatible pacing flow measuring device, semi-automatically with a flow chart and an automatic sampler capable of collecting discrete samples, or manually. Refer to Appendix E for procedures describing the first method and to the NPDES Compliance Inspection Manual (2) for details on the latter two methods.

4.7.4 Use of Automatic Samplers

4.7.4.1 General -- Automatic samplers may be used when several points are to be sampled at frequent intervals or when a continuous sample is required. Automatic samplers used by the Branch must meet the following requirements:

- Sampling equipment must be properly cleaned to avoid cross-contamination which could result from prior use (see Appendix B for cleaning procedures).

- No plastic or metal parts of the sampler shall come in contact with the water or wastewater stream when parameters to be analyzed could be impacted by these materials (See Section 4.7.6).

- The automatic sampler must be able to provide adequate refrigeration during the sampling period. This can be accomplished in the field by using ice.

- The automatic sampler must be able to collect a large enough sample for all parameter analyses (see Appendix A for required sample volumes).

- A minimum of 100 mls should be collected each time the sampler is activated if a peristaltic pump is used.

- The automatic sampler should provide a lift of at least 20 feet and the sampler should be adjustable so that the volume is not be a function of the pumping head.

- Pumping velocity must be adequate to transport solids and not allow solids to settle.

- The intake line leading to the pump must be purged before each sample is collected.

- The minimum inside diameter of the intake line should be 1/4 inch.

- An adequate power source should be available to operate the sampler for 48 hours at a 30-minute sampling interval.

- Facility electrical outlets may be used if available.

- Facility automatic samplers may be used for conventional parameters if they meets SOP criteria.

Specific operating instructions, capabilities, capacities, and other pertinent information for automatic samplers presently used by the Branch are included in the respective operating manuals and are not presented here.

4.7.4.2 <u>Equipment Installation</u>

4.7.4.2.1 <u>Conventional Sampling</u> -- Automatic samplers may be used to collect time composite or flow proportional samples. In the flow proportional mode, the samplers are activated by a compatible flow meter. Flow proportional samples can also be collected using a discrete sampler and a flow recorder and manually compositing the individual aliquots in flow proportional amounts (2).

All new tubing (Dow® Corning Medical Grade Silastic, or equal, in the pump and either Teflon® or Tygon®, or equal, in the sample train) will be used for each sampler installation.

Installation procedures include cutting the proper length of tubing, positioning it in the wastewater stream, and sampler programming.

For a time composite sample, the sampler should be programmed to collect 200 mls at 30-minute intervals or 100 mls at 15-minute intervals into a refrigerated 3-gallon glass jug. For a 5-gallon compositing container, the volume should be increased

For a flow proportional sample, the sampler should be programmed to collect a minimum of 100 mls for each sample interval, with the interval predetermined based on the flow of the waste stream.

At the end of each 24-hour sampling period, the contents of the glass compositing container with the sample should be stirred and siphoned (poured if there are no visible solids) into the respective containers, followed by immediate preservation, if required.

4.7.4.3 Automatic Sampler Security -- EPA owned equipment is assumed to be in the custody of the permittee as long as it is on their property. This assumption should be made known to permittees whenever equipment is left unattended. A lock or seal may be placed on the sampler to detect tampering. However, this does not prevent tampering with the sample collection tubing. If necessary, seals may be placed on the sampling pole and tubing line to further reduce tampering possibilities.

4.7.4.4 Automatic Sampler Maintenance, Calibration, and Quality Control - To insure proper operation of automatic samplers, and thus the collection of representative samples, the procedures outlined in this section shall be used to maintain and calibrate Branch automatic samplers.

The following maintenance and calibration procedures shall be used; any differences from those prescribed procedures will be documented.

Prior to each field trip, the sampler operation will be checked by warehouse personnel. This includes operation (forward, reverse, automatic) through three cycles of purge-pump-purge; checking desiccant and replacing if necessary; checking 12-volt batteries to be used with the sampler; and repairing any item if necessary.

During each field trip, prior to initiating sampling, the purge-pump-purge cycle shall be checked at least once. The constant pumping volume using a graduated cylinder or other calibrated container will be checked at least twice, and the flow pacer that activates the sampler shall be checked to be sure it operates properly.

Upon return from a field trip, the sampler shall be examined for holes, dents, etc., and repaired, if necessary. The desiccant will be checked and replaced if appropriate. The operation (forward, reverse, automatic, etc.) will

be checked and any required repairs will be made and documented. The sampler will then be cleaned as outlined in Appendix B.

The automatic sampler's pumping rate at multiple heads, the timing mechanisms, the multiplexer, or the flow pacer will be checked against the manufacturer's specifications and documented whenever one or more of these functions appears to be operating improperly.

Automatic sampler blanks must be collected for organic compounds and metals analyses when collecting samples for trace organic compounds analyses as described in section 4.7.6.1.

4.7.5 Manual Sampling

Manual sampling is normally used for collecting grab samples and/or for immediate in-situ field analyses. However, it can also be used in lieu of automatic equipment over extended periods of time for composite sampling, especially when it is necessary to evaluate unusual waste stream conditions.

The best method to manually collect a sample is to use the actual sample container which will be used to transport the sample to the laboratory. This eliminates the possibility of contaminating the sample with an intermediate collection container. The actual sample container must always be used for collecting samples for oil and grease and bacterial analyses.

A separate collection container can be used to collect the sample, from which the sample can be redistributed to other containers. If this is done, however, the container used to collect the sample must be properly cleaned (Appendix B) and must be made of a material that meets the requirements of the parameter(s) being investigated. Also, a separate container will be used at each sampling station. This will prevent cross contamination between sampling station.

If the water or wastewater stream cannot be physically reached by the sampling personnel or it is not safe to reach for the sample, an intermediate collection container may be used. The sample is collected by lowering a properly cleaned Teflon®, plastic, glass, or stainless steel collection vessel (type of collection vessel used depends on the parameter being investigated) into the material to be sampled. The collection vessel may be lowered by hand or attached to a pole or rope and then lowered into the stream.

In some cases it may be best to use a pump, either power or hand operated, to withdraw a sample from the water or wastewater stream. If a pump is used, it is imperative that all components of the pump that come in contact with the liquid are properly cleaned (Appendix B) to insure the integrity of the sample.

Samples are manually collected by tipping the collection container in the water or wastewater stream so the mouth of the container faces upstream. The container should be rinsed with this procedure at least twice before the sample is collected (exceptions to this rinsing procedure exist if preservatives are present in the sampling container and for certain analyses such as oil and grease and bacteria).

4.7.6 Special Sample Collection Procedures

4.7.6.1 Trace Organic Compounds and Metals -- Trace organic compounds and metals detection limits are usually in the parts per billion range, so extreme care must be exercised to insure sample integrity.

All containers, composite bottles, tubing, etc., used in sample collection for trace organic compounds and metals analyses should be prepared as described in Appendix B.

When possible, the sample should be collected directly into the appropriate sample container. If the material to be sampled cannot be physically reached, an intermediate collection device may be used. This should be a Teflon®, glass, or stainless steel vessel on a pole or rope or Teflon® tubing via a peristaltic type pump and a Teflon® vacuum container attachment which converts a sample container into a vacuum container. The device which is used should be cleaned as described in Appendix B.

Personnel handling the sample should always wear a new pair of disposable surgical gloves with each set of samples collected and change as often as needed. This is necessary to prevent cross-contamination. A more detailed discussion is given in Section 4.2.10 under special precautions for trace contaminant sampling.

When an automatic sampler is used for collecting samples for trace organic compounds and metals analyses, the installation procedures include cutting the proper length of new Teflon® tubing, water rinsing of the entire collection system with a minimum of two gallons of Milli-Q® water, and blank collection for organics and metals. In the Milli-Q® water rinse, approximately one-half gallon is initially pumped into the composite sampler container and discarded. An additional one and one-half gallons are then pumped into the composite sampler container for distribution into the appropriate blank container. Nitric acid must be added to the metals blank container. Finally the collection tubing should then be positioned in the wastewater stream and sampler programming initiated.

4.7.6.2 Bacterial -- Samples for bacterial analysis will always be collected directly into the prepared glass or plastic sample bottle. The sample bottle should be kept unopened until it is to be filled. When the cap is removed, care should be taken not to contaminate the cap or the inside of the bottle. The bottle should be held near the base and filled to within about one inch of the top without rinsing and recapped immediately. The bottle should be plunged, neck downward, below the surface and turned until the neck points slightly upward. The mouth should be directed toward the current (4, 5). Appendix A presents preservation procedures and holding times.

When the sample bottle must be lowered into the waste stream, either because of safety or impracticality (manhole, slippery effluent area, etc.), care must be taken to avoid contamination.

4.7.6.3 Immiscible Liquids/Oil and Grease -- Oil and grease may be present in wastewater as a surface film, an emulsion, a solution, or as a combination of

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these forms. Since it is very difficult to collect a representative sample for oil and grease analysis, the inspector must carefully evaluate the location of the sampling point. The most desirable sampling location is the point of greatest mixing. Quiescent areas should be avoided. Because losses of oil and grease will occur on sampling equipment, the collection of a composite sample is impractical. Individual portions collected at prescribed time intervals must be analyzed separately to obtain the average concentrations over an extended period.

4.7.6.4 Purgeable Organic Compounds Analyses (VOA) -- Samples to be analyzed for purgeable organic compounds should be collected in 40-ml septum vials with screw caps with a Teflon® lined silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

When sampling for purgeable organic compounds, triplicate samples should always be collected from each location. The investigator should determine if the water to be sampled contains chlorine. If the water contains no chlorine, three 40-ml vials containing four drops of concentrated HCl should be filled with the sample. The samples may be held up to 14 days before analysis. When preservation (HCl) is not feasible, samples can be held up to 7 days before analysis for purgeable aromatic hydrocarbons and 14 days for purgeable hydrocarbons compounds.

If the water contains chlorine, the following sampling and preservation procedure should be followed:

Fill an 8-ounce VOA sampling container with 8 drops of a 25% ascorbic acid solution and the water sample. Cap and mix thoroughly but gently by swirling to eliminate residual chlorine. Transfer the sample to three 40-ml VOA vials containing four drops of concentrated HCl*. Label each 40-ml vial with "P" (preserved/ascorbic acid).

* The ascorbic acid and acid preservatives must be added in this order and in two separate steps.

The purgeable organics vials (40-ml) should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure using a new 40-ml vial.

Sampling containers with preservatives should be prelabeled (i.e., P) prior to any field activities. This will reduce the chances of confusion during sampling activities by the investigation team. Sample preservation, containers, holding times, and sample volumes are listed in Appendix A.

4.7.7 Special Process Control Samples and Tests

Special process control samples collected and field tests performed on these samples are given in Appendix H.

4.7.8 Auxiliary Data Collection

While conducting wastewater sampling, the following information will also be obtained (if applicable):

- Field measurements - pH, DO, conductivity, temperature (see Section 6 and Appendix D for standard field analytical techniques);
- Flows associated with the samples collected -- continuous flows with composite samples and instantaneous flows with grab samples (Section 5);
- Diagrams and/or written descriptions of the wastewater treatment systems (if available);
- Photographs of pertinent wastewater associated equipment, such as flow measuring devices, treatment units, etc. (keep photolog as specified in section 3.2.3);
- Process control information on the wastewater treatment process (if applicable); and
- Completion of applicable forms required during specific investigations.

All observations, measurements, diagrams, etc., will be entered in bound field logbooks or attached thereto (where applicable as specified in Section 3.5).

4.8 SURFACE WATER AND SEDIMENT SAMPLING

4.8.1 General

Selection of a surface water sampling location for water quality studies is based on many factors, including: study objective, water use, point source discharges, nonpoint source discharges, tributaries, changes in stream characteristics, types of stream bed, stream depth, turbulence, presence of structures (weirs, dams, etc.), accessibility, personnel available, etc. When sampling in estuarine systems, tidal effects must be considered in selecting sampling locations.

If the study objective is to investigate a specific location as a source of water supply, recreation, or other discrete use, then considerations such as accessibility, flow, velocity, physical characteristics, etc., are not as critical from a water quality investigation standpoint.

If the objective of a water quality study is to determine patterns of pollution, provide data for mathematical modeling purposes, conduct assimilative capacity studies, etc., where more than a single sampling location is to be investigated, then several factors become interrelated and need to be considered in sampling location selection. An excellent guide to conducting surface water stream studies is F. W. Kittrells, "A Practical Guide to Water Quality Studies" (6).

4.8.2 Sample Site Selection

Before any sampling is conducted, an initial reconnaissance should be made to locate suitable sampling locations. Bridges and piers are normally good choices as sites since they provide ready access and permit water sampling at any point across the width of the water body. However, these structures may alter the nature of water flow and thus influence sediment deposition or scouring. Additionally, bridges and piers are not always located in desirable locations with reference to waste sources, tributaries, etc. Wading for water samples in lakes, ponds, and slow-moving rivers and streams must be done with caution since bottom deposits are easily disturbed, thereby resulting in increased sediment in the overlying water column. On the other hand, wadeable areas may be best for sediment sampling. In slow-moving or deep water, a boat is usually required for sampling.

Sampling station locations can be chosen without regard to other means of access if the stream is navigable by boat, especially in estuarine systems where boats frequently provide the only access to critical sampling locations.

Wading to collect samples may be feasible in some cases, but this method usually will be chosen for only very small streams. A field investigator usually has to carry a considerable amount of sampling equipment, field analytical instruments, and water samples. When it also is necessary to wear rubber boots to walk the streambed or to wade out to the main current, the physical effort involved often makes this method too difficult to be practical.

Fresh water environments are commonly separated into two types: (1) rivers, streams, and creeks; and (2) lakes, ponds, and impoundments. Since these waterways differ considerably in general characteristics, site selection must be adapted to each. Estuarine environments are a special case and are discussed separately.

4.8.2.1 Rivers, Streams, and Creeks -- In the selection of a surface water sampling site on rivers, streams, and creeks, areas that exhibit the greatest degree of cross-sectional homogeneity shall be located. When available, previously collected data may indicate if potential sampling locations are well mixed or vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately downstream of a riffle area will insure good vertical mixing. These locations are also likely areas for deposition of sediment since the greatest deposition occurs where stream velocity slows down. Horizontal (cross-channel) mixing occurs in constrictions in the channel, but because of velocity increases, the stream bottom may be scoured, and therefore, a constriction is a poor sediment sample location. In the absence of turbulent areas, the selection of a site that is clear of immediate point sources, such as tributaries and industrial and municipal effluents, is preferred for the collection of water samples.

Typical sediment depositional areas are located inside of river bends, downstream of islands, and downstream of obstructions in the water. Sites that are located immediately upstream or downstream from the confluence of two streams or rivers should generally be avoided since flows from two tributaries may not immediately mix, and at times due to possible backflow can upset the normal flow patterns.

When several stations along a stream reach are to be sampled, they should be strategically located:

- They shall be spaced at intervals based on time-of-water-travel, not distance. For example, sampling stations may be located about one-half day time-of-water-travel for the first three days downstream of a waste source (the first six stations) and then approximately one day through the remaining distance.

- If the study is to be compared to a previous study, the same sampling stations should be used, if possible, for comparison purposes.

- A station should be located whenever a marked physical change occurs in the stream channel. Example: A stream reach between two adjacent stations should not include both a long rapids section of swift shallow water with a rocky bottom, and a long section of deep, slow-moving water with a muddy bottom. Stations at each end of the combined reach would yield data on certain rates of change, such as reaeration, that would be an unrealistic average of two widely different rates. Much more would be learned of the actual natural characteristics of the stream by inserting a third sampling station within the reach, between the rapids and the quiet water sections.

- Station locations should be selected to isolate major discharges as well as major tributaries.

Dams and weirs cause changes in physical characteristics of a stream. They usually create quiet, deep pools in river reaches that, historically were swift and shallow. Such impoundments should be bracketed. When times of water travel through them are long, stations should be established within the impoundments.

Some stream structures, such as dams, permit overflow that accomplishes significant reaeration of oxygen deficient water. In such cases, stations should be located short distances upstream and downstream from the structures to measure the rapid, artificial increase in dissolved oxygen (DO), which is not representative of natural reaeration.

A minimum of three stations located between any two points of major change in a stream is a desirable precaution, when feasible, even when the time-of-travel between the points of change is short. Major changes may consist of a waste discharge, a tributary inflow, or a significant difference in channel characteristics. The use of three stations is especially important when rates of change of unstable constituents are being determined. If results from one of only two stations in a subreach are in error for some unforeseen reason, it may not be possible to judge which of the two sets of results indicate the actual rate of change. Results from at least two of three stations, on the other hand, will probably support each other and indicate the true pattern of water quality in the subreach.

If there is interest in the effects of certain discharges or tributary streams on ambient water quality, sites should be located both upstream and downstream from the tributaries or discharges.

Unless a stream is extremely turbulent, it is nearly impossible to measure the effect of a waste discharge or tributary immediately downstream of the source. Inflow frequently "hugs" the stream bank with very little horizontal (cross-channel) mixing for some distance. This is a major consideration in estuarine environments. Samples from quarter points may miss the wastes altogether and reflect only the quality of water above the waste source. Samples taken directly in the portion of the cross section containing the wastes would indicate excessive effects of the wastes with respect to the river as a whole.

Tributaries should be sampled as near the mouth as is feasible. This may be a bridge some distance upstream from the mouth. Frequently, the mouths of tributaries may be entered from the main stream for sampling by boat. Care should be exercised to avoid collecting water from the main stream that may flow into the mouth of the tributary on either the surface or bottom because of differences in density resulting from temperature, dissolved salts, or turbidity.

Actual sampling locations will vary with the size of the water body and the amount of turbulence in the stream or river. Generally, with small streams less than 20 feet wide, a sampling site can be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth at the center of the channel is adequate to represent the entire cross-section. A sediment sample can

also be collected at the center of the channel. For slightly larger streams, at least one vertical composite should be taken from mid-stream, with samples taken just below the surface, at mid-depth, and just above the bottom. Of course, DO, pH, temperature, conductivity, etc. should be measured on each aliquot of the vertical composite. For large rivers, several locations across the channel width should be sampled. Vertical composites across the channel width should be located in a manner that is roughly proportional to flow, i.e., they should be closer together toward mid-channel, where most of the flow travels, than toward the banks, where the proportion of total flow is smaller. The number of vertical composites required and the number of depths sampled for each are usually determined in the field by the sampling crew. This determination is based on a reasonable balance between the following two considerations.

1. The larger the number of subsamples, the more nearly the composite sample will represent the water body.

2. Taking subsamples is time-consuming and expensive, and increases the chance of contamination.

In most circumstances, a number of sediment samples should be collected along a cross-section of a river or stream in order to adequately characterize the bed material. A common procedure is to sample at quarter points along the cross-section of the site selected. When the sampling technique or equipment requires that the samples be extruded or transferred at the site, they can be combined into a single composite sample. However, samples of dissimilar composition should not be combined but should be stored for separate analysis in the laboratory. To insure representative samples, the preferred method is diver deployed coring tubes.

4.8.2.2 <u>Lakes, Ponds, and Impoundments</u> -- Lakes, ponds, and impoundments have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. Occasionally, an extreme turbidity difference may occur vertically where a highly turbid river enters a lake, and each layer of the stratified water column needs to be considered. Since the stratification is caused by water temperature differences, the cooler, heavier river water is beneath the warmer lake water. A temperature profile of the water column as well as visual observation of lake samples can detect the different layers and they can be sampled separately.

The number of water sampling sites on a lake, pond, or impoundment will vary with the purpose of the investigation as well as the size and shape of the basin. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each vertical composite aliquot. In naturally-formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam.

In lakes and larger impoundments, several vertical subsamples should be composited to form a single sample. These vertical sampling locations are often taken along a transect or grid. Again, the number of vertical subsamples and the depths at which subsamples are taken are usually at the discretion of the

sampling crew. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones, but normally a composite shall consist of several vertical subsamples collected at various depths.

In lakes with irregular shape and with several bays and coves that are protected from the wind, additional separate composite samples may be needed to adequately represent water quality. Similarly, additional samples should be taken where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

When collecting sediment samples in lakes, pond, and reservoirs, the site selected should be approximately at the center of water mass. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir, and the bed sediments near the center of the water mass will be composed of fine-grained materials. The shape, inflow pattern, bathymetry, and circulation must be considered when selecting sediment sampling sites in lakes or reservoirs.

4.8.2.3 Estuarine Waters -- Estuarine areas are zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types, dependent upon freshwater inflow and mixing properties (7, 8, 9, and 10):

- Mixed estuary -- Characterized by an absence of vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is found in major freshwater sheetflow areas, featuring shallow depths.

- Salt wedge estuary -- Characterized by a sharp vertical increase in salinity and channelized freshwater inflow into a deep estuary. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase.

- Oceanic estuary -- Characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh saline water mixing occurring near, or at, the vegetated shore line.

A reconnaissance investigation should be conducted for each estuarine study unless prior knowledge of the estuarine type is available. The reconnaissance should focus upon the freshwater and oceanic water dynamics with respect to the study objective. In this regard, National Oceanic Atmospheric Administration tide tables and USGS freshwater surface water flow records provide perspective to the estuary dynamics. The basic in-situ measurement tools for reconnaissance are: a boat, recording fathometer, salinometer, and dissolved oxygen meter. These instruments coupled with the study objective or pollution source location, whether it is a point or nonpoint source problem, provide the focus for setting

sampling locations. More often than not, preplanned sampling locations in estuarine areas are changed during the actual study period. Because of the dynamics of estuaries, initial sampling often reveals that the study objective could be better served by relocating, adding, or deleting sampling locations.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (11).

All estuarine sampling programs conducted by Branch personnel shall include vertical salinity measurements at one- to five-foot increments coupled with vertical DO and temperature profiles. A variety of water sampling devices are used, but in general, the Van Dorn (or similar type) horizontal sampler is employed.

Samples are normally collected at mid-depth in areas where the depths are less than 10 feet, unless the salinity profile indicates the presence of a halocline (salinity stratification). In that case, samples are collected from each stratum. Depending upon the study objective, when depths are greater than 10 feet, water samples may be collected at the one-foot depth, mid-depth, and one-foot from the bottom.

In general, estuarine investigations are two phased, with study investigations conducted during wet and dry periods. Depending upon the freshwater inflow sources, estuarine water quality dynamics cannot normally be determined by a single season study.

For a complete discussion of estuarine systems, refer to references 7, 8, 9, and 10.

4.8.2.4 Control Stations -- In order to have a basis of comparison of water quality, the collection of samples from control stations is always necessary. A control station above the source of waste is fully as important as are stations below, and should be chosen with equal care to ensure representative results. At times it may be desirable to locate two or three stations above the waste inflow to establish the rate at which the unstable material is changing. The time of travel between the stations should be sufficient to permit accurate measurement of the change in the constituent under consideration.

4.8.3 Sampling Equipment and Techniques

4.8.3.1 General -- Any equipment or sampling techniques used to collect a sample are acceptable as long as they do not cause the integrity of the sample to be violated and which provide a sample which is representative of the stream being sampled.

4.8.3.2 Water Sampling Equipment/Techniques -- The physical location of the investigator when collecting a sample may dictate the equipment to be used. If surface water samples are required, direct dipping of the sample container into the stream is desirable. This is possible, however, only from a small boat, a pier, etc., or by wading in the stream. Wading, however, may cause bottom deposits to rise and bias the sample. Wading is acceptable if the stream has a noticeable current (is not impounded), and the samples are collected directly

into the bottle while pointed upstream. If the stream is too deep to wade or if the sample must be collected from more than one water depth or from a bridge, etc., supplemental sampling equipment must be used.

Teflon® bailers may be used for surface water sampling, if the data requirements do not necessitate a sample from a strictly discrete interval of the water column. A closed top bailer with a bottom check-valve is sufficient for many studies. As the bailer is lowered through the water column, water is continually displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. This technique may not be successful where strong currents are found, or where a discrete sample at a specific depth is required.

If discrete samples are desired at a specific depth, and the parameters to be measured do not require a Teflon® coated sampler, a standard Kemmerer or Van Dorn sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position to allow free passage of water through the cylinder. The Van Dorn sampler is plastic and is lowered in a horizontal position. In each case, a messenger is sent down a rope when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill respective sample bottles. With a rubber tube attached to the valve, DO sample bottles can be properly filled by allowing an overflow. With multiple depth samples, care should be taken not to stir up the bottom sediment and thus bias the sample.

A plastic bucket can be used to collect samples if the parameters to be analyzed do not preclude it. However, the bucket should be rinsed twice with the sample water prior to collection of the sample. All field equipment should follow standard cleaning procedures.

4.8.3.3 <u>Sediment Sampling Equipment/Techniques</u> -- To collect a sediment sample from a streambed, a variety of methods can be used. Dredging (Peterson, Eckman, Ponar), coring, and scooping (BMH-60) are available. Regardless of the method used, precautions shall be taken to insure that the sample collected is representative of the streambed. These methods are discussed in the following paragraphs.

4.8.3.3.1 <u>Dredging</u> -- For routine analyses, the Peterson dredge can be used when the bottom is rocky, in very deep water, or when the stream velocity is high. The dredge should be lowered very slowly as it approaches bottom, because it can displace and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high velocities. It should not be used from a bridge more than a few feet above the water, because the spring mechanism which activates the sampler can be damaged by the messenger if dropped from too great a height.

The Ponar dredge is a modification of the Peterson dredge and is similar in size and weight. It has been modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

4.8.3.3.2 Corers -- Core samplers are used to sample vertical columns of sediment. They are particularly useful when a historical approach to sediment deposition is desired for they preserve the sequential layering of the deposit. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand push tubes to weight or gravity driven devices.

Coring devices are particularly useful in pollutant monitoring because the "shock wave" created by descent is minimal, thus the fines of the sediment-water interface are only minimally disturbed; the sample is withdrawn intact permitting the removal of only those layers of interest; core liners manufactured of glass or Teflon® can be purchased, thus reducing possible sample contamination; and the samples are easily delivered to the lab for analysis in the tube in which they were collected. The disadvantage of coring devices is that a relatively small surface area and sample size is obtained often necessitating repetitive sampling in order to obtain the required amount for analysis. Because it is felt that this disadvantage is offset by the advantages, coring devices are recommended in sampling sediments for trace organic compounds or metals analyses.

In shallow, wadeable waters, the direct use of a core liner or tube manufactured of Teflon® or glass is recommended for the collection of sediment samples. Their use can also be extended to deep waters when SCUBA equipment is available. Teflon® is preferred to avoid glass breakage and possible sample loss. Stainless steel push tubes are also acceptable and provide a better cutting edge and higher strength than Teflon®. The use of the glass or Teflon® tube by itself eliminates any possible metal contamination from core barrels, cutting heads, and retainers. The tube should be approximately 12 inches if only recently deposited sediments (8 inches or less) are to be sampled. Longer tubes should be used when the depth of the substrate exceeds eight inches. Soft or semi-consolidated sediments such as mud and clays have a greater adherence to the inside of the tube and thus can be sampled with larger diameter tubes. Because coarse or unconsolidated sediments such as sands and gravel tend to fall out of the tube, a small diameter is required for them. A tube about two inches in diameter is usually the best size. The wall thickness of the tube should be about 1/3 inch for either Teflon® or glass. The inside wall may be filed down at the bottom of the tube to facilitate entry of the liner into the substrate.

Caution should be exercised not to disturb the area to be sampled when the sample is obtained by wading in shallow water. The core tube is pushed into the substrate until only four inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is pushed will facilitate greater penetration and cut down on core

compaction. The tube is then capped with a Teflon® plug or a sheet of Teflon® held in place by a rubber stopper or cork. After capping, the tube is slowly extracted, the negative pressure and adherence of the sediment keeping the sample in the tube. Before pulling the bottom part of the core above the water surface, it too is capped.

For a detailed description of several types of coring devices, refer to "Sampling Protocols for Analysis of Toxic Pollutants in Ambient Water, Bed Sediment and Fish" (12).

4.8.3.3.3 Scooping -- If the water is wadeable, the easiest way to collect a sediment sample is to scoop the sediment using a stainless steel spoon or scoop. This reduces the potential for cross-contamination. This can be accomplished by wading into the stream, and while facing upstream (into the current), scooping the sample along the stream bottom in the upstream direction. If the stream is too deep to wade but less than eight feet deep, a stainless steel scoop attached to a piece of conduit can be used either from the banks if the stream is narrow or from a boat.

If the stream has a significant flow and is too deep to wade, a BMH-60 sampler may be used. It is not particularly efficient in mud or other soft substrates because its weight will cause penetration to deeper sediments, which are not desired when sampling for priority pollutants. It is also difficult to release secured samples in an undisturbed fashion that would readily permit subsampling. The BMH-60 may be used for priority pollutant sampling provided that caution is exercised by only taking subsamples that have not been in contact with the metal walls of the sampler.

4.8.3.3.4 Mixing -- Regardless of the method of collection, sediment samples collected for chemical analysis should be thoroughly mixed (except for purgeable organic compounds analysis) before being placed in the appropriate sample containers, as specified in Section 4.2.10.

4.8.4 Special Sample Collection Techniques

4.8.4.1 Trace Organic Compounds and Metals -- Since trace organic compounds and metals are usually found in extremely low concentrations in ambient waters, the possibility of contamination is greater than with sediment or fish. Precautions must be taken with sampling equipment and preservatives to ensure that contamination does not occur.

Direct dipping of the sample containers is the preferred method of collecting surface water sample for trace levels pollutants analyses. If samples are to be split for enforcement or quality control purposes, and duplicate samples will not suffice, a sufficient volume for all sample containers should be collected in a large glass compositing container and then, with mixing, be alternately siphoned or poured into the respective sample bottles. This technique is not to be used for samples collected for purgeable organic compounds analysis.

Many contaminants are partitioned more strongly to sediments than water; thus, if these contaminants have been deposited recently and are not quickly degraded or desorbed, they are evident in the sediment analysis. Ideally, only Teflon®, stainless steel, or glass should be used in sediment sampling for trace level contaminant analyses. The method using glass or Teflon® coring tubes, was discussed previously, is the preferred technique.

In many situations when the water is deep, divers are not available, or the only sampling location is from a bridge, a dredge may be used. In these cases, a high grade stainless steel Ponar dredge (properly cleaned, Appendix B) shall be used to collect the sediment samples. Direct scooping of the streambed sediment as described earlier is acceptable.

4.8.4.2 Bacterial -- Samples for bacteriological examination must be collected in bottles properly sterilized and protected against contamination. The preferable method is to scoop up the water with the open bottle just below the surface. This method usually is used when sampling by boat. While the bottle is open, both bottle and stopper must be protected against contamination. A small amount of water should be poured from the bottle after filling to leave an air space for subsequent shaking in the laboratory. The bottle should be closed at once.

When sampling from a bridge, the sterilized sample bottle can be placed in a weighted frame, opened, and then lowered to the water with a string or rope. The bottle can also be lowered by attaching twine directly to it. Care should be taken not to dislodge dirt or other material from the bridge that will fall into the open bottle. The mouth of the bottle may be faced upstream by swinging the bottle downstream under the bridge and dropping it quickly but without excessive slack in the rope. The bottle is then pulled upstream and out of the water.

Special equipment for collecting sterile samples at various depths is available. The JZ sampler, for example, includes a metal frame to hold the sample bottle, two sterile glass tubes connected by a rubber tube and inserted through the sterile bottle stopper, and a messenger. One of the glass tubes is bent so that the upper portion is horizontal. This portion is positioned next to a rope. The messenger breaks the tube, which allows the bottle to fill. The bottle, glass tube and rubber tube must be properly sterilized before use. Additional guidance for collecting samples for bacterial analyses is given in References 4 and 5.

4.8.5 Auxiliary Data Collection

A bound field log book will be used to record daily activities, describe sampling locations and techniques, list photographs taken, etc., as specified in Section 3.5. Visual observations are particularly significant and may prove invaluable in interpreting water quality study results. These visual observations, including weather and stream conditions (including tide stage) during the investigation should also be recorded in field records.

4.8.6 Specific Sampling Equipment Quality Assurance Procedures

All water and sediment sampling equipment shall be cleaned as outlined in Appendix B after field use and before being stored. This equipment shall be inspected and tested before being issued for each field study. Any repairs necessary shall be made and recorded.

During field studies, this equipment shall be cleaned as outlined in Appendix B and all such cleaning procedures shall be documented in field records.

4.9 GROUND WATER SAMPLING

4.9.1 General

Ground-water sampling may be required for a variety of reasons, such as examining potable or industrial water supplies, checking for and/or tracking contaminant plume movement in the vicinity of a land disposal or spill site, RCRA compliance monitoring, or examining a site where historical information is minimal or non-existent but where it is thought ground water contamination could have occurred.

Ground water is usually sampled through an in-place well, either temporarily or permanently installed. However, it can also be sampled anywhere ground water is present, as in a pit or a dug or drilled hole.

Occasionally, a well will not be in the ideal location to obtain the sample needed (for example, to track a contaminant plume). In that case, a well will have to be installed, and it may be either a temporary or permanently installed well. An experienced and knowledgeable person will need to locate the well and supervise its installation so that the samples ultimately collected will be representative of the ground water.

The procedures covered in this section are those used by the Branch. Additional guidance is given in the "RCRA Ground Water Monitoring Technical Enforcement Guidance Document" (TEGD) (13); the ground water sampling procedures used by Branch personnel will meet or exceed the requirements of this document.

4.9.2 Site Selection

The relationship of the following factors to potential pollution sources shall be considered and evaluated when selecting ground-water sampling sites:

- the direction of ground-water flow, depth to ground water, thickness of the aquifer (if applicable);
- type of stratigraphy;
- presence of perched water tables;
- types of soils;
- depth to bedrock;
- type of vegetation;
- surface drainage patterns;
- type of topography;
- general land use;

- and surface features such as rock outcrops, seeps, springs, streams, rivers, and wet areas (14).

The area of interest should be located on an aerial photograph, a USGS 7.5 minute quadrangle map, a USDA soils map, and/or any other appropriate map that shows topography and general relationships between surface features. Aerial photographs can usually be obtained at the local Agricultural Stabilization Conservation Service (ASCS) office or the local county tax office. USGS 7.5 minute quadrangle maps can be acquired from the State Geological Survey or from the USGS, and soils maps from the USDA-SCS (Soil Conservation Service). A visual inspection of the area may be sufficient to evaluate and determine the surface conditions and their relationship to the subsurface conditions (14). In some cases, surface conditions and subsurface conditions cannot be correlated by site inspection or reconnaissance. When this occurs, a more detailed study, possibly involving test drilling, will have to be conducted.

It is extremely important to sample the unconfined or surficial aquifer downgradient of potential pollution sources or spills to determine if it (the most easily contaminated aquifer) has been affected. Generally the direction of ground-water flow can be estimated by two vectors - one in the direction of surface water flow (i.e., downstream) and another toward the nearest surface water stream or river, if present. The relative magnitude of these vectors will vary according to site conditions and in some instances both direction and magnitude may be changed by construction activities. If both a shallow and a deep aquifer are involved in the zone of interest, a screening study will reveal whether or not the deep aquifer should be sampled and a more detailed study is required. To adequately assess subsurface conditions, a minimum of three wells is required; one in the upgradient portion of the area of interest, one in the middle portion, and one in the downgradient portion. In some cases, a more complex system of wells may be needed to define the subsurface conditions, especially in establishing the depth to the shallow ground-water aquifer and the direction of ground-water movement. Site conditions and the scope of the project will determine the total number of wells required. Existing wells should be used when possible. Where permanent well installation is necessary, the wells should be installed according to the procedures in Appendix E.

4.9.3 Purging Equipment and Techniques

4.9.3.1 General -- Wells shall be purged before taking samples in order to clear the well of stagnant water which is not representative of aquifer conditions. The method of purging is to pump the well until three to five times the volume of standing water in the well has been removed and until the specific conductance, temperature, and pH of the ground water stabilizes. Normally, a combination of the two methods is employed (i.e., specific conductance, temperature, and pH are measured at intervals and three to five volumes are purged). If a well is pumped dry, this constitutes an adequate purge and the well can be sampled following recovery (15, 17). However, if possible, monitoring wells should not be pumped dry. If the well is pumped dry, water that has been trapped in the sandpack may be sampled. In addition, as water re-enters the well it may cascade down the well screen and strip volatile contaminants.

4.9.3.2 Equipment Available -- Monitoring well purging is accomplished by using in-place plumbing/pumps or when in-place pumps are not available, by using EPA equipment; either a peristaltic, turbine, bladder, centrifugal, or other appropriate pump, depending on well depth. A Teflon®, closed top bailer may be used for purging; however, bailing may stir up sediment in the well if conducted improperly.

Other monitoring equipment used during purging includes water level indicators, pH meters, thermometers, and conductivity bridges (See Section 6, Field Analytical Procedures).

4.9.3.3 Purging Techniques (Wells Without Plumbing or In Place Pumps)

4.9.3.3.1 General -- For permanently installed wells, the depth of water shall be determined (if possible) before purging. This can be accomplished by attaching a weight on the end of a tape and lowering it into the well until it touches the water, or by use of a mechanical or electrical water level indicator (see Ground-Water Level Measurement Techniques, Section 7.7). Branch personnel shall exercise extreme caution during this procedure to prevent contamination of the ground water. This is a critical concern when samples for trace organic compounds or metals analyses are collected.

4.9.3.3.2 Using Pumps to Purge -- When suction lift or centrifugal pumps are used, only the intake line is placed into the water column. To minimize contamination, the line placed into the water is either standard cleaned (see Appendix B) Teflon®, in the case of the suction lift pumps, or standard cleaned stainless steel pipe attached to a hose, when centrifugal pumps are used.

When submersible pumps (bladder, turbine, displacement, etc.) are used, the pump itself is lowered into the water column. The pump must be cleaned as specified in Appendix B.

4.9.3.3.3 Using Bailers to Purge -- Standard cleaned (Appendix B) closed-top Teflon® bailers with Teflon® leaders and new nylon rope are lowered into top of the water column, allowed to fill, and removed and then the water is discarded.

4.9.3.3.4 Field Care of Purging Equipment -- Regardless of which method is used for purging, new plastic sheeting shall be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they need to be placed on the ground during the purging or they accidentally come into contact with the ground surface. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool, both during transporting and during field use, to further minimize contamination from the transporting vehicle or ground surface.

4.9.3.3.5 Purging Entire Water Column -- The pump/hose assembly or bailer used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into

the water column, the water above the pump may not be removed, and the subsequent samples collected may not be representative of the ground water.

To minimize cross contamination between wells, no more than three to five feet of hose should be lowered into the water column. If the recovery rate of the well is faster than the pump rate, the pump may be left hanging at the initial level until an adequate volume has been purged. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown.

After the pump is removed from the well, all wetted portions of the hose and the pump shall be cleaned as outlined in Appendix B.

Careful consideration shall be given to using pumps to purge wells which are excessively contaminated with oily compounds, because it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When these type wells are encountered, alternative purging methods, such as bailers, should be considered.

4.9.3.4 Purging Techniques - Wells With In Place Plumbing

4.9.3.4.1 General -- In-place plumbing is found at water treatment plants, industrial water supply wells, private residences, etc. The objective of purging is the same as with monitoring wells without in place pumps, i.e., to ultimately collect a sample representative of the ground water.

The volume to be purged depends on several factors: whether the pumps are running continuously or intermittently; how close to the source the sample can be collected; and the presence of any storage/pressure tanks between the sampling point and the pump. If storage/pressure tanks are present, an adequate volume must be purged to totally exchange the volume of water in the tank.

4.9.3.4.2 Continuously Running Pumps -- If the pump runs continuously, and the sample can be collected prior to a storage/pressure tank, no purge, other than opening a valve and allowing it to flush for a few minutes, is necessary.

4.9.5.4.3 Intermittently Running Pumps -- If the pump runs intermittently, it is necessary to determine the volume to be purged, including storage/pressure tanks that are located prior to the sampling location. The pump should then be run continuously until the required volume has been purged.

4.9.4 Sampling Equipment and Techniques

4.9.4.1 Equipment Available -- Sampling equipment used by the Branch includes closed-top Teflon® bailers and the peristaltic pump/vacuum jug assembly.

Other monitoring equipment used during sampling includes water level indicators, pH meters, thermometers, and conductivity bridges (see Sections 6 and 7).

4.9.4.2 Sampling Techniques -- Wells With In Place Plumbing -- Samples should be collected following purging from a valve or cold water tap as near to

the well as possible. Samples should be collected directly into the appropriate containers (see Standard Sample Containers, Appendix A). Also, refer to the Potable Water Supply discussion in Section 4.10.

4.9.4.3 Sampling Techniques -- Wells Without Plumbing -- Following purging, samples should be collected using a peristaltic pump/vacuum jug procedure, if possible, or with a closed top Teflon® bailer. The pump used for purging generally should not be used for sampling. When the peristaltic pump is used, samples for purgeable organic compounds analyses should be collected using a bailer or by allowing the Teflon® tube to fill and then allowing the water to drain into the sample vials. All equipment shall be cleaned using the procedures described in Appendix B. Also, refer to the Potable Water Supply discussion, Section 4.10, for additional information.

When bailing, new plastic sheeting should be placed on the ground around each well to provide a clean working area. The nylon rope should be attached to the bailer via a Teflon® coated stainless steel wire. This coated wire is attached to the bailer semi-permanently and is decontaminated for reuse as the bailer is cleaned.

4.9.5 Special Sample Collection Procedures

4.9.5.1 Trace Organic Compounds and Metals -- Special sample handling procedures shall be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which come into contact with the water in the well must be cleaned in accordance with the cleaning procedures described in Appendix B. Pumps shall not be used for sampling, unless the interior and exterior portions of the pump and discharge hoses can be thoroughly cleaned. Blanks should be collected to determine the adequacy of cleaning prior to collection of any sample using a pump. Peristaltic pumps using Teflon® tubing and a Teflon® insert can be used to collect samples without the sample coming into contact with the pump. This is accomplished by placing the Teflon® insert into the opening of a standard cleaned 4-liter glass container. The Teflon® tubing connects the container to the pump and sample source. The pump creates a vacuum in the container, thereby drawing the sample into the container without coming into contact with the pump tubing. Samples for purgeable organic compounds analyses shall be collected with well bailers. The procedures given in the General Considerations, Special Precautions for Trace Contaminant Sampling (Section 4.2.9) shall be followed.

4.9.5.2 Filtering -- As a standard Branch policy, ground-water samples will not be filtered. However, if samples are filtered, then both filtered and non-filtered samples will be submitted for analyses. Proper well installation and development (Appendix E) as well as proper well purging techniques should be utilized to minimize the turbidity of samples. If filtered samples for metals analyses must be collected, an additional unfiltered sample will also be collected for metals analyses. Samples for organic compounds analyses shall not be filtered.

4.9.5.3 Bacterial Sampling -- Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in Sampling for Organic Chemicals and Microorganisms in the Subsurface (19) as well as References 4 and 5. Additional information on bacterial sampling is also included in Section 4.10 (Potable Water Supplies), Section 4.7 (Wastewater Sampling), and Section 4.8 (Surface Water Sampling).

4.9.6 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground-water samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies. Cleaning procedures conducted in the field (Appendix B), or field repairs shall be thoroughly documented in field records.

4.9.7 Auxiliary Data Collection

Water table measurements from the top of the well casings (referenced to National Geodetic Vertical Datum) in permanent wells, and ground surface elevations in temporary wells should be made to determine the general direction of ground-water flow and gradient. The methodology to be used to determine well water levels are given in Section 7. Tracer dyes and radioactive and thermal detection methods can be used to determine direction and velocities of flow (14). Also, a study of the general topography and drainage patterns will generally indicate direction of ground-water flow.

Water table measurements shall not be taken until the water table has stabilized, preferably 24 hours after well installation for permanent wells (20). The ground surface elevation at the wells should be determined by standard engineering survey practices as outlined in Section 7.

In addition to water level measurements, the pumping rate used to purge a well, the volume of water in wells, and drillers' logs are examples of auxiliary data that should be collected during ground-water sampling activities. This information should be documented in field records. Methodology for obtaining these data are given in the following sections.

Temperature, specific conductance, and pH shall be measured each time a well is sampled. Stabilization of these parameters is measured during the purging process to evaluate the adequacy of the purging procedure. In this situation, the final measurements for these parameters prior to sampling shall be considered the measurement of record for the well. If these parameters were not evaluated during purging, they shall be obtained prior to sampling. Methodology for obtaining these data are given in Section 6.

4.9.7.1 Well Pumping Rate - Bucket/Stop Watch Method -- The pumping rate of a pump can be determined by collecting the flow of water from the pump in a bucket of known volume and timing how long it takes to fill the bucket. The pumping rate should be in gallons per minute. This method shall be used only with pumps with a constant pump rate, such as gasoline powered or electric

submersible pumps. It should not be used with battery powered pumps. As the batteries lose their charge, the pump rate decreases so that pumping rate calculations using initial, high pump rates are erroneously high.

4.9.7.2 Volume of Water in Wells -- In order to purge wells, the volume of water in the well should be known. To determine the volume, the following method should be used; measure the distance from the bottom of the well to the static water level, then measure the inside diameter of the well or casing. Obtain the volume of the well by the formula:

$$V = 0.041 \quad d^2h$$

Where h = depth of water in feet
d = diameter of well in inches
V = volume of water in gallons

If preferred, a quick reference nomograph or table may be used.

Additional ground-water related data can be obtained from most local, state, and federal agencies dealing with water resources. Some states require well drillers to be licensed, and all work performed on wells must be reported to the state on prescribed forms. These forms are available to the public, so a study of wells installed in the area of interest may provide background information as to the subsurface conditions. State geological surveys, as well as the USGS, have various types of water related papers and reports on all phases of ground-water studies in each state. City and county governments usually have departments that deal with water related projects that may provide data for the local area. Federal agencies such as the SCS, U. S. Army Corps of Engineers, the Bureau of Reclamation, U. S. Forest Service, Science and Education Administration, and the U. S. Public Health Service have water programs which may provide data. Other sources include the Bureau of Mines, colleges, universities, and technical societies such as American Association of Petroleum Geologists, American Institute of Mining and Metallurgical Engineers, American Water Well Association, Association of Engineering Geologists, and Geological Society of America (14, 21).

4.10 SAMPLING OF POTABLE WATER SUPPLIES

4.10.1 General

When sampling potable water supplies, utmost care must be taken to insure that samples are representative of the water supply being sampled. This is important not only from a technical and public health perspective, but also from a public relations standpoint. Poor sampling techniques may result in incorrect results (either not detecting a compound which is present or by contaminating the sample and falsely indicating a compound which is not present). If incorrect results are disclosed to the public, it may be impossible to change public opinion when correct results are reported.

4.10.2 Sampling Site Selection/Sampling Techniques

Even though the same care and techniques used in wastewater, ground-water, etc., sampling (including thorough documentation of location, date, time, etc.) are used by Branch personnel in potable water supply sampling, there are certain additional special procedures which shall be used.

When water samples are collected from wells, either by mechanical or hand pumping, the wells must be purged before the sample is collected (see Section 4.9 for ground-water sampling methods). This procedure insures that water representative of the formation is sampled, not the standing water in the well casing, pipes, or holding tank. As a rule of thumb, at least one volume of water in the well casing and storage tank should be evacuated (a 15-minute period is usually sufficient for residential wells). After purging for about 15 minutes, the pH, conductivity, and temperature should be measured until constant values are obtained. This procedure insures that any contaminants that might have entered the area of the tap from external sources have been removed (19).

Potable water samples shall be representative of the water quality within a given segment of the distribution network. Taps selected for sample collection should be supplied with water from a service pipe connected directly to a water main in the segment of interest and should not be separated from the segment of interest by a storage tank. The sampling tap must be protected from exterior contamination associated with being too close to the sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the bottle during the collecting procedure since it is difficult to place a bottle under a low tap without grazing the neck interior against the outside faucet surface. Leaking taps that allow water to flow out from around the stem of the valve handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations. Aerator, strainer, and hose attachments on the tap must be removed before sampling. These devices can harbor a bacterial population if they are not cleaned routinely or replaced when worn or cracked. Whenever a steady stream of water cannot be obtained from taps, after such devices are removed, a more suitable tap shall be sought. Taps where the water flow is not steady should be avoided because temporary fluctuation in line pressure may cause sheets of microbial growth that are lodged in some pipe section or faucet connection to break loose. The cold water tap should be opened for two or three minutes or for sufficient time to permit clearing the service line; a smooth-flowing water stream at moderate

pressure without splashing should be obtained. Then, without changing the water flow which could dislodge some particles in the faucet, the samples can be collected (19).

Occasionally, samples are collected to determine the contribution of transmission pipes, water coolers. water heaters, etc., to the quality of water in private residences, offices, etc. The purpose of these investigations may be to determine if metals, e.g., lead, are being dissolved into the water supply. In these cases, it may be necessary to insure that the water source has not been used for a specific time interval, e.g., over a weekend or a three- or four-day holiday period. Sample collection may consist of collecting a sample of the initial flush, collecting a sample after several minutes, and collecting another sample after the system being investigated has been completely purged.

Regardless of the type of sample bottle being used, the bottle cap should not be placed on the ground or in a pocket. Instead, hold the bottle in one hand and the cap in the other, using care not to touch the inside of the cap. Exercise care not to lose the Teflon® liner in certain bottle caps. Avoid contaminating the sample bottle with fingers or permitting the faucet to touch the inside of the bottle. When sampling for bacterial content, the bottle should not be rinsed before use. This may not only contaminate the bottle but also remove the thiosulfate dechlorinating agent (if used). When filling any container, care should be taken so splashing drops of water from the ground or sink do not enter into either the bottle or cap. In order to avoid dislodging particles in the pipe or valve, do not adjust the stream flow while sampling.

When sampling at a water treatment plant, samples should be collected both from the raw water supply and after chlorination.

Triplicate samples will always be collected for purgeable organic compounds analyses and duplicate samples for bacterial analyses. Single samples may be collected for extractable organic compounds, metals, phenol, cyanide, and conventional parameter analyses. The procedures given in Section 4.2.11 (Special Precautions for Trace Contamination Sampling) and in Section 4.7.6.4 (Purgeable Organic Compounds Sample Collection) shall always be followed when potable water supplies are sampled.

Branch personnel shall always obtain the name(s) of the resident or water supply owner/operator and the resident's exact mailing address, as well as the resident's home and work telephone numbers. The information is required so that the residents or water supply owner/operators can be informed of the results of the sampling program.

4.10.3 Sampling Equipment/Specific Sampling Equipment Quality Assurance Techniques

Sampling equipment and specific equipment quality assurance techniques are contained in Section 4.8 (Surface Water Sampling) and Section 4.9 (Groundwater Sampling).

4.11 SOIL SAMPLING

4.11.1 General

Soil sampling at hazardous waste sites will typically be approached in a totally different manner than sampling of other media. Sampling locations and rationale for other media are usually easily defined. For example, ground water samples may be collected at existing monitoring wells; surface water and sediment samples are usually collected from well defined surface drainage patterns at easily rationalized locations with respect to the suspected problem; and waste sources, such as drums, tanks, and piles, are easily identified sampling targets. Occasionally, surface soils may be stained or show evidence of vegetative stress, indicating that a contaminant may be present, but in many cases there may not be any direct evidence to suggest that a particular location is a candidate for soil sampling. The sampler may, in fact, be faced with investigating a virtually invisible contaminant distribution pattern, both in the surficial material, as well as in the subsurface region.

4.11.2 Sampling Location/Site Selection

Areas selected for soil sampling shall be strategically located in order to collect a representative fraction of the soils with the minimum number of samples. Although it is not always feasible to conduct a site reconnaissance prior to an investigation, a site reconnaissance can eliminate many uncertainties with respect to site characteristics and result in more complete and successful soil sampling studies. A surface inspection of the subject area should be made to locate pertinent features (e.g., rock outcrops, drainage patterns, surface runoff, ponds, lakes, wet areas, seeps, springs, permanent structures, fill areas, erosional areas, depositional areas, etc.) and to evaluate the relationship between these features and potential sources of pollution. A knowledge of these relationships and conditions, particularly soil conditions (type and thickness of soil overburden) and water table conditions are extremely important in developing sampling plans.

In addition to what is normally considered soil, i.e., in situ weathered rock overburden, soil samples may also consist of what is more correctly considered sediment, which has been deposited by both overland sheet runoff, as well as flow in normally dry wet-weather swales. The location of sediment sampling locations in these types of depositional areas is a useful screening tool, providing an indication of the presence of contaminants from the larger area contributing the sediment.

Initial investigations at most sites will consist of "screening-type" studies. Sampling for these investigations will generally be confined to a small number of surface or shallow subsurface samples. Typically, samples would be collected from depositional areas within and around the periphery of the site, as well as from obviously contaminated areas. Based on the results of the initial site-screening studies, more detailed studies, involving considerably more samples and with a greater emphasis on subsurface sampling, are usually required to fully characterize soil contamination at a site.

Study plans or work plans for soil sampling investigations must be carefully conceived with respect to the study objectives. This, in turn, requires a careful consideration of the types of samples to be collected, as well as the sampling methods to be employed. These areas are discussed below.

4.11.3 Basic Considerations for Soil Sampling

Three basic considerations, with respect to sample type, should be evaluated when developing a soil sampling plan and establishing investigation objectives. Should the samples be random, biased, or grid-based? Will they be collected from the surface or subsurface? Will a particular sample be a grab sample or a composite sample? When all of these questions are answered, it will be found that many investigations will involve the collection of most combinations of the above types of samples. A discussion of these considerations is found in the following sections.

4.11.3.1 Random, Biased and Grid-Based Sampling -- Generally, unless there is a strong indication of contamination, such as staining, or there are distinct depositional areas which provide excellent screening samples, soil samples collected for small investigations with limited areal extent, such as screening site investigations, must be randomly selected from several areas within the suspected area of contamination. Random in this sense is synonymous with casual, i.e., locations are often subjectively selected based purely on personal judgement.

If any areas show evidence of contamination, such as staining or vegetative stress, biased samples should be collected from each of the areas to characterize the contamination present in each area. If surface drainage patterns such as dry washes or swales are discernable, soil/sediment samples may be collected from the deposits in these features to characterize the immediate areas. Background and control samples are also biased, since they are collected in locations dictated by expected clean conditions or by anticipated impact from adjacent off-site areas.

When soil sampling investigations involve large areas, measured in acres for example, a systematic approach must be taken, not necessarily to the exclusion of other approaches, to characterize the presence and distribution of contaminants. In these situations, a grid-based soil sampling program is employed. There is no single grid size that is appropriate for all sites; however, in most cases, the smaller the site, the smaller the grid size. Common grid sizes are developed on 50-foot and 100-foot centers, although other sizes may be appropriate in given situations. It may be appropriate and acceptable to integrate several different grid sizes in a single investigation.

When the site is extremely large, over several acres for example, it may be impossible to consider sampling every grid and it will be necessary to statistically select a sub-set of the total number of grids in order to reduce the number of samples collected for the study. On the other hand, it may sometimes be appropriate to sample every grid and use relatively inexpensive and quick screening-level analytical techniques to define the areas which must be sampled and analyzed for a higher level of data quality. Because the screening level

analysis is relatively quick, the second phase sampling can sometimes be conducted during the same investigation. In all cases, however, the grid centers should be located using a site survey and semi-permanently marked to facilitate relocating the sample locations for subsequent sampling.

4.11.3.2 Surface and/or Subsurface Soil Samples -- In most initial investigations, particularly site screening-type studies, surface soil samples may comprise the great majority of soil samples collected. These are collected to look for the possible presence and distribution of contaminants in surficial materials. Subsurface soil sampling may be limited during initial investigations, but it may comprise the major portion of the soil sampling effort during subsequent phases of the investigation where the vertical extent of contamination in identified areas of surface contamination is the major objective.

4.11.3.3 Grab versus Composite Samples -- When a sample is needed to identify and quantify compounds at a specific location or interval, a grab sample is collected. Grab samples are limited in areal extent (for surface samples) or vertical extent (for subsurface samples). The sample should be comprised of no more than the minimum amount of soil necessary to make up the volume of sample dictated by the required sample containers. Composite samples are a mixture of a given number of subsamples and are collected to characterize the average composition of a given surface area or vertical interval. Areal composites are comprised of subsamples collected from the surface within the selected area. The number of subsamples forming a composite should remain consistent within the context of the study, i.e., a number and pattern for collection of subsamples within a grid should be selected and, for a given grid size, should not be changed. Likewise, if one of the objectives of the study is to determine if any contamination is present within a particular vertical interval, a vertical composite sample, comprised of vertically discrete samples collected over the selected interval may be collected. As with the areal composites, the number of subsamples is dependent on the objectives of the study. With the low analytical detection limits available today, compositing can usually be used to determine the presence or absence of compounds in the area or interval sampled.

There are two potential problems associated with compositing for which the sampler must be aware. Even though modern analytical detection limits allow for qualitative screening in many cases using compositing techniques, the risk still remains that low concentrations, present in individual composite aliquots, may be diluted to the extent that the total composite concentration is below the minimum quantification limit. Also, if the subsamples are predominantly moist and clayey, it will be very difficult to produce a homogenous mixture. The resulting sample, as represented by the portion selected by the analytical chemist, may not be representative, either qualitatively or quantitatively, of an average of all of the subsamples.

4.11.4 Sampling Methodology

This discussion of soil sampling methodology reflects both the equipment used (required/needed) to collect the sample, as well as how the sample is handled and processed after retrieval. Selection of equipment is usually based

on the depth of samples, but it is also controlled, to a certain extent, by the characteristics of the material. Simple, manual techniques and equipment, such as hand augers, are usually selected for surface or shallow, subsurface soil sampling. As the depth of the sampling interval becomes greater, some type of powered sampling equipment is usually needed to overcome torque induced by soil resistance and depth. The following is an overview of the various sample collection methods employed over three general depth classifications: surface, shallow subsurface, and deep subsurface. Any of the deep collection methods described may be used to collect samples from the shallower intervals. See Section 4.2.10 for special sampling considerations for purgeable organic compounds analyses.

4.11.4.1 Manual (Hand Operated) Collection Techniques and Equipment -- These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual, i.e., hand-powered, methods becomes impractical.

4.11.4.2 Surface Soils -- Surface soils may be collected with a wide variety of equipment. Spoons, shovels, hand-augers, push tubes, and post-hole diggers, made of the appropriate material, may be used to collect surface soil samples. As discussed in the section on powered equipment, surface soil samples may also be collected in conjunction with the use of heavy equipment.

Surface samples are removed from the ground and placed in pans, where mixing, as appropriate (Section 4.2.10), occurs prior to filling of sample containers. Section 4.11.5 contains specific procedures for handling samples for purgeable organic compounds analyses. If a thick, matted root zone is encountered at the surface, it should be removed before the sample is collected.

4.11.4.3 Subsurface Soils -- Hand-augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger-buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand-auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand-augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand-auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required. Some powered methods, discussed later, are not acceptable for actual sample collection, but are used solely to gain easier access to the required sample depth, where hand-augers or push tubes are generally used to collect the sample.

When a vertical sampling interval has been established, one auger-bucket is used to advance the auger hole to the first desired sampling depth. If the

sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a new bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole. Section 4.11.5 contains additional sample handling procedures.

Another hand-operated piece of soil sampling equipment commonly used to collect shallow subsurface soil samples is the Shelby or "push tube". This is simply a thin-walled tube, generally of stainless steel construction and having a beveled leading edge, which is twisted and pushed directly into the soil. This type of sampling device is particularly useful if a relatively undisturbed sample is required. The sampling device is removed from the push-head, then the sample is extruded from the tube into the pan with a spoon or special extruder. Even though the push-head is equipped with a check valve to help retain samples, the Shelby tube will generally not retain loose and watery soils, particularly if collected at lower depths.

4.11.4.3.1 Powered Sampling Devices -- Powered sampling devices and sampling aids may be used to acquire samples from any depth but they are generally limited to depths of 20 feet or less. Among the common types of powered equipment used to collect or aid in the collection of subsurface soil samples are Little Beaver®-type two-man power augers; split-spoon samplers driven with a drill rig drive-weight assembly or hydraulically pushed using drill rig hydraulics; continuous split-spoon samplers; specialized hydraulic cone penetrometer rigs; and back-hoes. The use of each of these is described below.

4.11.4.3.2 Power Augers -- Two-man power augers of the Little Beaver® variety, are commonly used to aid in the collection of subsurface soil samples at depths where hand augering is impractical. This type of equipment is technically a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range for this equipment. It is used to advance a hole to the required sampling depth, at which point a hand auger is usually used to collect the sample.

4.11.4.3.3 Drill Rigs -- Drill rigs offer the capability of collecting soil samples from greater depths. For all practical purposes, the depth of investigation achievable by this method is controlled only by the depth of soil overlying bedrock, which may be in excess of 100 feet.

When used in conjunction with drilling, split-spoon samplers are usually driven either inside a hollow-stem auger or inside an open borehole after rotary drilling equipment has been temporarily removed. The spoon is driven with a 140-pound hammer through a distance of up to 24 inches and removed. If geotechnical data are also required, the number of blows with the hammer for each six-inch interval is also recorded.

Continuous split-spoon samplers may be used to obtain five-foot long, continuous samples approximately 3 to 5 inches in diameter. These devices are

located inside a five-foot section of hollow-stem auger and advanced with the auger during drilling. As the auger advances, the central core of soil moves into the sampler and is retained until retrieval.

4.11.4.3.4 Cone Penetrometer Rigs -- A recent innovation is now available, which involves the modification of a standard split-spoon. The spoon has been modified with a releasable tip which keeps the spoon closed during the sampling push. Upon arrival at the desired depth, the tip can be remotely released and the push continued. During the subsequent push, the released tip floats freely up the inside of the spoon as the soil core displaces it. Split-spoon soil samples, therefore, can be collected without drilling, as has historically been required, by simply pushing the device to the desired depth. This technique is particularly beneficial at highly contaminated sites, because cuttings are not produced as with drill rigs. The push rods are generally retrieved with very little residue. This results in minimal exposure to sampling personnel and very little contaminated residue is produced as a result of equipment cleaning.

4.11.4.3.5 Back-Hoes -- Back-hoes are often utilized in shallow subsurface soil sampling programs. Samples may either be collected directly from the back-hoe bucket or they may be collected from the trench wall if proper safety protocols are followed. Trenches offer the ability to collect samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. Prior to collecting samples from trench walls, the wall surface must be dressed with a stainless steel shovel, spatula, knife, or spoon to remove the surface layer of soil which was smeared across the trench wall as the bucket passed. If back-hoe buckets are not cleaned according to the procedures described in Section B.8.3 of this manual, samples must be collected from material which has not been in contact with the bucket surface.

4.11.5 Special Techniques and Considerations

4.11.5.1 Collection of Soil Samples for Purgeable Organic Compound (VOA) Analyses -- These samples should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with a hand auger, the VOA sample may be collected directly from the auger bucket or immediately after an auger bucket is emptied into the pan. The sample should be placed in the appropriate container with no head-space, if possible, as is the practice with water samples. Samples for VOA analysis are not mixed (Section 4.2.10).

4.11.5.2 Dressing Soil Surfaces -- Any time a vertical or near vertical surface, such as is achieved when shovels or back-hoes are used for subsurface sampling, is sampled, the surface should be dressed to remove smeared soil. This is necessary to minimize the effects of cross-contamination due to smearing of material from other levels.

4.11.5.3 Sample Mixing -- It is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is representative of the interval sampled. Soil samples should be mixed as specified in Section 4.2.10.

4.11.5.4 Special Precautions for Trace Contaminant Soil Sampling - The procedures outlined in Section 4.2.9 shall be followed. All soil sampling equipment used for sampling for trace contaminants should be constructed of stainless steel where possible. Pans used for mixing shall be made of Pyrex®, or equivalent, glass. In no case will chromium, cadmium, or galvanized plated or coated equipment be used for soil sampling operations. Similarly, no painted or plastic equipment shall be used. All paint and primer must be removed from soil sampling equipment by sandblasting or other means before such equipment can be used for collecting soil samples.

4.11.5.5 Specific Sampling Equipment Quality Assurance Techniques - Drilling rigs and other major equipment used to collect soil samples shall be identified so that this equipment can be traced through field records. A log book shall be established for this equipment so that all cleaning, maintenance and repair procedures can be traced to the person performing these procedures and to the specific repairs made. Sampling spoons, hand augers, Shelby tubes, and other minor disposable type equipment are exempted from this equipment identification requirement.

- All equipment used to collect soil samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies.

- Any cleaning conducted in the field (Appendix B) or field repairs should be thoroughly documented in field records.

4.11.5.6 Auxiliary Data Collection - In addition to information pertaining to an area or specific site/location that may be available in EPA files from previous investigations (i.e., site screenings, water quality, well monitoring studies, etc.), information and data may be obtained from various city, county, state, and other federal agencies.

Samples should be accurately tagged and labeled with all pertinent site information at the time of sampling. See Section 3 for sample labeling and field recording procedures. The latitude and longitude shall be obtained for each site for future STORET data entry.

4.12 WASTE SAMPLING

4.12.1 General

Waste sampling as discussed in this section includes the collection of sludge samples from municipal and industrial wastewater treatment facilities; samples of liquid waste and sludge from pits, ponds, and lagoons; waste samples from open or closed containers such as drums, tank trucks, and storage tanks: and samples of waste piles and landfills.

Generally, the collection of sludge samples from municipal and industrial wastewater treatment plants is a low risk operation. However, the collection of liquid waste and sludge samples from open containers and liquid waste from pits, ponds, or lagoons and solid waste from waste piles may involve sampling operations that are inherently dangerous to the personnel involved. Sampling of closed containers (drums, storage tanks, etc.) shall be considered a high hazard operation by all Branch personnel. The procedures outlined in the Region IV Field Health and Safety Manual (23) will be strictly observed during all potentially hazardous sampling operations. Additional safety guidance is included in the draft EPA Safety Manual for Hazardous Waste Site Investigations (23). Branch specific safety protocols for these types of operations are included in Appendix K.

4.12.1.1 Specific Quality Control Procedures for Sampling Equipment

Sampling equipment contaminated during waste sampling must be cleaned as specified in Appendix B, Section B.1.5 before being returned from the field.

Contaminated disposable equipment and sampling equipment that is to be discarded must be properly disposed of as specified in the site-specific field sampling plan (Section 4.5).

All equipment used to collect waste samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of a field study. In some instances, special decontamination procedures in excess of the cleaning procedures outlined in Appendix B will be necessary. These procedures will be developed on a case-by-case basis according to the specific material encountered (26).

All air monitoring and field analytical equipment shall be tested before being issued for field studies, as specified in Section 6.0, and Appendix G.

Any cleaning procedures conducted in the field deviating from those specified in Appendix B, and all field repairs, shall be thoroughly documented in the field logbooks.

4.12.1.2 Collection of Auxiliary Information and Data -- The collection of auxiliary information and data is particularly important when collecting waste samples. Any field analyses, including those conducted with safety equipment such as photoionizers, explosion meters or approximate analyses such as those obtained with Ph indicator paper shall be recorded in field logbooks, as outlined in Section 3.5. Sketches of sampling locations, valving arrangements of tank

trucks and storage tanks, markings on drums, tanks, etc., should be thoroughly documented in the logbooks. Photographs are particularly useful for recording this information and they should be used extensively during waste sampling operations. A field log of the photographs taken should be maintained as outlined in Section 3.2.3.

4.12.2 Collection of Municipal Wastewater, Industrial Wastewater, and Municipal Water Treatment Plant Sludge Samples

4.12.2.1 Sampling Equipment -- Branch equipment available for the collection of sludge samples includes: sample containers; stainless steel spoons and shovels; stainless steel ponar dredges; stainless steel scoops attached to a conduit pipe; stainless steel push tubes; and Peterson and Eckman dredges.

4.12.2.2 Sampling Technique -- If the sampling technique involves multiple aliquots or if the final sample will consist of aliquots from several locations, all aliquots should be placed into a Pyrex® dish, or another suitable container, and mixed thoroughly before containerization, as specified in Section 4.2.10. The sample is containerized as specified in Appendix A.

If the sludge layer is shallow or if only the surface is to be sampled, samples can be collected directly into the sample container.

If depth samples are required, the methods described in Section 4.12.3.4.2 may be used.

Regardless of the method used, special care must be taken when collecting sludge sample to minimize the loss of fine materials by the excess water flowing out of the sampling device, thus biasing the sample.

4.12.2.3 Sampling Locations -- Sampling locations must be carefully selected to insure that the samples are truly representative of the material being sampled. The following are suggested locations for different sampling conditions.

4.12.2.3.1 Municipal Sludge Being Drawn to a Drying Bed -- Collect samples from the pipe flowing to the bed or at the discharge into the bed. Take three or more sample aliquots during the draw period to insure that variations in the sludge concentrations and consistency are accounted for.

4.12.2.3.2 Sludge From an Anaerobic Digester -- It is difficult to insure that the contents of these units are well mixed. Samples can be taken from sample ports in the recirculation lines if so equipped. Otherwise, samples can be taken from "thief holes" in the floating top of the digester.

4.12.2.3.3 Sludge From an Aerobic Digester -- It is much easier to sample these units because of the clear view of the contents. Samples should be taken while the contents are being mixed and from between 1/3 and 2/3 of the total depth of the digester.

4.12.2.3.4 Sludge From a Quiescent Holding Basin (Water or Wastewater) - One sample cannot be collected which will be representative of the total contents

of the basin since the material is generally stratified. Near bottom samples can be collected from the upper, relatively clear liquid layer as one would collect any water sample. Generally, a minimum of 3 to 5 grab sludge samples should be collected from the basin. These grab samples should be as representative of the sludge contents as possible. Samples should be collected near the inlet and discharge structures as well as from the open pond area. Samples may be analyzed individually or composited into a single sample. Sludge samples should be collected from the basin from a boat or a platform. Sediment sampling devices are required to collect these samples.

4.12.2.3.5 Sludge From Drying Beds -- After sludge is partially dried and cracked, samples can be collected with a stainless steel spoon, shovel, or similar device. Samples should be collected from three or four locations in the bed and composited to insure a representative sample. The sample should be collected to the full depth of sludge on the bed.

4.12.2.4 Special Precautions for Trace Contaminant Sampling -- See Section 4.7.6.1.

4.12.2.5 Sludge Samples Collected for Purgeable Organic Compounds Analyses See Section 4.7.6.4.

4.12.3 Pits, Ponds, and Lagoons

4.12.3.1 General -- For the purposes of this subsection, pits, ponds, and lagoons refer to any basin, pit, or open tank (lined or unlined) which contains or is suspected of containing unknown concentrated liquid, solid, or sludge chemical wastes. This discussion does not include municipal and industrial treatment ponds or natural or man-made surface water impoundments (discussed in Section 4.8.2).

4.12.3.2 Sampling Locations -- Sampling locations within pits, ponds, and lagoons should yield samples which are representative of that section, or of the entire pit, pond, or lagoon being sampled. All phases (floating solids, all liquid phases, and sludge) in the pit, pond, or lagoon should be sampled. The only exception is situations where representative samples cannot be safely collected or where the investigative team is attempting to determine worst case conditions.

Because of the inherent danger with sampling known or unknown concentrated waste, sampling personnel should never attempt to sample pits, ponds, or lagoons from a boat. All sampling should be accomplished from the banks of pits, ponds, or lagoons or from piers. Any exception must be approved by the appropriate Branch and/or Section Chief.

4.12.3.3 Sampling Equipment -- The following Branch equipment is available for field use in collecting liquid waste samples from pits, ponds, and lagoons: sampling containers; sampling containers affixed to a piece of conduit pipe, stainless steel scoop affixed to a piece of conduit pipe with a scoop bracket, stainless steel spoon affixed to a conduit pipe, peristaltic pump and vacuum jug arrangement, and Bacon-Bomb samplers. For sludge sampling of pits, ponds, and

lagoons; stainless steel ponar dredges, stainless steel scoops attached to conduit pipe, and stainless steel push tubes are available.

4.12.3.4 Sampling Techniques

4.12.3.4.1 Liquid Waste Sampling -- If the sampling technique utilized requires multiple aliquots, or if the final sample will consist of aliquots from several different locations in the pit, pond, or lagoon, all aliquots should be placed into a Pyrex® dish or a large glass sample container, or other suitable compositing container, and mixed thoroughly before containerization (Section 4.2.10).

The presence of individual liquid phases can be determined by using a peristaltic pump. The Teflon® tubing attached to the pump is strapped to a piece of conduit pipe and slowly lowered to the bottom of the unit to be sampled. The pump discharge (and the intake tubing) is examined to determine if phases are present. If phases are present, the top liquid phase can be sampled by direct dipping with the sample container, or dipping with the sample container attached to the conduit pipe - either directly or by way of a fishing pole type arrangement, or dipping the sample with a stainless steel scoop attached directly to conduit pipe with a scoop bracket. Alternatively, all liquid phases can be sampled with a peristaltic pump/vacuum jug arrangement with the Teflon® tubing attached to a conduit pipe and held at the desired depth or with the Bacon-Bomb sampler opened at the desired depth. The Bacon-Bomb sampler can be operated directly from the banks of pits, ponds, and lagoons; from piers; or operated by way of a fishing pole type arrangement using a piece of conduit pipe.

Floating solids can be sampled directly or with a stainless steel scoop or spoon attached to a piece of conduit pipe.

4.12.3.4.2 Sludge Sampling -- If the sampling technique involves multiple aliquots, or if the final sample will consist of aliquots from several different locations in the pit, pond, or lagoon, all aliquots should be placed into a Pyrex® dish or other suitable container and mixed thoroughly before containerization, as specified in Section 4.2.10. The sample is containerized as specified in Appendix A.

Sludge samples may be collected by pushing a stainless steel push tube into the sludge and emptying the tube contents into a Pyrex® dish or other suitable container. "Emptying" may include shaking to remove sludge or extrusion of thick or gummy sludges with a new wooden dowel. A disadvantage of this technique is the need for multiple insertions of the tube into the sludge to collect sufficient sample volume.

Sludge samples can also be collected with a stainless steel ponar dredge. An advantage of this technique is that one operation of the dredge usually yields sufficient sample volume for most sampling efforts.

One of the easiest methods of collecting a sludge sample consists of attaching a stainless steel scoop to a piece of conduit pipe with a scoop bracket, and inserting the scoop into the sludge. The scoop bracket has a

decided advantage in that it allows sampling personnel to adjust the angle between the scoop and the conduit pipe.

4.12.4 Open and Closed Container Sampling

4.12.4.1 General -- Sampling of closed containers (drums, storage tanks, etc.) should be conducted only when absolutely necessary. Whenever container sampling is necessary, the first priority should be the collection of samples from open containers since they generally present less hazard to the sampling personnel than closed containers (i.e., volatile organic components have already evaporated, extreme acute toxicity would probably be evident from dead animals or vegetation around the site, etc.). Closed containers must be considered as extremely hazardous from either the toxicity, explosion, or fire potential. Acute toxicity may pose a danger in both open or closed containers. Because of the dangers involved with container sampling, the sampling of drums or other containers containing either unknown materials or known hazardous materials shall be considered a hazardous duty assignment. Additional information regarding container sampling is available in the draft EPA Safety Manual for Hazardous Waste Site Inspections (24).

Safety procedures for container sampling will be in accordance with the Region IV Field Health and Safety Manual (23) and Appendix N.

A problem which often arises in container sampling is stratification and/or phase separation of the container contents. When this condition occurs, or is suspected, care must be taken to insure that the sample collected is representative of the container contents. If only one layer or phase is sampled, this should be noted and taken into account when interpreting analytical results. For example, if a large tank is being sampled for PCB's and the only valve or access port available for sampling is at the bottom of the tank, it should be noted that the concentration of PCB's might be biased on the high side, since PCB's are heavy and tend to settle near the bottom of containers.

If stratification is not present, samples may be composited by depth (i.e., collected throughout the entire depth of the container or at several different depths) to provide a representative sample. When a drum or cylindrical container is standing vertically, depth compositing provides a good quantitative estimate of the containers contents. In other cases where such containers are tipped, horizontal, deformed, etc., and stratification is not present, vertical compositing will provide a representative sample at least on a qualitative basis. (Note: a quantitatively representative sample could be collected, but would require sophisticated sampling methodology involving multilayer sampling and volume measurements; this is not recommended unless initial screening indicates it is absolutely necessary). Samples may not be composited across containers.

4.12.4.2 Sampling Equipment -- The following Branch equipment is available for use in collecting waste samples from open and closed containers: a complete set of spark-resistant (beryllium-brass) tools including barrel bung wrenches, adjustable wrenches, etc.; a remote barrel opening device; coliwasa samplers for drum sampling; glass tubes for drum sampling; glass profile tubes for container sampling; Bacon-Bomb samplers for container sampling; and peristaltic pumps and vacuum bottle arrangements for liquid waste sampling from containers.

4.12.4.3 Sampling Techniques -- Closed drums, or other containers (including storage tanks) containing unknown materials or known hazardous materials shall be opened using only spark proof opening devices and while the container is grounded. A remotely controlled device may be used when deemed necessary. Such a device involves the use of a remotely operated pneumatic wrench along with a brass pressure fitted bung socket (25).

The most commonly used Branch sampling device for 55-gallon drums is the coliwasa sampler. The coliwasa sampler is a single use glass sampler, consisting of an outer glass tube with one end tapered, and a separate inner glass tube with a small bulb on one end. In use, the outer tube is slowly lowered into the drum, tapered end first. This must be done slowly for two reasons. One, the drum may contain solid material which might break the tube and injure the sampler. Second, slowly lowering the tube allows the liquid phases in the drum to stay in equilibrium with the coliwasa sampler, ensuring a representative sample. The inner glass tube is inserted (bulb end first) into the outer tube. This may be done very slowly after the outer tube is fully inserted into the drum, or the inner tube may be inserted prior to immersing the outer tube. In the latter case, the bulb tip of the outer tube must be pulled back several inches from the tapered end of the outer tube. After both inner and outer tubes are inserted into the drum to be sampled, the inner tube bulb end is pressed gently against the tapered end of the outer tube, forming a seal. Both tubes are withdrawn from the drum and the ends of the tubes are held over the sample container. By manipulating the inner tube, the sampler can control the rate of flow of the sampled liquid into the sample container.

Samples from drums can also be collected using a four-foot length of glass tube. In most instances, glass tubes with a 1/2-inch or less inside diameter work best. The tube is inserted into the opening of the drum or barrel as far as possible. The open end is then sealed either with the thumb or a rubber stopper to hold the sample in the tube while removing the tube from the container. The sample is then placed in the appropriate container, and the procedure is repeated until an adequate amount of sample is collected. Sample volume shall be held to the absolute minimum required for analysis.

An optional method involves the use of a piercer valve which is inserted into the drum or barrel by use of a remotely operated hydraulic jack (24); however, this method should be used only as a last resort (24). The sample is collected directly from the valve. Several valves may be required at different depths on the drum or barrel if stratification has occurred.

Other sampling procedures including the use of automatic samplers, pumps, siphons, multiple valves and ports, etc., may be used depending on the specific container involved. These procedures should not be used unless it can be established that their use will not constitute a fire or explosion hazard. This determination shall be made only after field reconnaissance, collection of appropriate field data (explosion meter, photoionizer, etc.), and consideration of available file information on the site.

Tank trucks and storage tanks containing liquid wastes present a unique problem. Samples may be collected from access ports on top of these tanks or trucks using the techniques outlined above. Tank trucks are often compartment-

alized, and the investigator should insure that all compartments of the tank truck are sampled. Sampling from discharge valves usually found on tank trucks is not recommended due to potential stratification of the tank contents and the possibility of sticking or broken valves causing a release. However, if the investigator must sample from a tank truck discharge valve, the valving arrangement of the particular tank truck being sampled must be clearly understood to insure that the contents of the compartments of interest are sampled. The same precautions apply to sampling from storage tank valves. In either case, the investigator must realize that samples obtained from valves (particularly those at or near the bottom of tank trucks and storage tanks) may not yield representative samples. Sampling personnel should not utilize valves on tank trucks or bulk storage devices unless they are operated by the owner or operator of the facility, or a containment plan is in place should the valve stick or break.

4.12.5 Waste Piles and Landfills

4.12.5.1 General -- Waste piles consist of sludges and other solid waste, liquid waste mixed with soil, slag, or any type of waste mixed with construction debris, household garbage, etc. Each situation presents a unique challenge to the sampler in the selection of an appropriate sampling location and technique. Sampling at landfills is generally considered a routine operation. However, the sampling personnel must be aware that, in the past, landfills were not selective in the types of waste materials accepted. Therefore, sampling at landfills known or suspected to contain hazardous wastes could involve sampling operations that are inherently dangerous to the personnel involved.

4.12.5.2 Sampling Locations -- Sampling locations should be selected which will yield a sample which is representative of the waste pile or landfill being investigated. The only exception is situations in which representative samples cannot be collected safely or where the investigative team is attempting to determine worst case conditions.

4.12.5.2.1 Waste Piles -- A representative sample from a small waste pile can often be obtained by collecting a single sample. The collection of representative sample from large waste piles presents problems with both the number and locations of samples. For a sample to be truly representative, a statistical approach should be used in selecting both the numbers of samples and the location where they are to be collected. A discussion of statistical methods which can be utilized is given in the Test Methods for Evaluating Solid Waste (SW-846) issued by the EPA Office of Solid Waste and Emergency Response (28).

4.12.5.2.2 Landfills -- Representative samples from landfills are often difficult to obtain because of the heterogenous nature of the wastes deposited. Geophysical instruments may occasionally be useful in locating buried drums and tanks, but the signal is often lost in the background noise of waste ferrous materials. As with samples from waste piles, for a sample to be truly representative, a statistical approach should be used in selecting both the number of samples and the location where they are to be collected. A discussion of statistical methods which can be utilized is given in the Test Methods for Evaluating Solid Waste (SW-846) issued by the EPA Office of Solid Waste and Emergency Response (28). The sampler should be aware that landfills often generate leachate at one or more locations downgradient of the fill material.

Leachate samples can provide a limited overview of materials deposited in a landfill which are migrating via groundwater.

4.12.5.3 Sampling Equipment -- The following Branch equipment is available for field use in collecting samples from waste piles and landfills: stainless steel hand augers, stainless steel push tubes, stainless steel shovels, stainless steel scoops, stainless steel slag hammer/slag pan, drill rig, and stainless steel spoons.

4.12.5.4 Sampling Techniques -- All samples collected should be placed into a Pyrex® dish and mixed thoroughly before containerization, as specified in Section 4.2.10. Samples for volatile organic compounds analyses may not be composited and must not be mixed. Stainless steel shovels, spoons, or scoops should be used to clear away surface materials before samples are collected. Near surface samples can then be collected with a clean stainless steel spoon. Depth samples can be collected from the cleared location by forcing a stainless steel push tube into the waste pile or by augering to the desired depth in the landfill or waste pile with a stainless steel hand auger. When the desired depth is reached with a hand auger, a clean auger head should be used for collecting the sample. An alternate method for collecting depth samples is to dig to the desired depth with a stainless steel shovel or scoop and collecting the sample with a stainless steel spoon.

Sometimes the waste material is too hard to mix in a Pyrex® dish or the sample material retrieved is too large to contain in the sample container (for example slag wastes). This refractory material may be sampled by crushing representative portions of the waste material with the stainless steel slag pan and hammer. Once crushed, the material may be thoroughly mixed and containerized for analysis. Mixing is done as specified in Section 4.2.10 and the sample is containerized as specified in Appendix A. Any remaining waste materials must be properly disposed of, in accordance with the waste handling procedures for that process.

4.12.6 Contaminated Surfaces Sampling

4.12.6.1 General -- Sampling may be required to determine whether or not various surfaces are contaminated, or to evaluate the effectiveness of decontamination procedures. The procedures outlined below are intended for non-absorbent surfaces e.g., metal, concrete, glass, plastic, etc. These types of surfaces may be sampled using wipes or swabs that are purchased commercially. The wipe or swab material must be compatible with the solvent used and the analyses to be performed, and should not come apart in use. The wipes are saturated with either methylene chloride, hexane, or deionized water depending upon the parameters to be analyzed. Sampling personnel should be aware of this and take the proper precautions against skin contact and inhalation of these solvents as outlined in Appendix N. For routine scheduled wipe sampling, ASB requests two weeks notice to prepare the wipes. ASB must be notified as to what analyses are required. ECB should provide sufficient precleaned 8-oz sampling jars to ASB for storage of the prepared wipes. Wipe samples should not be collected for volatile organic compounds analysis.

4.12.6.2 Sampling Locations -- Surfaces contaminated by hazardous wipes may include walls, ceilings, floors, exposed beams, inner walls of the equipment, furniture, etc. Sampling locations will often be dictated by the surface to be sampled. If possible, however, the surface sampled should be horizontal and facing up. Surfaces in this position are generally the most likely to become contaminated by spills, splashing, settling dust, etc.

4.12.6.3 Sampling Equipment -- Branch sampling equipment consists of specially prepared wipes in sample jars. A sufficient number of wipes for each sample are kept in separate containers. These containers are precleaned 8-oz sample jars.

4.12.6.4 Sampling Techniques -- The sample jar containing the prepared wipes is opened and a prepared wipe is removed. Wipes may be handled either with stainless steel tongs, tweezers, or gloves. Gloves may be used only if the contaminants of interest are not present in the glove. The entire area to be sampled is wiped with firm strokes using only one side of the wipe. The wipe is then returned to the sample jar from which it was taken. This process is repeated until the area is visibly free of contamination or no more wipes are left in the jar. Care should be taken to keep the sample jar tightly sealed to prevent evaporation of the solvent. Samplers must also take care to not touch the used side of the wipe, to prevent loss of the contaminants. Unused wipes should not be removed. All wipes in the jar will analyzed by the laboratory.

If surface contamination is to be quantified (e.g., ug/cm^2) the surface area that is to be wiped must be measured. This can often be accomplished using a template made of decontaminated aluminum foil with an opening of the desired size, generally 10 cm by 10 cm.

4.12.7 Contaminated Documents Sampling

4.12.7.1 General -- Contaminated documents that require sampling are usually business records that are suspected to be contaminated with hazardous materials. If business records are to be sampled (files, file folders, correspondence, receipts, etc.), care must be taken that no evidentiary materials are destroyed in the sampling process.

4.12.7.2 Sampling Locations -- Blank letterhead, unused receipts, unlabeled file folders, etc., should receive first consideration. If these are not present in sufficient quantity, it may be necessary to collect the sample by removing material from the unused portions of the documents.

4.12.7.3 Sampling Equipment -- A Pyrex® pan and a pair of scissors decontaminated as specified in Appendix B. The handles of the scissors should not be painted or constructed of plastic.

4.12.7.4 Sampling Techniques -- The material selected for sampling should be as representative as possible. Once the sample material has been removed, it must be reduced in size and mixed prior to containerization. This can be accomplished by cutting the paper into small pieces with a pair of scissors and mixing the pieces in a glass pan. The shredded material is then placed into a precleaned 8-oz glass jar.

4.13 AIR TOXICS MONITORING

4.13.1 Formaldehyde Sampling Using Dinitrophenylhydrazine Cartridges Using Method TO-11

4.13.1.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the handling and field use of dinitrophenylhydrazine (DNPH) cartridges for formaldehyde sampling. This is from METHOD TO-11 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following generic procedures should be adhered to at all times.

- Polyethylene or Nylon gloves must be worn whenever handling any of the DNPH cartridges (in the extraction laboratory, during preparation for shipment, during field set-up, in field during preparation for return shipment, and in the laboratory during preparation for analysis and during analysis).

- Coated DNPH cartridge which have been prepared for longer than 90 days shall not be used.

- All padding material shall be either clean tissue paper or polyethylene-air bubble padding. Never use polyurethane foam, cardboard, or newspaper as padding material. DNPH cartridges which have been properly prepared for shipment may be shipped in cardboard containers or preferably in coolers with eutectic salt (Blue Ice) packs.

- Chain-of-custody shall be maintained for all samples.

- A minimum of one trip blank shall be transported per one to ten samples collected.

4.13.1.2 Extraction Laboratory -- Upon completion of preparation of the DNPH cartridges, both ends shall be plugged with polypropylene Luer® male plugs and each DNPH cartridge placed in a borosilicate glass culture tube with polypropylene screw caps (tightened). A serial number, expiration date and a lot number label will be placed on each glass culture tube. The batches of culture tubes shall be placed in sealed friction-top metal containers which contain 1-2 inches of granular activated charcoal (or a pouch filled with a similar amount of charcoal) for storage in the refrigerator in the Air Laboratory. The culture tubes should be enclosed in two Zip-Lock® bags to prevent contamination from charcoal dust.

4.13.1.3 Air Compliance Unit -- The Air Compliance Unit will notify and keep the Extraction Unit informed as to the anticipated number of prepared DNPH cartridges needed for field use. On routine studies, the Air Compliance Unit will notify the Extraction Unit of needs at least two weeks in advance of needed pick-up date. Only the number of DNPH cartridges needed for a maximum of 60 days (including trip blanks and extra DNPH cartridges for breakage) will be requested.

- On the date of shipment or when loading out for a study, the Air Compliance Unit will remove the sealed cans (which contain the DNPH cartridges sealed in glass culture tubes) from the refrigerator in the Air Laboratory. If only a small number of tubes are needed for a particular study, the correct number of tubes will be transferred to another, smaller, solvent-washed shipping can.

- An appropriate amount of packing material shall be placed in the metal container to prevent breakage of the glass culture tubes. A label shall be affixed onto each metal container listing the number of DNPH cartridges in the container. The metal containers should be shipped in coolers containing eutectic salt packs (such as Blue Ice) to maintain a temperature of approximately 4°C. The DNPH cartridges shall be shipped the same day they are packed.

- On each sampling date, the metal container(s) will be removed from the refrigerator or cooler for transport to the field. At each sampling location the metal container will be opened and one glass culture tube will be removed (wearing clean polyethylene or nylon gloves) and allowed to warm to ambient temperature (before removing the DNPH cartridge from the glass culture tube). The plugged DNPH cartridge will be removed from the culture tube and the two Luer® end plugs will be removed from each end of the DNPH cartridge which will be immediately placed on the sampling train. The Luer® end plugs will be placed back into the glass culture tube and the cap placed on the tube and tightened. The culture tube will be left in the sampler enclosure at the site. The same procedure will be adhered to at each sampling location. A trip blank (in a sealed culture tube) will be placed in a sampler enclosure at one on the sites for the duration of a sampling event.

The sampler will be manually turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

- The operator should collect the sample as soon as possible after the sampling period ends. The sampler should manually be turned on and allowed to run for two minutes and a final flowrate and elapsed time from the elapsed time meter should be recorded on the sample data sheet. The exposed DNPH cartridge will then be removed from the sampling train (wearing clean polyethylene or nylon gloves). The two Luer® end caps will be removed from the glass culture tube and placed on the ends of the DNPH cartridge. The DNPH cartridge will be placed back into the glass culture tube, the lid tightened and placed back into the metal container. The same procedure is to be followed at each sampling site.

- At the end of the day on which the samples are collected, the sealed metal can (which contains the exposed DNPH cartridges) shall be either placed in a refrigerator for storage overnight or placed in a cooler. The cooler will be used to transport the samples to the EPA, Region IV, Analytical Support Branch in Athens, GA. The

duration of the non-refrigerated period shall be kept to a minimum but absolutely not more than two days.

4.13.1.4 Analytical Support Branch -- Upon arrival of the metal container at the Athens laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.13.2 Volatile Organic Compounds (VOC) Sampling With SUMMA® Electropolished Stainless Steel Canisters Using Method TO-14

4.13.2.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the cleanup and use of Summa® canisters in sampling air for Volatile Organic Compounds (VOC). This summary is adapted from Method TO-14 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following procedures must be followed in the preparation and use of Summa® canisters for sampling VOC.

- All new Summa® canisters must be individually checked for contamination by the ESD laboratory before use. One of each batch of 10 Summa® canisters that are subsequently cleaned must be analyzed to check for contamination.

- All sampler tubing, fittings, and wetted parts of valves must be solvent washed in hexane and heated to >100° C. These parts should then be assembled and flushed with nitrogen for at least 8 hours prior to use in the sample train or in the canister cleanup apparatus.

- Each canister's valve and fitting will be inspected for damage before cleaning. Any damaged valve will be replaced with a previously cleaned (see procedure above) valve. After replacing any valve, the canister will be cleaned and analyzed to verify that it is free of contamination.

- If any canister is used to sample a high concentration source, it must be cleaned and analyzed to verify it is free of contamination before it can be used again.

- Chain-of-custody must be maintained for all samples.

4.13.2.2 SUMMA® Canister Cleanup -- The following cleanup procedure will be followed for the preparation of all Summa® canisters:

- The canisters should initially be pressurized to >2 atm with humidified nitrogen[1] then evacuated to 1 atm. This filling and evacuation sequence shall be repeated five times to dilute any residual contaminants. The addition of the water from the humidified nitrogen may also displace some of the more reactive contaminants that could adhere to active sites on the wall of the canister. After the fifth evacuation to 1 atm, the vacuum pump will

be valved on and left on for a minimum of 3 hours or until a vacuum of <150 millitorr is reached. The identification number of the canister, the date and the final vacuum will be recorded in the canister cleanup logbook. After cleaning, the canister's valve should be capped with a Swagelok® plug. A label will then be affixed to the canister denoting the date it was cleaned and the name of the person who performed the cleaning.

1. (The nitrogen should be certified 99.999% pure by the manufacturer. A molecular sieve scrubber should be attached to the nitrogen line after the regulator to remove any trace impurities).

4.13.2.3 Sample Collection -- Two types of VOC samples can be collected with Summa® canisters. The canister can be opened and allowed to fill rapidly to obtain a grab sample or filled slowly by using a flow controller to collect a time integrated sample. With either type of sample, the following general procedures should be followed:

- An EPA, pre-numbered sample tag should be tied to the handle of the Summa® canister prior to sampling.

- A Chain-Of-Custody Record should be completed detailing time of sampling, sampling interval, and signed by the person taking the sample.

- After the sample has been collected, the Summa® canister should be capped, the pre-numbered EPA tag should be completed, and the canister should be placed in a shipping container with a copy of the Chain-Of-Custody Record and sealed with EPA sample custody tape.

4.13.2.4 Grab Sample Collection -- Before a grab sample for VOC analysis is collected in a Summa® canister, the canister inlet valve should be fitted with a pre-cleaned (Section 4.13.2.2) stainless steel particulate filter. At the sample collection location, the main valve should be opened and the canister allowed to fill. After about one minute (when no audible sound of rushing gas can be heard), close and cap the main valve of the Summa® canister.

4.13.2.5 Time Integrated Sample Collection -- This sample collection method involves the use of a flow controller or a sampler containing a flow controller to slowly meter the flow of air entering a Summa® canister. With this method, a sample is collected over a longer period of time than with a grab sample. If a constant flowrate was maintained, the resulting sample will have a VOC content that is the average of the VOC concentrations for the sampling interval (a time integrated sample).

The following procedures should be followed to collect time integrated samples:

- All sampler systems should be checked for contamination prior to use or after any major repair. This is accomplished by metering zero air or nitrogen[1] to the inlet of the sampler. Excess zero air or nitrogen flow should be vented with a Swagelok® tee from the sampler

inlet to atmosphere. The evacuated canister should then be filled at the normal sampling rate with the zero gas.

- Initial flowrates will be determined with a mass flow meter. The initial flowrate and initial vacuum (at least 29 inches of Hg) should be recorded on the sample data sheet. Adjust the flowrate so that at the end of the sampling interval the ending pressure of the canister is approximately 0.9 atm.

- Final flowrates should also be determined with a mass flow meter. Final flowrate and final vacuum should be recorded on the sample data sheets. The final vacuum should be between 5 inches and 1 inch of Hg. The final flowrate should be at least 1 scc/min.

After sample collection, all canisters should be double checked to verify that each has an EPA pre-numbered tag with all information filled out. Place the canister in a shipping container and seal the container with EPA sample custody tape.

4.13.3 Semi-Volatile Organic Compounds (SVOC) Sampling With High Volume PUF Samplers Using Methods TO-4 & TO-13

4.13.3.1 General -- The following is a synopsis of procedures which should be strictly adhered to for use of the High Volume Polyurethane Foam (PUF) sampling method for sampling semi-volatile organic compounds (SVOC) including pesticides and polychlorinated biphenyls. This summary is adapted from Method TO-4 (pesticides and PCBs) and TO-13 (polynuclear aromatic compounds) of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following procedures must be followed in preparation of PUF sampling media and using the High Volume PUF method for sampling for SVOCs:

- All PUF sampling media should be pre-cleaned, loaded into High Volume PUF sample cartridges and sealed in solvent washed cans by the extraction lab prior to use.

- Chain-of-custody shall be maintained for all samples.

4.13.3.2 PUF Cleaning -- The Air Compliance Unit has responsibility for buying the PUF media and cutting the PUF plugs. PUF media should be specified as not containing any fire retardants. It should be stored in the dark to prevent photo-oxidation. It should be less than two years old, and should be stored in a pesticide free environment.

Care should be exercised in cutting the PUF. It should be thoroughly wet with tap water prior to cutting. A drill press and stainless steel PUF cutting die should be used. The drill press area should be free of oil and a polyethylene cutting block should be used to stop the die at the bottom of the drill press stroke (do not use wood). Water should be sprayed on the die as the PUF is cut to help prevent snagging. After the plugs are cut, they should be

rinsed with tap water and followed by a rinse with deionized water. Finally, the excess water should be squeezed out.

The rinsed PUF plugs should be placed in a polyethylene plastic bag and delivered to the Analytical Support Branch extraction laboratory for preparation of the PUF/XAD-2 cartridges. The extraction laboratory will be given a minimum of three weeks notice for cleaning and checking the PUF/XAD-2 cartridges. The cleaned PUF/XAD-2 cartridges should be wrapped in aluminum foil and packed in metal cans cushioned by cleaned polyurethane foam to prevent breakage during shipment. Prepared PUF/XAD-2 sample cartridges that are pre-packed in solvent washed metal cans will be obtained from the extraction laboratory prior to sampling. The cans should be packed inside coolers which are lined with polyurethane foam for shipment.

4.13.3.3 Sample Collection -- The following procedures will be followed for all High Volume PUF sampling.

Nylon gloves will be used when handling all PUF cartridges and quartz particulate pre-filters. Assure that the red silicon upper and lower gaskets, located in the cartridge housing, are in place. Then remove the PUF cartridge from the shipping can, remove from the foil and insert the cartridge into the High Volume PUF Sampler's chamber. The pre-filter should be installed in the filter holder using caution not to over tighten the fittings. The foil should be sealed back in the shipping can. The can should be labeled with site ID, operators name, and sample date, and placed in the High Volume PUF sampler enclosure until the sample is collected.

The High Volume PUF sampler should be turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

The operator should collect the sample as soon as possible after the sampling period ends. The sampler should be manually turned on and allowed to run for two minutes. A final flowrate should be recorded on the sample data sheet. The final flowrate should be at least 150 liters per minute. The PUF cartridge should be removed, and the quartz pre-filter folded and placed in the top of the PUF cartridge. The PUF cartridge and pre-filter should be re-wrapped in the original aluminum foil and placed back in the shipping can. The can should be tightly sealed. Complete the sample data sheet and Chain-Of-Custody Record and seal the shipping can with a sample custody seal. Finally, the shipping can containing the sample should be placed in a cooler containing frozen eutectic salt packs (at a nominal temperature of -4° C). When all samples are collected from all sites, the cooler should be sealed with sample custody tape for transport back to the ASB.

4.13.3.4 Analytical Support Branch -- Upon arrival of the metal container at the Athens ASB laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.13.4 Sampling For Metals Using The High Volume Sampler

4.13.4.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling of metals in air. This summary is adapted from 40 CFR, PART 50, APPENDIX B - Reference Method For The Determination Of Suspended Particulate Matter In The Atmosphere (High Volume Method), and 40 CFR, PART 50, APPENDIX G - Reference Method For The Determination Of Lead In Suspended Particulate Matter Collected From Ambient Air.

The following procedures must be followed in preparation for collecting samples for metals analyses with the High Volume sampler.

- All filters used will be supplied by the EPA National Filter Distribution Program, and of the same quality as supplied to the State and Local Agency Air Monitoring Stations.

- Prior to use, all filters will be checked for pinholes, and desiccated at 15°C - 30°C, ± 3°C, and less than 50 percent relative humidity, ± 5 percent, for at least 24 hours.

- A filter field blank will be taken to the field, but not exposed. Filter field blanks will be analyzed by the Analytical Support Branch (ASB) to determine the background concentration of metals. The number of filter blanks will be determined based on the number of samples collected, or one blank for each ten samples collected.

- Chain-of-custody must be maintained for all samples.

4.13.3.4 Sample Collection Procedures -- Samples will be collected using the High Volume sampler as described, and operated in accordance with 40 CFR, PART 50, APPENDIX B:

- All flow calibration orifices will be traceable to a Primary Standard Rootsmeter. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).

- Digital manometers used to determine flow rates will be checked against a U-Tube water manometer prior to use in each study.

- Air Compliance Unit personnel will remove a 2-inch strip of the exposed filter from one end and discard it. Two 1-inch strips will be cut from the same end and transported to the ASB for analysis.

4.13.4.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial and final flow rates will be determined with a calibrated orifice and a digital manometer.

- After the sample has been collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.

- A Chain-Of-Custody Record should be completed which contains the time of sampling, the sampling interval, and the signature of the person taking the sample.

After sample collection, all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container. Filters will be cut by the Analytical Support Branch and transported to the ASB for analysis.

4.13.5 Sampling and Analysis of Mercury In Ambient Air Using Arizona Instrument® Mercury Dosimeter Tubes and the Model 511 Gold Film Mercury Vapor Analyzer

4.13.5.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling and analysis of mercury (Hg) in ambient air. This summary is adapted from the Arizona Instruments® (AZI), Model 511, Gold Film Mercury Vapor Analyzer Manual.

The following generic procedures should be adhered to at all times:

- Chain-of-custody shall be maintained for all samples
- A minimum of one trip blank shall be transported per one to ten samples collected.
- All mercury dosimeter tubes shall be cleaned and analyzed each sample day prior to use.

4.13.5.2 Dosimeter Cleanup -- Each dosimeter tube should be connected to the AZI® model 412 dosimeter controller and AZI® Gold Film Mercury Analyzer as shown in Figure 1 of the AZI® model 511 Mercury Analyzer Operation Manual. The mercury analyzer analysis cycle should be started and immediately afterward the dosimeter controller's START button should be depressed. This will cause the gold plated wire inside the dosimeter tube to heat up and liberate any elemental mercury that forms an amalgam on the gold plated wire inside the dosimeter. Continue this cycle until less than 2 ng of Hg is detected from the dosimeter tube. Remove the clean dosimeter tube from the dosimeter controller, tag it with the cleanup date and operators name, and connect the inlet and outlet dosimeter ports together with a clean 8-inch section of 3/16" ID x 1/16" wall Tygon® tubing (this effectively caps the dosimeter tube).

4.13.5.3 Sample Collection -- Each sampling pump will be calibrated with a mass flow meter before and after each sampling event. Connected the dosimeter to the battery powered sampling pump with Tygon® tubing. Adjust the sampling pump to obtain a flowrate of 50 cc/min. The sampling interval should not extend beyond 8 hours. The following steps should be followed to collect each sample.

- Disconnect one end of the Tygon® tubing from the dosimeter tube and connect it to the battery powered sampling pump.

- Program the pump to run the desired number of hours. Position the dosimeter tube inlet so that there is no obstruction of flow. Record the dosimeter tube number, site ID, sample date, start time, and initial flowrate on the sample data form.

- As soon as possible after the sampling event, disconnect the Tygon® tubing from the sample pump and connect the loose end to the inlet of dosimeter tube. Record the elapsed time from the pump display. Check the ending flowrate with a mass flow meter and record it on the sample data form.

4.13.5.4 Sample Analysis -- Before any mercury analysis of dosimeter tubes, the AZI® model 511 should be calibrated. The AZI® model 511 should only be used under laboratory conditions. All glassware should be scrupulously cleaned and used exclusively for mercury analysis. All tygon tubing that is used should be new. The following calibration procedure is adapted from the AZI® model 511 operation manual:

Calibration

- Calibration of the AZI® model 511 is accomplished by the reaction of a mercuric chloride standard solution with stannous chloride which liberates elemental mercury. The elemental mercury is sparged from an impinger for analysis in the mercury analyzer.

- Before calibration, a film heat cycle should be initiated to clean the mercury analyzer sensor.

- Fresh working 100 ng/ml mercuric chloride standards should be prepared daily from a 1000 ug/ml stock solution. From the 100 ng/ml working standard, calibration standards of 10 ng/ml, 20 ng/ml, and 40 ng/ml should be prepared. Use the procedure outlined in the AZI® operation manual to introduce the stannous chloride solution into the impinger containing the 40 ng/ml standard. IMMEDIATELY depress the SAMPLE START button on the analyzer. Use the calibration potentiometer to adjust the analyzer to read 40. Analyze the 10, 20, and 40 ng/ml standards to verify that the calibration curve is linear. All analyzer readings should be within 2 ng of the actual values of the standards. Record the readings in the logbook.

- Once the mercury analyzer is calibrated, connect an exposed dosimeter tube to the model 412 dosimeter controller. Connect a zero filter to the inlet of the dosimeter tube. Simultaneously press the mercury analyzer SAMPLE START button and the dosimeter controller START button. Record the analyzer reading (in ng) in the logbook. Repeat this sequence three times and sum the values. This value is the total ng of mercury that was captured on the dosimeter tube.

- Divide the sum of the mercury analyzer readings (in ng) by the total volume of air sampled (in liters) to give the concentration of mercury present in ug/M^3.

4.13.6 Dioxin and Dibenzofuran Sampling With High Volume PUF Samplers Using Method TO-9

4.13.6.1 General -- The following is a synopsis of procedures which should be strictly adhered to for use of the High Volume Polyurethane Foam (PUF) sampling method for sampling for polychlorinated dibenzo-p-dioxins and dibenzofurans. This summary is adapted from Method TO-9 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

Since this method requires High-Resolution Mass Spectrometry which ESD does not have, all sample media preparation and analysis will have to be contracted. At least one months notice prior to sampling should be given to the Analytical Support Branch to obtain a contract laboratory program (CLP) contract for any dioxin and dibenzofuran analysis. It is important that the contract specify a number of details to assure accurate results:

- All of the PUF media and a representative number of each batch of quartz pre-filters should be checked by the contract laboratory to assure that there is no contamination. Each PUF plug should be pre-spiked by the contract laboratory with dioxin and dibenzofuran surrogates as a check of the accuracy of the method.

- Each set of PUF plugs and quartz filters should be securely packed in sealed containers and in coolers to prevent damage during shipment. The sampling media should be shipped air freight to minimize the time between cleanup and sampling.

- Chain-of-custody shall be maintained for all samples.

4.13.6.2 Sample Collection -- The following procedure will be followed for all High Volume PUF sampling for dioxins and dibenzofurans.

Nylon gloves will be used when handling all PUF cartridges and quartz particulate pre-filters. Assure that the red silicon upper and lower gaskets are in place in the PUF cartridge housing. Remove the PUF cartridge from the shipping can. Unwrap and insert the PUF cartridge into the High Volume (Hi-Vol) PUF sampler's chamber. Install the pre-filter in the filter holder using caution not to over tighten the fittings. The removed aluminum foil should be sealed in the shipping container. The container should be labeled with the site ID, the operators name, and the sample date, and placed in the Hi-Vol PUF sampler enclosure until the sample is collected. The Hi-Vol PUF sampler should be turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

The operator should collect the sample as soon as possible after the sampling period ends. The sampler should be manually turned on and allowed to run for two minutes and a final flowrate recorded on the sample data sheet. The final flowrate should be at least 150 liters/minute. The PUF cartridge should be removed, and the quartz pre-filter folded and placed in the top of the PUF cartridge. The PUF cartridge and pre-filter should be re-wrapped in the original aluminum foil and placed back in the shipping container and the container should

be tightly sealed. Complete the sample data and sample custody sheets. Each shipping container should have a sample custody seal. Finally, the shipping container containing the sample should be placed in a cooler containing frozen eutectic salt packs (at a nominal temperature of ~ 4° C). When all samples are collected from all sites, the cooler should be sealed with sample custody tape for shipment to the contract laboratory.

4.13.6.3 Contract Laboratory -- Upon arrival of the metal container at the contract laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.14 CRITERIA POLLUTANT MONITORING (REFERENCE MONITORS)

4.14.1 Monitoring Ozone In Ambient Air

4.14.1.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the monitoring of ozone in air. This summary is adapted from 40 CFR 50, APPENDIX D - Measurement Principle and Calibration Procedure For The Measurement Of Ozone In The Atmosphere , and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.7 (EPA-600/4-77-027a).

The following procedures must be followed in monitoring for Ozone in ambient air:

- Calibration systems will meet 40 CFR, Part 50, Appendix D specifications for a Primary Standard Calibration Photometer.
- Calibration systems will be verified against the National Bureau of Standards (NBS) Standard Reference Photometer #10 before use.
- Monitor enclosures will meet the specifications of monitor reference/equivalent designation for temperature control.
- Probes must meet the requirements stated in 40 CFR, Part 58 for materials and sample residence time.
- All flow calibrations will be traceable to a Primary Standard. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).
- Chain-of-custody must be maintained at all times.

4.14.1.2 Monitoring Procedure -- Measurements will be made using the procedure as described, and operated in accordance with 40 CFR, PART 50, APPENDIX D:

- Monitors will be calibrated at the beginning and end of each study, and at least quarterly during the study.
- Monitors will be calibrated after major maintenance or when a quality assurance (QA) check shows an out-of-control condition exists.
- A zero/span check will be conducted daily on all monitors.
- Precision checks of all monitors will be conducted at least weekly.
- Quality assurance audits as specified in 40 CFR, Part 58, Appendix A will be conducted quarterly, or at least once for short duration studies.

controllers. Flow rate look-up tables will be verified using a calibrated orifice on a routine basis, or at least annually.

4.14.2.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial and final flow rate will be determined with a digital manometer based on the manufacturer's flow rate look-up table.
- After the sample is collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.
- A Chain-Of-Custody Record should be completed detailing the time of sampling and the sampling interval, and the signature of the person taking the sample.

After the sample are collected, all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container and the container transported to the Athens, Georgia facility for final weighing of filters.

4.14.3 Sampling Of Particulate Matter In Air As PM_{10}

4.14.3.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling of particulate matter as PM_{10} in air. This summary is adapted from 40 CFR, PART 50, APPENDIX J - Reference Method For The Determination Of Particulate Matter as PM_{10} In The Atmosphere, and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.11 (EPA-600/4-77-027a).

The following procedures must be followed in sampling for particulate matter as PM_{10}:

- All filters used will be supplied by the EPA National Filter Distribution Program, and of the same quality as supplied to the State and Local Agency Air Monitoring Stations.
- Prior to use, all filters will be checked for pinholes, and desiccated at 15°C - 30°C ± 3°C, and less than 50 percent relative humidity ± 5 percent, for at least 24 hours.
- Initial and final (exposed) filter weights will be determined by the Air Compliance Unit. One of ten filters will be reweighed as a quality assurance check. For batches less than ten, one filter will be reweighed.
- After sampling, filters will be desiccated as described above.
- Chain-of-custody must be maintained for all samples.

4.14.3.2 Sample Collection -- Samples will be collected using the High Volume sampler as described, and operated in accordance with, 40 CFR, PART 50, APPENDIX J:

- All flow calibration orifices will be traceable to a Primary Standard Rootsmeter. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).

- Digital manometers used for flow rate determination will be checked against a U-Tube water manometer prior to use in each study.

- Volumetric flow controllers will be used on all PM_{10} samplers. Flows will be determined using the manufacturer's flow rate look-up table supplied with the controllers (Section No. 4.14.2.2). Flow rate look-up tables will be verified using a calibrated orifice on a routine basis, or at least annually.

4.14.3.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial flow rate will be determined with a digital manometer based on the manufacturer's flow rate look-up table.

- Final flow rate will be determined with the same method.

- After the sample is collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.

- A Chain-Of-Custody Record should be completed detailing the time of sampling and the sampling interval, and the signature of the person taking the sample.

After sample collection all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container and the container transported to the Athens, Georgia facility for final weighing of filters.

4.15 SATURATION MONITORING (NON-REFERENCE MONITORS)

4.15.1 Pm_{10} Saturation Monitoring Using Non-Reference Portable Monitors

4.15.1.1 Introduction -- This document gives procedures for use of the PM_{10} Saturation Monitors constructed by Lane Regional Air Pollution Control Authority located in Springfield, Oregon. These monitors are not referenced by the U.S. EPA.

4.15.1.2 General Description -- Each monitor is shipped with the following items:

Description	Qty
Sampler Body	1
PM_{10} Head	1
Filter Holders	2
Rechargeable Battery Packs	2
Battery Charger	1
Sampler Hanger	1
Storage Boxes	2

Procedures for siting requirements, monitor calibration, filter media inspection and preparation, sampler preparation, and battery pack preparation and changing are discussed in Appendix O of the manufacturers Operations Manual.

4.15.1.3 Calibrations -- Calibrations will be performed before and after each study for each sampler. Recalibration will be performed before field use on units which require major maintenance. Detailed calibration procedures are given in Appendix O of the manufacturers Operation Manual.

4.15.1.4 Sampling Procedure -- This sampling technique does not comply with EPA's ambient air monitoring regulations for PM_{10} sampling. The method has been shown to represent effective and efficient means for the collection of quality PM_{10} data.

Sample Preparation:

- Filters will be kept in protective cassettes. Prior to use, all filters will be visually inspected for defects.
- Each filter will have an ID number assigned to it.
- Each battery will be checked before load-out.

Sample Collection:

- Record information on Data Sheets.
- Install clean filter, and start system to check for leaks.
- Set initial flow to 5 L/min, and stop system.

- Input timer program, and verify.
- Input pulse factor into calculator, and start system.

Sample Retrieval:

- Start system, and record the ending flow rate.
- Note the ending sampling conditions, and record any problems on Data Sheets.
- Remove and replace sample filter following the double bag procedure.

Sample Preservation:

- Extreme care must be taken in removing exposed filters and reloading of filter heads.
- Filters will be returned to the original sample cassettes, and the ID number verified.
- Complete data sheets and store them and the filter samples in a container sealed with custody tape.

4.15.1.5 Sample Custody -- Chain-of-custody will be followed at all times during the sampling study. Chain-of-custody procedures can be found in Section 3.3, of this manual.

4.15.2 Carbon Monoxide Saturation Monitoring

RESERVED

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5.0 FLOW MEASUREMENT

5.1 INTRODUCTION

The measurement of flow with surface water and wastewater sampling is essential to almost all water pollution control activities. Activities such as water quality enforcement studies, NPDES permit compliance monitoring, water quality monitoring, municipal operation and maintenance investigations, planning, and research rely on accurate flow measurement data. The importance of obtaining accurate flow data cannot be overemphasized, particularly with respect to enforcement investigations since these data will be used as evidence in enforcement case preparation. NPDES permits often limit the quantity (mass loading) of a particular pollutant that may be discharged, and the calculation of mass loadings are also frequently necessary for water quality studies and other purposes. As much attention and care should be given to flow measurement in the design of a sampling program as to the collection of samples and their subsequent laboratory analysis.

The basic objectives of this section are to:

- outline standard practices for Branch personnel with respect to wastewater flow measurements during water enforcement and NPDES compliance monitoring activities and other studies where wastewater flow measurements are required;
- outline standard practices for obtaining surface water flow during water quality surveys;
- present acceptable, commonly used flow measurement techniques; and
- present general and specific quality assurance procedures for Branch flow measurement equipment and techniques.

A complete discussion of all available flow measurement techniques and the theory behind them is beyond the scope of this manual. However, most of the common techniques currently in use are covered in general terms. A comprehensive list of references is included at the end of this section and a detailed discussion of flow measurement techniques may be found in the references.

5.2 WASTEWATER FLOW MEASUREMENT

5.2.1 General

The USDI Water Measurement Manual (1) is the standard Branch reference for details on checking the installation of primary open channel flow devices. Basic guidance for making wastewater flow measurements and a basic description of all common wastewater flow measurement systems are given in the EPA Compliance Inspection Manual, May 1988 (2). This manual shall be used as Branch guidance for such measurements.

5.2.2 Site Selection

It is the field investigator's responsibility to insure that the wastewater flow measurement system or technique used measures the total wastewater discharged (described by the NPDES permit, if applicable). All recycled waters must be accounted for so that any reported flows accurately reflect the volume of wastewaters discharged. The actual location of wastewater flow measurement is not important so long as these criteria are met, and the location chosen is suitable for the technique or flow measurement system utilized to actually measure flow.

5.2.3 Flow Measurement Systems

Flow may be measured on an instantaneous or a continuous basis. A typical continuous system consists of a primary flow device, a flow sensor, transmitting equipment, a recorder, and possibly a totalizer. Instantaneous flow measurements can be obtained without using such a system.

The heart of a typical continuous flow measurement system is the primary flow device. This device is constructed to produce predictable hydraulic responses which are related to the flow rate of water or wastewater through it. Examples of such devices include weirs and flumes which relate water depth (head) to flow, Venturi and orifice type meters which relate differential pressure to flow, and magnetic flow meters which relate induced electric voltage to flow. Standard primary flow devices have undergone detailed testing and experimentation, and their accuracy has been verified.

A flow sensor is required to measure the particular hydraulic responses of the primary flow measurement device and transmit them to the recording system. Typically, sensors include floats, pressure transducers, capacitance probes, differential pressure cells, electromagnetic cells, etc.

The sensor signal is generally converted using mechanical, electromechanical, or electronic systems into units of flow which are recorded directly on a chart or transmitted into a data system. Systems which utilize a recorder are generally equipped with a flow totalizer which displays the total flow on a real time basis.

Studies that necessitate continuous flow measurements require a complete system. Instantaneous flow measurements do not necessarily dictate the use of any portion of such a system. Techniques which are described later in this Section are available for measuring instantaneous flows with portable equipment.

An important consideration during wastewater studies is that the investigator may want to obtain continuous flow data at a facility where only instantaneous flow data are being measured. If an open channel primary flow device is utilized for making instantaneous measurements, only the installation of a portable field sensor and recorder is necessary. If, on the other hand, the facility being investigated does not utilize a primary flow device, and a continuous flow record is desired, a portable primary flow device will have to be installed. ESD investigators have both open channel equipment and closed conduit flow meters available for field use. This chapter does not cover in detail the installation of primary flow devices, but many of the references cited treat this area quite adequately.

Wastewater flow measurement systems are generally very accurate. The total error inherent in a flow measuring system is the sum of each component part of the system. However, any system that cannot measure the wastewater flow within ± 10 percent of the actual flow is considered unacceptable for use in measuring wastewater flow.

5.2.4 Use of Existing Flow Measurement Systems

The installation of systems to measure wastewater flows can be a time consuming task, particularly if a primary device is not available. Therefore, Branch field personnel shall always use existing facility primary flow devices and flow measurement systems when the accuracy of these devices and the system can be verified. The objective of this section is to outline the responsibilities of Branch field personnel in verifying the accuracy of existing primary flow devices and systems.

The field investigator must verify that any existing flow measurement system (including primary flow device) utilized to measure wastewater flows conforms with recognized design and installation standards, and any deviation from standard conditions shall be thoroughly documented. The accuracy of the primary flow device should be checked by making an independent "calibration" or flow measurement. If there is no usable or existing primary flow measuring device or if the device has been mislocated, the investigator shall attempt to install a portable primary flow device.

If the discharger's flow measurement system is accurate within ± 10 percent of the actual flow, the investigator can use the installed system. The accuracy of flow sensors and recorders can be easily checked for open channel flow devices by making an instantaneous measurement utilizing the primary flow device and comparing this against the recorder reading. The accuracy of the recorder time trace shall be checked by actually marking times on the flow chart and comparing these to the correct time. It is necessary to make an independent flow measurement when closed conduit systems must be checked, although ESD inspectors have a closed conduit system (Polysonics) available. If the existing equipment cannot be calibrated in a timely manner, the investigator should install a portable flow sensor and recorder for the duration of the investigation. The installation and use of such equipment is preferred over attempts to correct erroneous flow measurement systems. The investigator should note the action taken in the study or inspection report and inform the discharger that the equipment should be calibrated as soon as possible if flow is required for calculating mass loadings or is itself a permit monitoring requirement. If non-standard primary flow devices are being used, data supporting the accuracy and precision of the methods being employed should be provided by the discharger.

5.2.5 Specific Techniques

This section outlines and familiarizes the field investigator with the most commonly used methods for wastewater flow measurements and the primary devices that will be encountered during field studies. Volumetric and dilution techniques are presented at the beginning of this section, since they are applicable to both open channel and closed conduit flow situations. The remaining methods are grouped under categories dealing with open channels and closed con-

duits. The general method of checking individual primary flow devices is given, where applicable. Several estimation techniques are presented. However, it should be recognized that flow estimates do not satisfy NPDES permit monitoring requirements unless the permit specifically states that this is permissible. The following methods are included only to enable the field investigator to make accurate flow estimates when necessary.

5.2.5.1 Volumetric Techniques -- Volumetric flow measurement techniques are among the simplest and most accurate methods for measuring flow. These techniques basically involve the measurement of volume and/or the measurement of time required to fill a container of known size.

5.2.5.1.1 Vessel Volumes -- The measurement of vessel volumes to obtain flow data is particularly applicable to batch wastewater discharges. Accurate measurements of the vessel volumes and the frequency that they are dumped are all that is required. An accurate tape to verify vessel dimensions and a stop watch are the only required field equipment. The NPDES Compliance Inspection Manual (2) is a useful reference on the equations for calculating volumes of various containers.

5.2.5.1.2 Sump Pumps -- This measurement is made by observing the sump levels at which the pumps cut on and off and calculating the volume contained between these levels. This volume, along with the number of pump cycles, will give a good estimate of the daily wastewater flow. The inspector must also account for the quantity of wastewater that flows into the sump during the pumping cycle.

5.2.5.1.3 Bucket and Stop Watch -- The bucket and stop watch technique is particularly useful for the measurement of small wastewater flows. It is accurate and easy to use. The only equipment required to make this measurement is a calibrated container (bucket, drum, tank, etc.) and a stop watch. A minimum of 10 seconds to fill the container is recommended. Three consecutive measurements should be made, and the results should be averaged.

5.2.5.2 Dilution Methods -- Dilution methods for water and wastewater flow measurements are based on the color, conductivity, fluorescence, or other quantifiable property of an injected tracer. The dilution methods require specialized equipment, special attention to detail by the investigator, and are time consuming. However, these techniques offer the investigator:

- a method for making instantaneous flow measurements where other methods are inappropriate or impossible to use;
- a reference procedure of high accuracy to check in-situ those primary flow devices and flow measurement systems that are non-standard or are improperly installed; and
- a procedure to verify the accuracy of closed conduit flow measuring systems.

The Turner Designs nomograph (3), the NPDES Compliance Inspection Manual (2), and the Geological Survey publication (4) outline recommended reference

procedures. The dilution method utilizing Rhodamine WT dye is the preferred reference procedure to be utilized by Branch personnel when verifying the accuracy of flow measurement systems.

5.2.5.3 Open Channel Flow Measurements -- The measurement of wastewater flow in open channels is the most frequently encountered situation in field investigations. An open channel is defined as any open conduit, such as a channel or flume, or any closed conduit, such as a pipe, which is not flowing full. The most commonly encountered methods and primary flow devices used in measuring open channel wastewater flows are described in this section. Several flow estimation techniques are also presented.

The measurement accuracies quoted in this section apply only to the specific method or to the primary flow device being discussed. The total error involved in a continuous flow measurement system, which is the sum of the errors of each component, is beyond the scope of this discussion. The reader is referred to the list of references at the end of this chapter for such a discussion.

5.2.5.3.1 Weirs -- A weir is basically defined as an overflow structure built according to specific design standards across an open channel to measure the flow of water. The theory of flow measurements utilizing weirs involve the release of potential static energy to kinetic energy. Equations can be derived for weirs of specific geometry which relate static head to water flow (discharge). Weirs are generally classified into two general categories; broad crested and sharp crested.

Broad crested weirs take the following form; $Q=CLH^{3/2}$. Values for the coefficient C are given in hydraulic handbooks (5, 6). Unless such weirs have been independently calibrated, they are usually not accurate enough for wastewater flow measurements.

Sharp crested weirs are constructed in a wide variety of shapes; the most commonly encountered are: V-notch, rectangular, and Cipolletti weirs. If such weirs are constructed as outlined in the USDI Water Measurement Manual (1), they are considered standard primary flow devices.

All weirs should be inspected to determine if the weir installation and construction conform to the conditions given in the USDI Water Measurement Manual (1) and provide a uniform influent flow distribution, and the weir is placed squarely across the channel perpendicular to the direction of flow. Useful tools for checking weir construction and installation include a carpenter's level, a framing square, a measuring tape, and a staff gage. Any problems observed during the inspection or study should be noted in the field log book.

A set of weir tables is necessary for calculating flows. The USDI Water Measurement Manual (1), the Stevens Water Resource Data Book (7), and the ISCO Open Channel Flow Measurement Handbook (8) contain a complete set of tables.

5.2.5.3.2 Flumes -- The conditions that must be met in a flume are similar to those that occur at a weir or spillway crest since water passing through the throat should not be impeded by downstream conditions (constrictions, bends in

channel, obstructions). There are several types of flumes, Palmer-Bowlus, Cutthroat, H, and Trapezoidal, but the most widely used is the Parshall flume. The Parshall flume is considered a standard primary flow device when constructed and installed as outlined in the USDI Water Measurement Manual (1). A complete discussion of other types of flumes is given in references 9, 10, 11, and 12.

All flumes should be inspected to determine if entrance conditions provide a uniform influent flow distribution, the flume dimensions conform to those given in the USDI Water Measurement Manual (1), the flume converging throat section is level, and the throat section walls are vertical. Useful tools for checking the construction and installation of Parshall (and other) flumes include a carpenter's level, a framing square, and a measuring tape. The flume should be closely examined to determine if it is discharging freely. If there is any question about free discharge, the downstream head (Hb) should be measured and compared to the head at the proper location (Ha) in the converging section. A staff gage is useful for making head measurements. Any problems observed during the inspection or study should be noted in the field log book.

A set of flume tables is necessary for calculating flows. The USDI Water Measurement Manual (1), the Stevens Water Resources Data Book (7), and the ISCO Open Channel Flow Measurement Handbook (8) contain a complete set of tables. The explanatory material accompanying these tables should be read and understood before they are used. In many cases, tabulated flow values are given for measured heads that are not within the usable measurement range.

5.2.5.3.3 Open Flow Nozzles -- Open flow nozzles such as parabolic or Kennison nozzles are factory calibrated and are ordinarily supplied as part of a flow measurement system. Calibration and installation information for each nozzle should be supplied by or obtained from the manufacturer. The accuracy of these devices is reported to be often better than ± 5 percent of the indicated flow (10). A framing square is useful for checking the installation. A volumetric flow measurement may be used to check accuracy of this device if flow volumes are not excessive.

5.2.5.3.4 Velocity-Area Method -- The basic principal of this method is that the flow in a channel (cubic feet/second) is equal to the average velocity (feet/second) times the cross sectional area (square feet) of the channel. The velocity of the water or wastewater is determined with a current meter; the area of the channel is either measured or calculated using an approximation technique in conjunction with a series of velocity measurements. The USGS mid-section method and the stream gaging techniques described in the USGS publication, Discharge Measurements at Gaging Stations (9) shall be the standard practice of the Branch. This technique shall be used (where appropriate) as an independent flow measurement to verify the accuracy of existing flow measurement systems.

5.2.5.3.5 Slope-Area Method -- The slope-area method consists of using the slope of the water surface, in a uniform reach of channel, and the average cross-sectional area of that reach, to estimate the flow rate of an open channel. The flow rate is estimated from the Manning formula (5, 6). This method is an estimation technique.

5.2.6 Closed Conduit Flow Measurements

The accuracy of closed conduit flow measuring devices shall be checked when necessary, by making an independent flow measurement, preferably using a dilution technique.

5.2.6.1 Venturi Meter -- The Venturi meter employs a conversion of static head to velocity head whereby a differential is created that is proportional to flow. The typical accuracy of a Venturi meter is given at 1 to 2 percent (10, 11, 12, and 13).

5.2.6.2 Orifice Meter -- The Orifice meter is a pressure differential device that measures flow by the difference in static head. Orifice meters require from 40 to 60 pipe diameters of straight pipe upstream of the installation. They can be quite accurate, i.e., within 0.5 percent, although their usable range is limited (10).

5.2.6.3 Flow Nozzle -- The basic principle of operation is the same as that of the Venturi meter. The flow nozzle has an entrance section and a throat, but lacks the diverging section of the Venturi. Flow nozzle accuracies can approach those of Venturi meters (10).

5.2.6.4 Electromagnetic Flow Meter -- The electromagnetic flow meter operates according to Faraday's Law of Induction where the conductor is the liquid stream, and the field is produced by a set of electromagnetic coils. The accuracy of the device is within ± 1 percent of full scale (10).

5.2.6.5 Other Closed Conduct Devices -- References for other closed conduit flow measurement methods such as acoustic flow meters, trajectory methods, pump curves, and water meters can be found in the NPDES Compliance Inspection Manual (2).

5.3 SURFACE WATER FLOW MEASUREMENTS

5.3.1 General

Surface waters are considered to be open channel for flow measurement purposes. All of the techniques utilized by Branch personnel to measure open channel flows have been discussed in the wastewater flow measurement portion of this section. Except for very small surface streams, the installation of primary flow devices is not practical. Most surface water flow measurements are made utilizing classical stream gaging techniques. These techniques involve the use of the velocity-area open channel technique which was discussed in the wastewater portion of this section. Branch personnel shall use the techniques outlined in the USGS publication Discharge Measurements at Gaging Stations (9) to:

- select the flow measuring site;
- perform stream gaging; and
- calculate flow.

5.3.2 Techniques

Where possible Branch stream studies shall be conducted utilizing existing permanent stream gaging stations operated by the USGS, the U. S. Army COE, or other federal or state agencies. These permanent gaging stations have established water stage - discharge relationships that permit the flow to be obtained from water stage measurements. Staff gage or recorder readings of water stage at these stations may be converted to flow by using the rating curve for that gaging station. The rating curve is available from the operator of the permanent gaging station. An additional benefit of utilizing these permanent gaging stations is that long-term flow records are generally available. These long-term flow records are invaluable in planning water quality studies and assessing data trends.

Where permanent gaging stations are not present, surface water flow will have to be measured utilizing classical stream gaging techniques. If a station is to be used more than one time during a water quality survey, a rating curve should be developed for that station. This may be done by making a series of independent flow measurements and simultaneous tape down or staff gage measurements for that station (see Section 7) at different water levels. The rating curve is developed utilizing the same measurement section each time; at least two, preferably three, flow measurement - tape downs should be made. The flow measurements used to develop the rating curve must bracket the lowest and highest flows encountered during the study. A tape-down rating curve is constructed by plotting the tape-down measurements verses flows on a piece of semi-log graph paper.

5.4 GENERAL QUALITY ASSURANCE PROCEDURES

All Branch personnel shall use the techniques and procedures for making wastewater and surface water flow measurements outlined in this section. The USDI Water Measurement Manual (1), the USGS publication Discharge Measurements at Gaging Stations (9), the EPA NPDES Compliance Inspection Manual (2) and a set of weir and flume tables shall be supplied to all Branch field employees. However, the measurements of wastewater and water flows require considerable experience. Therefore, no Branch employee shall make flow measurements until he/she has at least six months of actual field experience and has performed these measurements under the supervision of a senior member of the Branch staff.

Wastewater flow shall be expressed in million gallons per day (mgd) or the metric equivalent (m^3/day); stream flow shall be expressed in cubic feet per second (second feet) or the metric equivalent (m^3/sec). Time records associated with flow measurements shall be kept in local time, shall be made in the 2400 hour military time format, and shall be recorded to the nearest five minutes.

All flow measurements conducted by Branch personnel shall be thoroughly documented in field records. All measurements shall be traceable both to the individual making the measurements and the equipment utilized.

A log of all maintenance, calibration, and repair for each piece of flow measuring equipment shall be established. The log shall be kept in such a manner that all maintenance and calibrations performed on the equipment are traceable to the person performing them and to the calibration standard utilized. All equipment shall be numbered, or the US-EPA property or serial number shall be

used to facilitate identification.

5.5 EQUIPMENT AVAILABLE

The equipment available to Branch personnel for the measurement of surface water or wastewater flows is categorized as follows: water level/stage hardware and recorders, velocity measuring equipment and assemblies, and direct flow measurement equipment and instrumentation.

The hardware available to Branch personnel to determine the rise and fall of a water surface with time (the water stage) includes the following recording devices: Stevens Model F horizontal drum recorders and Stevens Model A-71 continuous strip chart recorders, ISCO Model 1870 recording flow meters used in the linear head mode, and ISCO Model 2870 recording flow meters that have programmable functions. Non-recording equipment available includes vertical staff gages and tape-down systems (see Section 7).

Instruments and equipment available to make velocity cross-sectional area measurements include current meters and sounding (depth) equipment. The current meters available to Branch personnel are the vertical-axis mounted Price AA and Price pygmy meters (including direct readout meters), and ENDECO solid state memory current meters. Sounding (determination of depth) is accomplished using Ratheon recording fathometers or with a standard top setting wading rod. Width measurements are made by Branch personnel using a Lee-Au galvanized steel tag line which is segmented into equal divisions of length by metal beads.

The equipment available for direct flow measurement includes the following primary devices available for installation by Branch personnel: V-notch weir plates and rectangular weir plates. The corresponding conversion of water level to flow rate can be accomplished instantaneously from stage/staff gage readings corresponding to the primary flow device in use, or by instantaneous readings of the available recording flow meter systems. The continuous recording systems presently available are the ISCO Model 1870 and 2870 recording flow meters.

The Polysonics Ultrasonic Flowmeter (Model UFM84P) is available for measuring flow in closed pipes. The pipe must be flowing completely full and not contain large amounts of air pockets. A coupling jelly is spread on the face of two transducers, and the transducers are mounted opposite each other on the outside of the pipe. The meter must then be calibrated according to the manufacturer's instructions.

5.6 SPECIFIC EQUIPMENT QUALITY CONTROL PROCEDURES

A log book shall be kept of all equipment utilized for measuring water flows, water stage/tape downs, velocity measurements, flow recordings, etc. The following maintenance and calibration procedures shall be implemented.

5.6.1 Stevens Model A-71 and Model F Stage Recorders

See specific equipment and quality control procedures in Section 7.

5.6.2 ISCO Model 1870 and 2870 Recording Flow Meters

The recording flow meter shall be thoroughly tested annually to insure that the accuracy, resolution, and precision are within the technical specifications as established by the manufacturer. This shall be accomplished by operating the instruments in a controlled test environment for a period not less than 24 hours. The test environment shall consist of a controlled atmospheric temperature, power source, and water level/head. Operation during the testing period shall be according to the manufacturer's instruction manual. The functions that shall be tested include: flow meter totalizer accuracy, flow recorder tracing accuracy, and chart speed accuracy.

In addition to the above annual testing program, an abbreviated testing procedure will be conducted on the flow meters and recorders which will include a check on the following functions: flow meter and recorder response to changing heads as shown on the meter's liquid level indicator and the recorder's flow indicator, bubble rate adjust response, flow recorder accuracy, full scale span sensitivity, sample signal initiation response, zero adjust response, and chart speed response. The flow meters and recorders shall be checked through the abbreviated procedure whenever they are scheduled for field use.

The following routine maintenance procedures shall apply whenever the equipment is returned from the field: the exterior of the meter and recorder case will be cleaned with soapy water (Appendix B), the front panel desiccant and external desiccant cartridges will be reactivated, and the bubble line will be inspected and cleaned.

5.6.3 Vertical Staff Gages and Tape Down Systems

See specific equipment and quality control procedures in Section 7.

5.6.4 Price AA and Price Pygmy Current Meters

All meters shall be sent to the USGS for recalibration once every five years. All meters shall be examined before and after each discharge measurement. The examination shall include the meter cups or vanes, pivot and bearing, and shaft for damage, wear, or faulty alignment. Meter balance and alignment shall be checked prior to each use in the field (9). Meters shall be cleaned and oiled daily when in use. Surfaces that shall be cleaned and oiled on a yearly basis are the pivot bearing, pentagear teeth and shaft, cylindrical shaft bearing, and thrust bearing at the cap.

5.6.5 Top Setting Wading Rod

This equipment shall be cleaned and examined before and after each discharge measurement. The examination shall include a check on the sliding rod and lock set mechanism.

5.6.6 Lee Au Tag Line

This equipment shall be inspected for damage and cleaned before and after each discharge measurement. The accuracy of the tag line will be checked initially and then once per year utilizing the Invar steel surveyors chain. The tag

line(s) shall be accurate to 0.1 foot per 100 feet. Any tag lines that do not conform to this accuracy specification shall be repaired, recalibrated, or discarded. Yearly maintenance shall include an inspection for potential breaks, a thorough washing, and a finish oiling.

5.6.7 V-Notch and Rectangular Weir Plates

These plates shall be cleaned and examined before and after each field installation. Construction and condition of weir plates shall conform to recognized standards (2). The plates shall be cleaned with a soapy wash water, followed by a distilled water rinse. The weir plates will be inspected to insure that the upstream edge of the plate remains sharp.

5.7 REFERENCES

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6.0 FIELD ANALYTICAL PROCEDURES

6.1 GENERAL

Field analytical equipment used by Branch personnel should be suitable for the analysis to be accomplished and properly calibrated. In addition to being accurate, field analyses must be conducted on a sample which is representative of the source from which it was collected. Therefore, the type of sample and location of the sampling site are critical. A detailed discussion of sample type and sample site selection is given in Section 4 for the various media investigated by Branch personnel.

The objectives of this section are to:

- list the specific field analytical techniques that shall be used by Branch personnel;
- list the specific quality control procedures and calibration techniques for each piece of field analytical equipment used by Branch personnel;
- list the source of all reagents and standards used to perform field analyses and/or calibrate field analytical equipment; and
- specify the training required of Branch personnel to perform the listed field analyses.

Specific field analytical methodology for each parameter is given in Appendix D.

6.2 SPECIFIC ANALYTICAL TECHNIQUES

The specific field analytical techniques used by Branch personnel are listed below and the specific procedures for each analytical technique and field test are presented in Appendix D.

Analytical Parameter	Method	Reference	Equipment
Temperature	Calibrated glass (mercury), dial (mechanical), or electrometric thermometer	1	Mercury filled glass, mechanical dial type thermometer, or thermistor with electronic readout
pH	Electrometrically using a glass electrode in combination with a reference potential or a combination electrode	1	Portable field pH meter
Dissolved Oxygen (DO)	Modified Winkler or membrane electrode	1	Standard DO kit with fresh sodium thiosul-

			fate, or membrane electrode and electronic readout
Specific Conductance	Wheatstone bridge type or equivalent meter corrected to 25_oC	1	Self-contained conductivity meter, Wheatstone bridge type, or equivalent with automatic temperature compensation to 25_oC or "dial in" temperature compensation
Total Chlorine Residual	Back titration, iodometric with starch or amperometric end-point or DPD colorimetric	1	Iodometric backtitration kit with fresh reagents, or amperometric titrator with fresh reagents, or DPD kit with color standards
Tracer-Fluorescence	Analysis of fluorescent dyes using a fluorometer	2	Rhodamine WT dye and Turner fluorometer
Salinity	Electrodeless Inductive Conductivity Cell Salinometer	3	Beckman RS5-3 Portable Salinometer and Hydrolab Surveyor II Meter

6.3 SPECIFIC QUALITY CONTROL PROCEDURES

Quality assurance procedures for field analysis, and field analytical and test instrumentation calibration are an essential part of these standard operating procedures. All field analytical procedures shall be conducted in duplicate at least 10 percent of the time. A record of these duplicate analyses shall be kept in field logbooks. A significant difference in the replicate analyses (greater than specified in the following sections) shall result in recalibration of the instruments used, re-examination of the analytical methodology being used, or re-examination of the sampling location.

All field analyses must be traceable to the specific individual performing the analyses. Time records shall be kept in local time using the military 2400 hour format and shall be recorded to the minute. This information shall be entered into the field logbooks for all field analyses performed by Branch personnel.

A specific calibration and/or standardization plan for all field analytical equipment is presented in this subsection. Included in this plan are: calibration and maintenance intervals; listing of required calibration standards and conditions requiring recalibration.

6.3.1 Temperature

6.3.1.1 Initial Calibration -- All thermometers shall be initially calibrated against a National Bureau of Standards (NBS) certified thermometer or one traceable to NBS certification.

6.3.1.2 Inspection and Calibration -- Each glass mercury filled thermometer shall be inspected before each field trip to see that it is not cracked and has no air space in the mercury column. If a mechanical dial-type thermometer is used, it should not have a broken face cover or otherwise show damage. A cross-check with a calibrated NBS certified thermometer shall be made at least semi-annually. Thermistors and electronic readout units should be calibrated in the same manner. Recording thermometers shall be checked for recording accuracy before each use. The recorder time scale accuracy shall be checked semi-annually. Before using a thermometer in the field, a visual observation shall be made to assure that it has not been damaged. If a thermistor is used, the instrument shall be checked against a thermometer before field use. Cross-checks and duplicate field analyses should agree within $\pm 0.5^{o}C$.

6.3.1.3 Calibration Records -- A logbook shall be maintained with each thermometer number and/or equipment property number recorded. All calibration information including individuals making the calibrations and dates of calibration shall be recorded.

6.3.1.4 Reporting Units -- Report all temperature data to the nearest $0.5^{0}C$.

6.3.2 pH

6.3.2.1 Equipment -- Only electronic (portable) pH meters with automatic temperature compensation (ATC) should be used. Temperature resistant, combination electrodes should be employed in conjunction with the meters. pH test paper will be used only for determining pH ranges, for determining approximate pH values, or for concentrated hazardous waste samples which would damage the instrument.

6.3.2.2 Equipment Inspection and Calibration -- The pH meter shall be checked before each field trip for any mechanical or electrical failures, weak batteries, and cracked or fouled electrodes. The slope of the meter shall also be checked initially with three fresh standard buffer solutions (e.g., 4, 7, and 10). All pH recorders shall be checked for recording accuracy and time scale accuracy. While in the field, the meter shall be calibrated daily before use with two buffers bracketing the expected sample pH. Thereafter, the meter shall be checked against two buffers when moving to a new sample location. Fresh buffer solutions shall be used for each field trip. In case of an apparent pH violation, the electrode shall be checked with pH 7.0 buffer and recalibrated to the closest reference buffer. Then the sample shall be retested. Duplicate tests should agree within 0.1 standard unit.

6.3.2.3 Reporting Units -- Report pH to the nearest 0.1 standard unit.

6.3.3 Dissolved Oxygen (DO)

6.3.3.1 Equipment -- Modified Winkler kits and membrane electrode DO meters should be used.

6.3.3.2 Equipment Inspection and Calibration -- DO meters shall be checked before each field trip by inspecting the membrane for air bubbles and holes. If the membrane is dry, it shall be replaced and soaked in water before calibrating. Calibration should be made against the modified Winkler test.

DO kits shall be refilled with new standardized sodium thiosulfate before each field trip. Each solution shall be checked for clarity and volume.

Before using the DO meter each day, duplicate deionized or known clean water samples shall be collected by siphoning water from a bucket into two DO bottles. These duplicate samples shall be analyzed by the modified Winkler test for DO content. The DO meter shall be calibrated against the DO content measured by the Winkler test by placing the DO probe in the bucket containing the water used for the Winkler test.

While using the DO meter, the instrument shall be recalibrated at least twice per day or if a change in water quality is noted. If the sample temperature is 5^0C greater than the calibration temperature, the meter shall also be recalibrated.

Duplicate analyses should agree with $\pm$ 0.1 mg/l.

6.3.3.3 Reporting Units -- Results for the DO test should be reported to the nearest 0.1 mg/l.

6.3.4 Specific Conductance

6.3.4.1 Equipment -- A portable specific conductance meter, Wheatstone bridge type or equivalent should be used.

6.3.4.2 Inspection and Calibration -- Each conductivity meter shall be checked before each field trip. Batteries shall be checked, and conductivity cells shall be cleaned and checked against known conductivity standards (KCl).

6.3.4.3 Field Calibration -- Before using in the field, check instrument daily with known standards. Refer to the instrument instructions for temperature conductance calculations. Duplicate field analyses should agree within $\pm$ 10 percent.

6.3.4.4 Reporting Units -- Results should be expressed in micromhos/centimeter (umhos/cm) corrected to 25^0C. Results should be reported to the nearest ten units for readings under 1,000 umhos/cm and the nearest 100 units for readings over 1,000 umhos/cm.

6.3.5 Total Chlorine Residual

6.3.5.1 Equipment -- The iodimetric back titration method with a starch-iodide end point or amperometric end point or a Hach DR 100 colorimetric (DPD) kit may be used.

6.3.5.2 Inspection and Calibration -- Each titration kit or meter shall be checked before each field trip by inspecting the meter for battery strength and fresh reagents. The normality of the iodate should be checked with a distilled water blank to establish a correction factor for the titrant. This will also serve to check the response of the amperometric titrator. Duplicate chlorine residual analyses should agree within ± 0.01 mg/l.

If the Hach DR 100 colorimeter (DPD) kit is used, the method must agree with the requirements of Method 408E, "Standard Methods," 16th Edition, or Method 330.5 "Methods for Chemical Analysis of Water and Wastes," and calibration scales must be calibrated on site at a minimum of three points (blank and two standards) that bracket the expected sample concentration.

6.3.5.3 Reporting Units -- Results should be reported to the nearest 0.01 mg/l residual chlorine.

6.3.6 Fluorescent Tracing

6.3.6.1 Tracer -- Rhodamine WT dye is the standard tracer used by Branch personnel.

6.3.6.2 Fluorometer -- A filter fluorometer (fluorometer) is the instrument used to determine intensity of emitted light or concentration of dye in the sample.

6.3.6.3 Fluorometer Calibration and Calibration Standards -- Before a fluorometer is used in the field, it shall be checked against a set of standard dye solutions. All standard concentrations shall be made relative to the stated concentration of the manufacturer's solution.

All standard solutions shall be made with distilled water. Sufficient solution volumes shall be made to permit calibration checks. Calibration checks shall be conducted whenever the fluorometer has been turned off for an extended period of time.

The fluorometer and all associated equipment shall be thoroughly cleaned between uses.

6.3.6.4 Reporting Units -- Turner Design fluorometer results shall be reported as ± 1 percent of full scale concentration.

6.3.7 Salinity

6.3.7.1 Equipment -- A portable salinometer, electrical conductivity type shall be used.

6.3.7.2 Inspection and Calibration -- Each salinometer shall be checked before every field trip. Batteries shall be checked and the cell inspected to determine if it is free of marine growth and salt. The meter shall be checked against the resistor loop supplied with the meter.

6.3.7.3 Reporting Units -- Results should be reported to the nearest 0.1 part per thousand of salinity.

6.4 SEMI-ANNUAL MAINTENANCE

All analytical and test instruments and kits shall be inspected on a semiannual basis, whether used during the intervening period or not. The purpose of the semi-annual inspection is to maintain the equipment in a ready-to-use condition. This inspection shall consist of a general examination of the electrical system (including batteries) and a calibration against standards. Any expired reagents, broken glassware, or parts shall be replaced.

6.5 SOURCES OF CHEMICALS AND STANDARDS

All chemicals used in test kits and with field analytical instruments as reagents and standards shall be supplied and standardized by the Analytical Support Branch (ASB). Certified pH buffer solutions shall be purchased from chemical supply houses. All reagents and solutions shall have expiration dates attached to the containers. All out-of-date reagents, buffers, and chemical solutions shall be properly disposed of at their expiration date. All field reagent containers shall be identified with the chemical name, concentration, and date prepared.

Tracer-fluorescence standards will be prepared for each study using the actual tracer as outlined in Appendix D.9.

6.6 TRAINING

Each member of the Branch involved in field studies shall undergo an initial review of field analytical and test procedures and equipment. After the initial review, subsequent reviews shall take place annually. The Branch Quality Assurance Officer, in conjunction with personnel from the ASB, shall conduct the instruction. Any new instrumentation adopted by the Branch will be introduced to Branch personnel in a training session before it will be authorized for routine use.

6.7 REFERENCES

1. "Guidelines for Establishing Test Procedures for the Analysis of Pollutants," Federal Register, Volume 49, No. 209, 40 CFR 136, October 26, 1984, and any subsequent revisions.

2. Wilson, J. F., Fluorometric Procedures for Dye Tracing: USGS Techniques of Water-Resources Investigations, Book 3, Chapter A12, United States Department of Interior, Geological Survey, 1968.

3. Standard Methods for the Examination of Water and Wastewater, 1985, 16th Edition.

4. Methods for Chemical Analysis of Water and Wastes, EPA, 600/4-79-020, and all current revisions.

7.0 FIELD PHYSICAL MEASUREMENTS

7.1 GENERAL

Field measurements of topographic features, water levels, time of travel, geophysical parameters, and physical dimensions are frequently required during comprehensive water quality, groundwater, hazardous waste, wastewater treatment system, and related field investigations conducted by the Branch. The scope of such measurements obviously depends on the purpose of the particular investigation.

All sampling locations used during Branch field investigations shall be depicted on an accurate drawing or a topographic or other standard map, or be referenced in such a manner that their location(s) are firmly established. The Region IV library has a complete collection of 7.5 minute USGS (1:24,000 scale) topographic maps and a map copier available.

Each field measurement made by Branch personnel shall be traceable to the actual person making the measurement and to the field equipment used to make that measurement. All equipment maintenance and calibration records shall be kept in log books and field records so that all such procedures are traceable. All time records shall be kept in local time using the 2400 hour format, and time shall be recorded to the nearest minute.

New Branch employees shall perform each of the physical field measurements described in this section under the supervision of a senior technical staff member at least once before being permitted to make these measurements on their own.

The specific objectives of this section are to:

- present the standard practices used by the Branch to make physical field measurements;
- list the field equipment utilized to make such measurements: and
- present specific quality control procedures to insure that such measurements are accurate.

A. SURVEYING (HORIZONTAL CONTROL)

7.2.1 General

Surveying is described as the art and science of determining the area and configuration of portions of the earth's surface, and representing them on maps. Generally, surveying can be divided into two categories or classes: horizontal control surveying and vertical control surveying. Horizontal control surveying pertains to the measurement of the relative difference in the horizontal location of two or more control points. Vertical control surveying involves the measurement of the relative difference in vertical location, or elevation, of two or more control points and is treated separately in Section 7.3. This Section discusses the standard procedures and techniques used by the Branch to survey, or locate sample points or site features horizontally. Basic surveying and field geology textbooks should be consulted for more detailed information on this topic (1, 2, 3).

7.2.2 Introduction

Several field methods may be used to horizontally locate sample points or various site features during hazardous waste site investigations and/or other site investigations that may result in enforcement actions. Traverse methods used by the Branch utilize horizontal angle or direction (azimuth/bearing) measurements and calculated horizontal distances from a starting point to a second point, and from the second to the third, and so forth to the last point. The last point in a traverse is usually a return to the starting point, thus making a closed loop. During a traverse for site control, sample points or site features may be located by employing various techniques at the traverse control points, i.e., by angle (azimuth or bearing) and distance measurements from a control point, by angular intersection from two control points, by perpendicular offset from a line between two control points, by angle from one control point and distance from another control point, etc. (1).

Regardless of the method(s) used, surveying by the Branch should be based on established control points. A network of horizontally (and vertically) located control data points has been established and is continually maintained by the National Oceanic and Atmospheric Administration (NOAA) through its National Ocean Survey (formerly U. S. Coast and Geodetic Survey). The system of horizontal control points, or Triangulation Stations, have established latitude and longitude positions and provide the basis for the coordinate grid systems used by many States (1, 2).

When measuring horizontal angles, compensation must be made for the angle between true north and magnetic north. This angle is called the magnetic declination. Branch field surveying methods must be referenced to true north. The first step in this procedure is to determine from an isogonic map, the declination for the area of work. Isogonic maps may be found in basic surveying and field geology textbooks referenced above.

Sources of existing information on triangulation stations or coordinate grid data and their exact locations may be obtained from local, state or federal departments or agencies. Typically, the engineering or public works departments of counties, cities or towns may have data on file that is near the particular site being investigated. State or federal agencies which are good sources of useful data include: (1, 2, 3)

- State highway or transportation departments
- State geodetic or land surveying offices
- State natural or water resources bureaus
- State geological surveys
- NOAA/National Ocean Survey
- United States Geological Survey
- Corps of Engineers, Department of the Army
- Soil Conservation Service
- Tennessee Valley Authority
- Bureau of Land Management

When the exact locations of sampling points or other physical features at a site are needed, Branch surveying methods must be based on existing control data. In all cases, the site property boundary survey, description, and any physical property corners or monuments must be located by a professional Registered Land Surveyor (RLS). Often times, before or when the surveyor is at a site, the registered surveyor can be requested to set control data points for Branch use. At a minimum, the registered land surveyor will be asked to establish at least two control points upon which the elevation and Universal Transverse Mercator (UTM) coordinates are set. The data on control points shall be of at least third-order accuracy. The control points will be permanent markers set at locations that are unlikely to be disturbed by future site activities.

If no existing control data exists in the site vicinity, an arbitrary point may be established at a permanent location, e.g., set a nail or spike beneath the ground or set a nail and cap in asphalt or foundation. However, the coordinates for that point (and, therefore all other points) should be determined at a later

date. As with all Branch field work, the location of all control data used and all field measurements shall be recorded in the field logbook as outlined in Section 3.5.

7.2.3 Equipment Available

The following Branch equipment is available for field use in conducting surveying in support of site investigations:

- Topcon GTS-2, total station theodolite/electronic distance meter (EDM)
- tripod(s)
- reflector prism(s)
- range pole
- steel tape
- cloth tape
- optical tape measure
- Rola tape
- compass

7.2.4 Specific Equipment Quality Control Procedures

All field surveying methods using Branch equipment shall be made only by those Branch personnel who have been trained to use them. All Branch professional staff and field technicians must be trained and checked out in surveying procedures by qualified staff before using this equipment.

Each piece of field equipment (as appropriate) shall be numbered, and a log book shall be kept containing all maintenance and calibrations made on the equipment. The following specific maintenance and calibration procedures shall be used for all surveying equipment:

7.2.4.1 Theodolite -- This equipment shall:

- be serviced and calibrated by a qualified private service shop annually or sooner if damaged or suspected to be in error;
- be checked out using procedures outlined in basic surveying textbooks and appropriate users manuals before use (1, 2, 3); and
- be cleaned and maintained using procedures outlined in basic surveying textbooks and appropriate users manuals during field use and before being returned to storage (1, 2, 3).

7.2.4.2 Steel and Cloth Measuring Tapes, and Mechanical Rola-Tape -- The following procedures shall be used for all measuring tapes:

- All measuring tapes and the mechanical Rola-tape will be calibrated annually against an Invar steel surveyors chain or the theodolite/EDM both of which are traceable to the National Bureau of Standards (NBS). Those steel tapes that are not within 0.01 foot per 100 feet or cloth tapes not within 0.02 foot per 100 feet shall be discarded. The

7.2.4.2 Steel and Cloth Measuring Tapes, and Mechanical - Rola-Tape -- The following procedures shall be used for all measuring tapes:

- All measuring tapes and the mechanical Rola-tape will be calibrated annually against an Invar steel surveyors chain or the theodolite/EDM both of which are traceable to the National Bureau of Standards (NBS). Those steel tapes that are not within 0.01 foot per 100 feet or cloth tapes not within 0.02 foot per 100 feet shall be discarded. The shorter carpenter-type steel tapes (6-12 feet) shall also check within 0.01 foot or they will be discarded.

- All tapes shall be checked to see that they are not damaged and are clean before and after use.

7.2.4.3 Optical Tape Measure -- Each Branch employee using the optical tape measure shall become proficient in its use by measuring known distances before using this equipment in the field.

7.2.4.4 Compass -- All compasses shall:

- be checked for proper movement of the compass meddle. If the compass needle movement is sluggish, the glass cover can be removed by prying a knife point under the spring washer. The copper wire on the needle is then moved until the needle lies level (3);

- be checked for proper alignment of clinometer level. The clinometer is checked by setting the clinometer to 0, and placing the compass on a surface that has been leveled exactly with either a carpenters level or a water tube level. If the horizontal level bubble on the clinometer does not rest at the center, the compass is opened as described above and the clinometer level vial is moved and rechecked as appropriate. If the level vial becomes broken, the compass must be sent to the manufacturer to be repaired (3); and

- be cleaned after use and before storage. If the compass should become wet, the compass is opened as previously described and the interior is dried using a toothpick and a piece of soft cloth or soft paper. They should not be used, exposed to or stored in strong electrical fields (3).

7.2.4.5 Range Poles and Reflector Prisms -- All of this equipment shall:

- be checked for warpage and/or damage before use by sighting through the theodolite/EDM while the poles/prisms are rotated in two planes at 90° intervals. The bullseye bubble will be reset as appropriate; and

- be cleaned daily after use and before being returned to storage.

7.2.5 Procedures for Traversing

When traverse methods are used, at least two stations or control points of known horizontal location (expressed in terms of UTM coordinates and/or the local State coordinate system) must be in the site vicinity. These control points can usually be set for the specific site by a governmental agency or registered land surveyor.

The total station theodolite, which measures horizontal angles, vertical angles, and slope distances, is set up over an existing control point. The theodolite is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads appropriately. Once the bullseye bubble is centered, the theodolite is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The instrument is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman has either a range pole equipped with a reflector prism (single or triple) or a tripod with the reflector prism. The prism is used to reflect the signal from the electronic distance meter in the total station theodolite. While located over the point(s) whose location is desired, the rodman holds the range pole vertically by means of centering the bullseye bubble, or sets up the tripod and reflector prism similarly as stated above. The instrument man sights through the telescope on the theodolite, lines up the horizontal and vertical cross-hairs on the center of the prism and records the horizontal angle (Ah), vertical angle (Av), and the slope distance (Ds) to the prism. The difference in location between the point where the theodolite is set up and the point where the prism is held is determined trigonometrically. A compass and measuring tape could also be used to reference field measurements to a map or vice versa.

The following examples depict some of the field measurements that must be considered and accounted for, the calculations that must be performed, and the conversions that must be made when the Branch uses traverse methods to horizontally locate sampling points or other site features.

EXAMPLE 1: Figure 7.2.1. Horizontal Angle (map view).

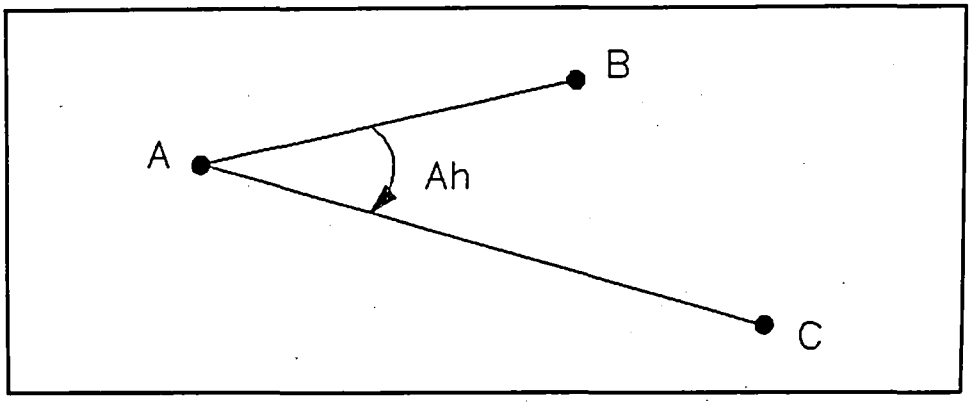
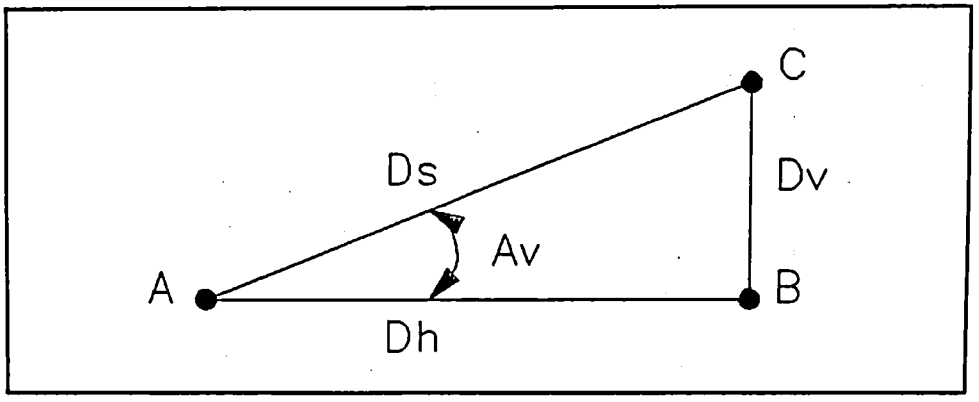


Figure 7.2.1 illustrates that while the instrument is at point A (a control point), one reads the backsight angle (azimuth or bearing) to point B, then turns and measures the foresight angle (azimuth or bearing) to point C. The difference between the two angles is the interior angle included at the intersection of line AB and line AC, or the horizontal angle (Ah).

The field notation for the measurement of the angle above would be represented as angle B-A-C. Typically, the first column to the left in the field book is labeled: (BS - ⊤ - FS) or Station and the second column is labeled Ah (see Example 5 Field Notation).

EXAMPLE 2: Figure 7.2.2. Vertical Angle (side view).



After the horizontal angle is determined, the vertical angle (Av) is measured, in Figure 7.2.2, from point C to point B to determine the angle between the line of sight AC and the horizontal line AB. The vertical angle is the included angle between a line connecting two points of different elevations and a line horizontal to the earths gravity.

To determine the height of the point C, measure the slope distance (Ds) with the electronic distance meter from A to C. Using the theodolite or transit, measure the vertical angle between line AC and AB. The height of point C would be obtained by the formula:

$$Dv = (\sin Av)\ Ds$$

The horizontal distance (Dh), which is the distance used when drawing the map, would be obtained by the formula:

$$Dh = (\cos Av)\ Ds$$

If the vertical distance to be measured was to the top of a building, tree, or other point where the measurement of the slope distance is impractical, simply measure the horizontal distance and determine the height by:

$$Dv = (\tan Av)\ Dh$$

The field notation for the third column from the left in the field book is labeled: Av and the forth column is labeled Ds/Dh (see Example 5 Field Notation).

EXAMPLE 4: Coordinates.

When the local State rectangular grid coordinate points near a particular site are obtained, Branch personnel should be able to convert rectangular coordinates to polar coordinates. This is important since through this conversion, the azimuths and distances between each point can be obtained and then used as the starting control points for the site control traverse. Simple programmable or non-programmable calculators are extremely useful in providing precise results from the field surveying measurements. The following is an example of a conversion from rectangular to polar coordinates:

The instrument is set up at TP1, and given the rectangular coordinates:

Control Point	North (y)	East (x)
TP1	7935.07	6178.78
MCT3	7851.75	6209.99

The relative change in location between the north and east coordinates (from TP1 to MCT3), respectively, are:

$$\Delta N = -83.32, \quad \Delta E = 31.21$$

The negative symbol for ΔN indicates the relative movement from TP1 to MCT3 downward (-) along the y axis. The positive symbol for ΔE indicates relative movement from TP1 to MCT3 to the right (+) along the x axis. Solving for the formula (Pythagorean theorem):

$$c^2 = a^2 + b^2$$

The resulting distance between TP1 and MCT3 is c = 88.97'.

The azimuth is obtained by first computing the inverse tangent of the change in north divided by the change in east:

$$\tan^{-1} (\Delta N \div \Delta E) = -69.4651°$$

This is the negative angle, expressed in decimal degrees, and is measured from the (x) axis into the southeast quadrant. The azimuth from TP1 to MCT3 is obtained, in this case, by changing the sign (- to +) and adding 90° and then converting to degrees, minutes, and seconds. The resulting azimuth from TP1 to MCT3 is 159°27'54".

Note: The trigonometric formula above always gives the angle measured from the (x) axis. When using this procedure, it is wise to make a sketch showing the change in direction between the points relative to north. This will aid in visually and mentally seeing which geometric quadrant that the foresight angle falls in relation to the instrument.

EXAMPLE 5: Figure 7.2.4. Traverse Field Notation.

The following is an example of the field notation for a traverse to horizontally locate sampling points. Figure 7.2.5 shows some of the physical features, sampling points, and traverse control points that should be sketched on the right hand side of the field log book. The coordinates for each point are then determined and usually entered in red ink after the traverse is finished.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Pg. 1 of 2
Landis Surveyor - ⊤
Ben Chmark - ⊥
Weather: Clear; 0-5 mph N

-Set traverse points around property to locate the 5 monitoring wells that were recently installed.

Given: TP1: N=7935.07, E=6178.78
MCT2: N=8297.79, E=6598.14
MCT3: N=7851.75, E=6209.99

TP1 to MCT3 : ΔN=-83.32 ΔE=31.21

$c^2 = a^2 + b^2$, c = 88.97'

$\tan^{-1} (\Delta N + \Delta E) = -69.4651$

∴ Azimuth TP1 to MCT3 = 159°27'54"

(BS - ⊤ - FS) Station	Ah	Av	Ds / Dh	Coordinates	Remarks/Comments
MCT3-TP1-	Set: Ah= 159°27'54"	90°45'24"	88.98' 88.97'	N=7935.07 E=6178.78	Notes: Instrument (⊤) is set up at TP1, back sight (BS) to MCT3 and set instrument to read 159°27'54".
MCT3-TP1-A	125°26'18"	89°44'06"	502.64' 502.635'	N=7643.63 E=6588.30	Set nail in ground for point A.
MCT3-TP1-MW5	124°09'12"	90°07'21"	375.58' 375.58'	N=7724.22 E=6489.59	Locate MW5.
TP1-A-	Set: Ah= 305°26'18"	--------			Instrument at A, back sight to TP1 and set the reciprocal azimuth, i.e. add 180°.
TP1-A-B	228°00'54"	90°32'54"	470.94' 470.94'	N=7328.60 E=6238.24	Set nail for point B.
A-B-	Set: Ah= 48°00'54"	--------			Reciprocal azimuth as above.
A-B-MW2	343°55'21"	90°21'54"	113.68' 113.68'	N=7437.83 E=6206.76	Locate MW2.
A-B-C	300°46'27"	89°59'54"	762.46' 762.46'	N=7718.72 E=5583.14	Set point C.

EXAMPLE 5: Figure 7.2.4. Traverse Field Notation (continued).

[}~«ò<"^\[~·-´"£¡¯B}~«ò<"^\[~·-´"£¡¯B}~«ò<"^\[~·-´"£¡¯B}~«ò<"^\[~·-´"£¡¯B}~«ò<"^\[~·-´"£¡¯B}~«ò<"^\[~·-´"£¡¯B}~«ò<"^\[~·

EXAMPLE 5: Figure 7.2.4. Traverse Field Notation (continued).

01/23/90 Project 90E-000
Region IV Site Name
City, State

Pg. 2 of 2
Landis Surveyor - ∓
Ben Chmark - ∤
Weather: Clear; 0-5 mph N

Station	Ah	Av	Ds / Dh	Coordinates	Remarks/Comments
B-C-	Set: Ah= 120°46'27"	--------			Reciprocal azimuth.
B-C-D	14°40'24"	89°49'39"	698.34' 698.34'	N=8394.28 E=5760.03	Set point D.
B-C-MW1	24°11'21"	90°21'12"	132.96' 132.96'	N=7840.01 E=5637.62	Locate MW1.
B-C-MW3	26°50'36"	89°44'45"	612.76' 612.754'	N=8265.45 E=5859.83	Locate MW3.
C-D-	Set: Ah= 194°40'24"	--------			Reciprocal azimuth.
C-D-E	67°36'15"	90°03'48"	715.66' 715.66'	N=8666.95 E=6421.71	Set point E.
C-D-MW3	142°17'51"	89°45'03"	163.14' 163.14'	N=8265.20 E=5859.80	Locate MW3 (again, just in case).
D-E-	Set: Ah= 247°36'15"	--------			Reciprocal azimuth.
D-E-MCT2	154°27'09"	90°04'33"	409.08' 409.08'	N=8297.87 E=6598.13	Actual: N=(8297.79), E=(6598.14).
E-MCT2	Set: Ah= 334°27'09"	--------			Reciprocal azimuth.
E-MCT2-A	180°51'42"	89°36'24"	654.28' 654.265'	N=7643.68 E=6588.30	Coordinates first computed to be: N=(7643.63), E=(6588.30).
E-MCT2-MW4	249°56'39"	88°32'48"	85.66' 85.63'	N=8268.50 E=6517.69	Locate MW4.
MCT2-A-	Set: Ah= 360°51'42"	--------			Reciprocal azimuth.
MCT2-A-TP1	305°26'18"	--------	------ (502.635')	N=7935.12 E=6178.78	Should have ended at: N=(7935.07), E=(6178.78).
MCT2-A-MW5	309°13'33"	91°10'36"	127.50' 127.47'	N=7724.29 E=6489.55	Locate MW5 (again, just in case).
					Closure: Σ Dh=4,716.015 N Dh=0.0466', E Dh=0.00'

Figure 7.2.3 - EXAMPLE OF SITE MAP SHOWING TRAVERSE POINTS USED TO LOCATE MONITORING WELLS

Figure available upon request.

7.3 ELEVATION SURVEYS (VERTICAL CONTROL)

7.3.1 Introduction

The field of surveying that pertains to measuring the relative differences in elevation of two or more points is called "running levels" or "Leveling". The two most commonly used methods are Differential Leveling and Trigonometric Leveling. Differential leveling is the most precise and easiest method because it utilizes "level" measurements with simple addition and subtraction. Trigonometric leveling is slightly less precise and more difficult as it uses vertical angle and distance measurements combined with the principles of trigonometry. Differences in elevation can also be determined from controlled altimeter measurements by the method called Barometric Leveling. However, the altitude (elevation) readings are not as precise as elevation measurements obtained from differential or trigonometric leveling since most altimeters permit readings to within about 5 feet of the actual elevation. This subsection discusses the standard procedures and techniques used by the Branch to obtain differences in elevation and are described in more detail in basic surveying and field geology textbooks (1, 2, 3).

Regardless of the method(s) used, elevation surveys by the Branch should be based on established control points. A network of vertically located control data points has been established and is continually maintained by the National Oceanic and Atmospheric Administration (NOAA) through its National Ocean Survey (formerly U. S. Coast and Geodetic Survey). The system of vertical control points, or Benchmarks (B.Ms.), are referenced to a surface of fixed and precisely known elevation above mean sea level and is referred to as the datum or datum plane. The datum for vertical control (elevation) is called the National Geodetic Vertical Datum (NGVD), formerly known as the 1929 sea level datum, established by the U. S. Coast and Geodetic Survey (1).

Sources of existing information on benchmark data and their locations may be obtained from local, state or federal departments or agencies. Typically, the engineering or public works departments of counties, cities or towns may have data on file that is near the particular site being investigated. State or federal agencies that are good sources of useful data include: (1, 2, 3)

- State highway or transportation departments
- State geodetic or land surveying offices
- State natural or water resources bureaus
- State geological surveys
- NOAA/National Ocean Survey
- United States Geological Survey
- Corps of Engineers, Department of the Army
- Soil Conservation Service
- Tennessee Valley Authority
- Bureau of Land Management

When the exact elevations of sampling locations or other physical features are needed, benchmarks of precisely known elevation should be used when leveling. At a minimum, during the course of a site investigation, a registered land surveyor will be asked to set at least two third-order accuracy vertical control points or benchmarks. The vertical control points shall have established Universal Transverse Mercator (UTM) coordinates (see section 7.2.2) and the elevations shall be referenced to NGVD.

If no benchmark is located in the site vicinity, an arbitrary temporary benchmark should be established on a permanent location, e.g., bridge wingwall, foundation, corner post, or a nail or spike in a tree or telephone pole. However, the elevation of the temporary benchmark (and, therefore all other points) should be determined at a later date. As with all Branch field work, the location of all benchmarks used shall be shown on the site sketch map and all field measurements shall be recorded in the field logbook as outlined in Section 3.5.

7.3.2 Equipment Available

The following Branch equipment is available for field use in conducting elevation surveys in support of site investigations:

Differential Leveling

- Lietz B2C, precision automatic level
- tripod
- telescoping level rod

Trigonometric Leveling

- Topcon GTS-2, total station theodolite/electronic distance meter (EDM)
- tripod(s)
- reflector prism(s)
- range pole
- steel tape
- compass

Barometric Leveling

- Micro M-1, American Pauli System altimeter

7.3.3 Specific Equipment Quality Control Procedures

All field surveying methods using Branch equipment shall be made only by those Branch personnel who have been trained to use them. All Branch professional staff and field technicians must be trained and checked out in surveying procedures by qualified staff before using this equipment.

Each piece of field equipment (as appropriate) shall be numbered, and a log book shall be kept containing all maintenance and calibrations made on the equipment. The following specific maintenance and calibration procedures shall be used for all surveying equipment:

7.3.3.1 Theodolite/EDM, Level and Altimeter -- This equipment shall:

- be serviced and calibrated by a qualified private service shop annually or sooner if damaged or suspected to be in error.
- be checked out using procedures outlined in basic surveying textbooks and appropriate users manuals before use (1, 2, 3).
- be cleaned and maintained using procedures outlined in basic surveying textbooks and appropriate users manuals during field use and before being returned to storage (1, 2, 3).

7.3.3.2 Level Rods, Range Poles, Reflector Prisms -- All of this equipment shall:

- be checked for warpage and/or damage before use by sighting through the theodolite/EDM and lining up the two vertical cross hairs on the rod(s). The poles/prisms are rotated at 90° intervals and the bullseye bubble is reset as appropriate.
- be checked for proper alignment of the reflector prism by comparing the measurement obtained with the EDM to the measurement obtained with an Invar steel surveyors chain (see Section 7.2.4.2).
- be cleaned daily after use and before being returned to storage. Level rods should be stored in carrying tubes or a cloth slip cover to protect markings.

7.3.3.3 Steel Tape -- The procedures found in Section 7.2.4.2 shall apply.

7.3.3.4 Compass -- All compasses shall:

- be checked for proper movement of the compass needle. If the compass needle movement is sluggish, the glass cover can be removed by prying a knife point under the spring washer. The copper wire on the needle is then moved until the needle lies level (3).
- be checked for proper alignment of the clinometer level. The clinometer is checked by setting the clinometer to 0, and placing the compass on a surface that has been leveled exactly with either a carpenters level or a water tube level. If the horizontal level bubble on the clinometer does not rest at the center, the compass is opened as described above and the clinometer level vial is moved and rechecked as appropriate. If the level vial becomes broken, the compass must be sent to the manufacturer to be repaired (3).
- be cleaned after use and before storage. If the compass should become wet, the compass is opened as described above and the interior is dried using a toothpick and a piece of soft cloth or soft paper. They should not be used, exposed to or stored in strong electrical fields (3).

7.3.4 Procedures for Differential Leveling

The level, or instrument, is set up by the instrument man at a location not more than 250 feet from the benchmark and at a height above the benchmark and the next point(s). The level is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads accordingly. Once the bullseye bubble is centered, the level is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The level is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman then holds the rod as plumb (vertical) as possible on the benchmark so the instrument man can read where the horizontal cross-hair in the telescope of the level intersects the graduations on the rod. The rodman "rocks" the rod in two planes, when instructed by the instrument man, to obtain a level reading. The rod is white with large red numbers which indicate the foot-marks and smaller black numbers which indicate the tenths of feet and has black graduations the entire length which indicate hundredths of feet. The instrument man sights through the telescope and takes the first rod reading which is called a backsight (denoted BS or + in the field log book). The backsight (+) reading added to the elevation of the benchmark gives the height of the level, or instrument, (denoted H.I. in the field log book). Next the rodman holds the rod on a point (called a turning point and denoted TP) of fixed but unknown elevation such as a nail in the ground, spike in a tree or telephone pole, or the top of a fire hydrant. The instrument man then takes his second rod reading which is called a foresight (denoted FS or - in the field log book). If the foresight (-) reading is subtracted from the H.I. the result is the elevation of the point. That is, the difference between the first reading obtained from the benchmark and the second reading obtained from the point is the difference in elevation between the point and the benchmark. Note that the distance between each sighted reading shall not ordinarily exceed 250 feet with turning point backsight and foresight distances deviating no more than 50 feet from one another.

The instrument man then goes ahead of the rodman, sets the level up as stated before and takes a rod reading (backsight) from the previous turning point. The rodman then moves ahead of the instrument man for a new turning point rod reading (foresight) and so forth until the desired final point is located vertically. Once the final point is located, the instrument man breaks the set up of the level (i.e., changes the H.I.) and relevels the level. The instrument man and rodman then run levels from the last or final point to the first point or benchmark. This is called making a closed circuit or closed level loop.

When practical, leveling should be conducted to form a closed circuit. That is, the level circuit or loop should close back in close agreement to a benchmark by within 0.02 foot of the original reading or third order accuracy whichever is greater. If the level circuit does not close within these limits of accuracy, then the level circuit must be repeated until this accuracy is attained. Third order accuracy is defined by the formula: 0.05 foot × (√number of miles run), which means for a one-mile level circuit, the closure should be within five hundredths of a foot. The following is an example of field notation for differential leveling:

EXAMPLE 1: Figure 7.3.1. Field notation for differential leveling.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Landis Surveyor - ∓
Ben Chmark - ∓
Weather:60's overcast; 5-10mph NW

Station/ Point	+ or BS	H.I.	- or FS	ELEV.	Remarks
B.M. 523	6.13	25.69		19.560	Top of brass cap in concrete mon. marked B.M. 523 El.=19.560'
TP01	2.10	19.58	8.21	17.48	Set nail in ground
TP02			8.39	11.19	RR spike in tele. pole NW corn. Athens St. and Georgia Ave.
MW01			6.17	13.41	Top of casing for MW01
GS01			8.88	10.70	Ground shot at MW01
WSCS			12.13	7.45	Water surface of cyprus swamp
Weir 01			10.30	9.28	Invert of weir 01 south of plant
					(Break set up to run levels back)
TP02	7.89	19.08		11.19	RR spike in tele. pole NW corner Athens St. and Georgia Ave.
T.B.M.01	6.26	20.78	4.56	14.52	Set nail in 24" Oak for temporary bench mark 01
B.M. 523			1.23	19.55	Checked to BM 523 (Off -0.01')

7.3.5 Procedures for Trigonometric Leveling

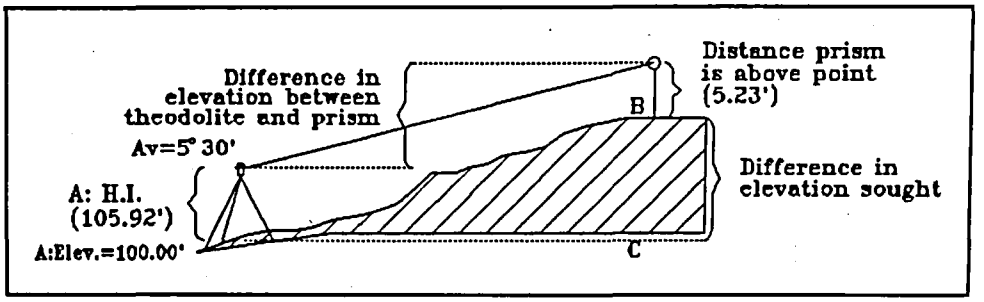
The total station theodolite, or instrument, is usually set up above a benchmark and the elevation of the instrument (H.I.) must be obtained. The theodolite is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads accordingly. Once the bullseye bubble is centered, the theodolite is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The instrument is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman has either a range pole equipped with a reflector prism (single or triple) or a tripod with the reflector prism. The prism is used to reflect the signal from the electronic distance meter in the total station theodolite. While located over the point(s) whose elevation is desired, the rodman holds the range pole level by means of centering the bullseye bubble, or sets up the tripod by means of centering the bullseye bubble with the three-screw leveling heads. The instrument man sights through the telescope on the theodolite, lines up the horizontal and vertical cross-hairs on the center of the prism and takes a reading of both the vertical angle (Av) and the distance to the prism. The difference in elevation between the theodolite and the prism is determined trigonometrically. A compass with a clinometer and a measuring tape could also be used for field measurements or as a map reference.

The following three examples graphically depict the distances that must be considered and accounted for when using the trigonometric leveling method to compute the vertical changes in elevation. The field notation for trigonometric leveling follows.

EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.

EXAMPLE 2: Figure 7.3.2. Elevation of point desired is above the instrument.



The elevation at point A in Figure 7.3.2 is 100.00 ft. The instrument is set up 5.92 ft. above point A which makes the height of the instrument (H.I.) 105.92 ft. Given a slope distance (Ds) shot to the prism (distance AB) of 323.88 ft. and a vertical angle (Av) of 5°30', the difference in elevation at point B is computed using the trigonometric formula:

elevation difference = distance AB × sin(Av)

The method described above only accounts for the relative difference in elevation between the theodolite (H.I.) and the center of the prism. The distance that the prism is held above the point in question must be subtracted from the resulting elevation of the prism to obtain the elevation of the point. Substituting in the trigonometric formula:

elevation difference = 323.88 ft. × sin(5°30') = 31.04 ft.

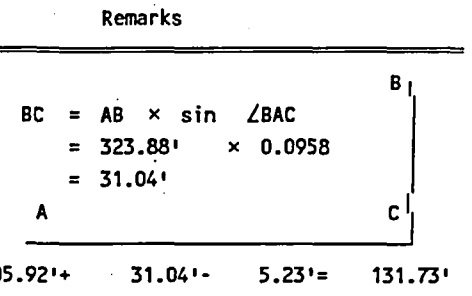
The elevation of point B is: 105.92 ft. + 31.04 ft. - 5.23 ft. = 131.73 ft.

Figure 7.3.3 Field notation for Example 2.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Landis Surveyor - ⊤
Ben Chmark - ⊥
Weather:60's overcast; 5-10mph NW

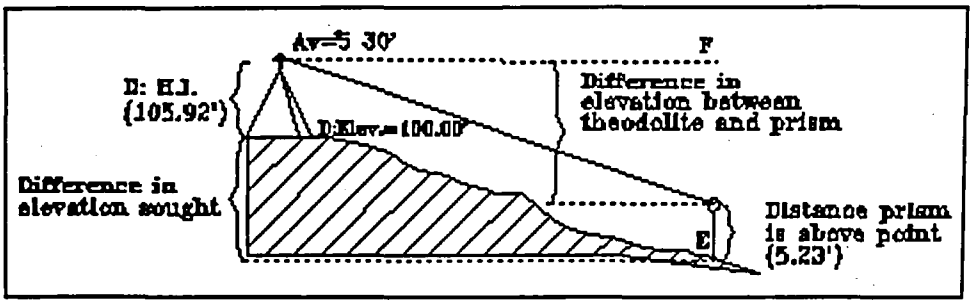
Station/ Point	+/Ds	H.I.	-/Av	ELEV.	Remarks
@ A	5.92	105.92		100.00	
Dist.A-B	323.88				
V. ∠BAC			5°30'		
@ B			5.23	131.73	B=105.92'+ 31.04'- 5.23'= 131.73'



BC = AB × sin ∠BAC
= 323.88' × 0.0958
= 31.04'

EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.

EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.



The elevation at point D in Figure 7.3.4 is 100.00 ft. The instrument is set up 5.92 ft. above point D which makes the height of the instrument (H.I.) 105.92 ft. Given a slope distance (Ds) shot to the prism (distance DE) of 323.88 ft. and a vertical angle (Av) of 5°30', the difference in elevation at point E is computed by substituting in the trigonometric formula:

elevation difference = 323.88 ft. × sin(5°30') = 31.04 ft.

The distance that the prism is held above the point in question must be subtracted from the resulting elevation of the prism to obtain the elevation of the point.

The elevation of point E is: 105.92 ft. - 31.04 ft. - 5.23 ft. = 69.65 ft.

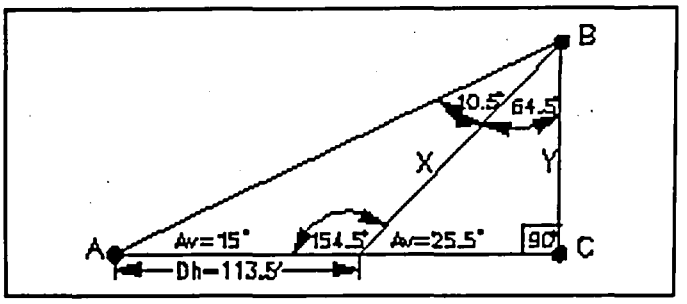
Figure 7.3.5. Field notation for Example 3.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Landis Surveyor - ⊤
Ben Chmark - ⊥
Weather:60's overcast; 5-10mph NW

Station/ Point	+/Ds	H.I.	-/Av	ELEV.	Remarks
@ D	5.92	105.92		100.00	D F
Dist.D-E	323.88				EF = DE × sin ∠EDF
V. ∠EDF			5°30'		= 323.88' × 0.0958 = 31.04' E
@ E			5.23	69.65	E=105.92'- 31.04'- 5.23'= 69.65'

EXAMPLE 4: Figure 7.3.6. Spot elevation differences using the law of sines.



When the measurement of the slope distance is not possible, differences in elevation can be determined using the law of sines from trigonometry:

$$\frac{\sin \alpha}{a} = \frac{\sin \beta}{b} = \frac{\sin \gamma}{c} \quad \text{or} \quad \frac{a}{\sin \alpha} = \frac{b}{\sin \beta} = \frac{c}{\sin \gamma}$$

Simple spot elevation differences can be determined by taking only a few measurements. The measurements can be obtained with the total station theodolite or by using a compass (equipped with a clinometer) and a measuring tape. In the above example (Figure 7.3.6), the vertical angle (Av) is measured at two locations and the horizontal distance (Dh) between those two measurements is also measured. Since the sum of the interior angles of each triangle should equal 180°, all the other interior angles are calculated. Substituting the measurements into the law of sines and solving for x and y shown in Figure

7.3.5.5:

$$\frac{x}{\sin 15^\circ} = \frac{113.5'}{\sin 10.5^\circ} \qquad \frac{y}{\sin 25.5^\circ} = \frac{161.36'}{\sin 90^\circ}$$

$$x = \frac{(\sin 15^\circ)\ 113.5'}{\sin 10.5^\circ} \qquad y = \frac{(\sin 25.5^\circ)\ 161.36'}{1}$$

$$x = 161.36' \qquad y = 69.4'$$

Note that the method described above only accounts for the relative difference in elevation between point A and the point in question, point B. If an instrument, such as a compass or theodolite, is used at point A, the <u>H.I.</u> at point A <u>must be added</u> to the resulting elevation of the point in question. The field notation would include the figure drawing, all field measurements, and all of the calculations.

7.3.6 Procedures for Barometric Leveling

An "aneroid barometer" or altimeter is an instrument that measures variations in atmospheric pressure. Because the pressure of the earth's atmosphere varies with height above sea level, a barometer could be used to measure the approximate differences in altitude or elevation. However, atmospheric pressure also varies with changes in temperature, humidity and regional or local pressure changes caused by weather conditions. The appropriate corrections for these changes in air column temperature, humidity, and barometric pressure must be applied where maximum accuracy is desired. Humidity corrections are normally negligible, and the additional readings to compensate for humidity are of questionable value. However, temperature and barometric corrections to the altimeter readings are necessary to obtain favorable results. A complete discussion of the altimeter observation corrections as well as the theory and general procedures used in reading the American Paulin System altimeter may be found in Precision Altimeter Survey Procedures - A Comprehensive and Authoritative Treatise on Modern Altimeter Surveys, by Dr. Robert A. Hodgson. The procedures contained herein have been paraphrased from this manual with permission from the American Paulin System.

There are two types of altimeters in common use for determining differences in elevation. They are the American Paulin System altimeter and the Wallace and Tiernan altimeter. The American Paulin System surveying altimeter, used by Branch personnel, offers excellent results when third order accuracy is not of prime importance. The Branch altimeter is graduated in one-foot increments and has an operating range of -1,000 feet to +5,000 feet of altitude. The altimeter is useful when it is desirable to measure differences in elevation on mountainous or wooded terrain; where the use of cumbersome surveying equipment is prohibitive; or, as a supplemental tool used in conjunction with other surveying equipment. The altimeter could also be useful when site specific geologic mapping is necessary. A compass could be used as a field measurement to map reference.

Although the altimeter is specially constructed for rugged field use, as with all sensitive Branch equipment, reasonable care should be exercised to prevent damage to the internal parts of the instrument. The following general procedures for the "single altimeter method with temperature and barometric corrections" should be followed when reading the altimeter and when recording and computing traverse data:

7.3.6.1 Reading the Altimeter

Procedure at the Base Station (See Figure 7.3.7.)

(1) Allow approximately 10 minutes for the altimeter to adjust to the ambient temperature. (Do not place altimeter in direct sunlight at any time. Use shading when possible.)

(2) Place altimeter on the base station (typically a benchmark or other point where the elevation has been previously determined).

(3) Level the altimeter by means of the bullseye bubble on the plastic window.

(4) Balance the altimeter by turning the large pointer knob at the center of the face of the altimeter. By using the reflecting mirror and reading directly above the Balance Indicator needle, the parallax in reading can be avoided.

Note: Always balance the instrument from the positive (+) side of the window. Make sure that the Balance Indicator needle covers its own image in the mirror.

(5) After the altimeter is balanced, the pointer may be set to the desired elevation (elevation of the base station benchmark) by raising and turning the Reset Control knob. While doing this, view the Pointer from directly above (a magnifying glass is provided) so that the sides of the knife edge are not visible when the pointer is directly above the engraved elevation mark.

(6) Record the elevation of the base station, temperature (to the nearest degree), and the time of the reading.

Procedure at Subsequent Stations

(1) Place altimeter at the next station point.

(2) Level the instrument (bullseye bubble).

(3) Balance the instrument using the large pointer knob. (Do not reset small knob).

(5) Record elevation, time, and temperature.

Note: (This procedure is continued at each station. The traverse is considered to be complete by returning to the base station or other benchmark).

7.3.6.2 Recording and Computing Altimeter Data

The American Paulin System altimeter is calibrated to measure true differences in altitude when used at a temperature of 50°F (assuming no change in barometric pressure). When the average temperature of two successive temperature readings fall above or below 50°F, it is necessary to apply a temperature correction to adjust the recorded differences in elevation that are a result of temperature change. The difference in altitude between two successive stations is recorded in the field book as positive when moving from a lower to a higher station (altitude) and negative when moving from a higher to a lower station (altitude). The temperature correction takes the same sign as the difference in altitude when the average temperature is above 50°F and will take the sign opposite the sign of the difference in altitude when the average temperature falls below 50°F.

Temperature corrections can be determined by referencing the tables or graph found in Dr. Hodgson's manual. The following formula may also be used to compute the percent adjustment due to temperature change:

$$\% = (T_1 + T_2 - 100) \times 0.102$$

Example: The temperatures recorded at two successive stations are 40°F and 41°F, respectively. The uncorrected difference in altitude between the two stations is 31 feet. Substituting in the percentage adjustment formula we get:

$$\% = (40 + 41 - 100) \times 0.102 = -1.938\%$$

By multiplying the uncorrected difference in altitude by the percentage factor, we get the temperature correction given in feet:

$$-0.0194 \times 31 \text{ ft.} = -0.6 \text{ ft. (temperature correction)}$$

After the altimeter readings are corrected for temperature, the change in barometric pressure that occurred during the time of the traverse must be applied. For Branch purposes, it will be assumed, that the rate of change of barometric pressure is constant. The change in barometric pressure that occurs

during the time of the traverse is taken to be the difference between the temperature corrected reading of the last station (benchmark or other point of known elevation) and the actual elevation of that last station or benchmark. To obtain the barometric correction (C_B) for each reading, the change in barometric pressure is divided by the number of minutes in the traverse. The barometric change per minute is obtained. By multiplying this factor by the number of minutes between each station, the amount of barometric change for each station is obtained.

Certain considerations should be taken into account when using the altimeter. A sudden change in weather conditions during the time of the traverse may affect the rate of change in the local barometric pressure which could lead to incorrect barometric corrections. A change in wind velocity and turbulence could also adversely affect the recording and, therefore, the barometric correction. Generally, good altimeter traverse results can be obtained during the early morning or late afternoon. Before starting the altimeter traverse, it is a good practice to check the altimeter at two or more base stations or bench marks. This is done to insure that the altimeter is in good working order, to be certain the proper procedures are being used, and to provide a background check on the local barometric conditions. The following is an example of field notation for the above described single altimeter method traverse:

EXAMPLE 5: Figure 7.3.8. Field notation for the single altimeter method.

01/22/90 Project 90E-000 | Landis Surveyor - ⊤
Region IV Site Name | Ben Chmark - ⊥
City, State | Weather: Clear; 0-5 mph NW

No.	Remarks	Time	Reading	T (°F)	▲ in Reading	Av. Σ of Temp.	Temp. %	Cor. Total	Adj. Reading	C_B	Elevation Comp.	Elevation Actual
▲-1	BM-ESD-IV Athens	07:30	747	40°								747
					+31	40.5°	-0.6					
◆-2	Top of waterfall	07:37	778	41°				-0.6	777.4	+2.9	780	
					+20	41.0°	-0.4					
◆-3	Invert culvert 4	07:45	798	41°				-1.0	797.0	+6.3	803	
					-93	41.5°	+1.6					
◆-4	Base of falls	07:55	705	42°				+0.6	705.6	+10.6	716	
					+27	42.5°	-0.4					
▲-1	BM-ESD-IV	08:05	732	43°				+0.2	732.2	+14.8		747
▲-1	BM-ESD-IV	08:15	747	45°								747
					-22	46°	+0.2					
◆-5	Epps Bridge	08:24	725	47°				+0.2	725.2	+2.2	727	
					-5	48°	+0.02					
◆-6	Weir W-2 invert	08:30	720	49°				+0.22	720.2	+3.6	724	
					+45	50°	0					
▲-4	BM-UGA-IV	08:37	765	51°				+0.22	765.2	+5.3	770	768
					+21	52°	+0.09					
◆-7	Athens airport 1	08:45	786	53°				+0.31	786.3	+7.2	793	
					-75	54°	-0.6					
◆-8	Oconee R. @ 441	08:56	711	55°				-0.29	710.7	+9.8	721	
					+24	55.5°	+0.3					
▲-9	BM-ESD-IV	09:05	735	56°				+0.01	735.0	+12.0		747

7.4 AERIAL IMAGERY

7.4.1 General

Aerial imagery is unique and distinct from the other field measurement tools and procedures discussed in this manual. However, it is frequently an invaluable supplement to field studies. It records a great deal of detail that can provide a guide for other field measurements as well as historical documentation of conditions at the time of acquisition.

Aerial imagery is obtained and interpreted using state-of-the-art techniques to the extent justifiable for the intended use. Photographic interpretation is by its nature, very subjective at times. When an interpretation is questionable, the opinions of several photographic analysts will be solicited. Environmental interpretation, where natural features have been slightly modified by man, is much more subjective than military interpretation, where definite, man-made features are sought out. Therefore, where environmental interpretations are not clear-cut, they should be used only as tentative findings to be further verified or modified by subsequent field investigations.

7.4.2 Litigation

Several limitations apply to photographic missions for the specific purpose of collecting evidence to be used in litigation.

- The military services cannot be used for such purposes (4).
- If a court injunction prohibiting trespassing is in effect against EPA, a search warrant must be obtained for the overflight.
- Even in the absence of a court injunction, if the case is in litigation or in the preparation for likely litigation, the Regional Counsel must be consulted for his/her recommendation on the need for a search warrant.

The following, more general-purpose imagery, can also be used in litigation, subject to the guidance of the Office of the Regional Counsel:

- Imagery or overlays prepared from imagery acquired by the military, or anyone else, for other purposes: i.e., for broad-area mapping or inventorying, routine missions clearly not connected with the litigation, etc.;
- Archival imagery antedating the litigation in question; and
- "Targets of opportunity," such as a stack putting up dense smoke, an unusual discharge from an outfall, etc., which are photographed while on a mission for another purpose or for general surveillance. (This is equivalent to stopping at the side of a road to photograph a suspected violation of any law.)

7.4.3 Access

All requests for aerial imagery and other remote sensing services shall be coordinated through the Regional Remote Sensing Coordinator as specified in the April 2, 1980, memorandum on this subject by the Deputy Regional Administrator (5). The coordinator shall make appropriate contacts with the Remote Sensing Branch, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada (EMSL-LV), with the Environmental Photographic Interpretation Center (EPIC) in Warrenton, Virginia, or with others as necessary; and the coordinator will arrange for direct follow-up contacts between the requestor and the group to provide the service if desired. All Enviropod activities will be under the administrative direction of the Regional Remote Sensing Coordinator. However, to the extent practical, efforts will be made to involve the user of the imagery in the missions for acquiring it.

Interpretation of photographs and other imagery within the Branch will be the responsibility of each individual program, although some limited assistance may be available from the Remote Sensing Coordinator. Requests for this service from groups outside the Region should be initiated as specified above.

7.4.4 Funding

In general, each program requesting remote sensing services will have to pay, from either national or regional funds, for necessary flight time, film and processing costs, and interpretation and preparation expenses. Costs can often be minimized by the Remote Sensing Coordinator by combining missions, locating archival imagery, and by using limited ORD support funds when available. The Remote Sensing Coordinator will arrange for cost estimates as needed.

7.4.5 Enviropod Procedures

The Enviropod will be installed and operated by personnel familiar with the detailed instructions prepared following the Enviropod Installation and Operations Course at EPIC (6). Mission planning will be done using appropriate nomograms supplied by EPIC or with the HP-97 Enviropod Program (7). All flight lines shall be logged on a data sheet. After exposure, film and log sheets should be promptly shipped to EPIC at Vint Hill Farms in Warrenton, VA, for processing.

7.4.6 Specific Quality Control Procedures for Aerial Imagery

All film is processed using the manufacturer's recommendations for temperature, time, and density of solutions. At the end of each Enviropod mission, approximately eight or ten frames will be exposed for trial development for EPIC to determine whether adjustments must be made in processing rates or temperatures to obtain a clear image. These will be noted on the log sheet with notes on lighting and weather conditions. Enviropod personnel at EPIC will be contacted before each mission (or monthly, whichever is less frequent) to determine current experience and recommend f-stop settings for various cloud covers and atmospheric conditions.

7.5 BATHYMETRY

7.5.1 Procedures

Recording fathometers are used to provide bathymetric traces of water depths. Because water depths are time dependent (especially in tidal areas), the date and time of all traces should be noted. Operation manuals provide operation and calibration procedures to be followed. In particular, tide and draft adjustments provide datum calibration in regard to the respective tidal amplitude and sensor probe depth. During the initial setup of each survey, the fathometer calibration should be checked against a field measurement of water depth made using a graduated sounding line. All traces should be noted with transect description, chart speed, direction of travel, and pertinent reference points and then indexed to a site map. When working in tidal areas, a water stage recorder (see Section 7.6) should be positioned to provide a histogram of water levels to correlate with the bathymetric trace.

7.5.2 Equipment Available

The following Branch equipment is available for bathymetric surveys:

- recording fathometers;
- water level recorder and/or referenced gaging station(s); and
- calibrated sounding line(s).

7.5.3 Specific Equipment Quality Control Procedures

All equipment used for bathymetric studies shall be numbered and a record shall be kept of all maintenance and calibration procedures. The following procedures shall be used to maintain and calibrate bathymetric measurement equipment.

7.5.3.1 Recording Fathometers -- These fathometers shall:

- Be calibrated and maintained according to the manufacturer's instructions before use. The chart speed should be checked against a reliable time source before the instrument is sent to the field;
- Be checked in the field against a field measurement of water depth utilizing a calibrated sounding line; and
- Be cleaned daily after use and prior to being stored.

7.5.3.2 Sounding Lines -- All sounding lines will be calibrated against a steel surveyors tape and shall be accurate ± 3 percent.

7.6 SURFACE WATER STAGE/TAPE DOWNS

7.6.1 Procedures

Water level recorders provide a time series record of water levels. Where possible, these instruments should be referenced to National Geodetic Vertical Datum (NGVD). All water level tracings should be noted with beginning and ending date and time, site location, stage scale, and time scale and initialed by the servicing Branch personnel. Standard USGS staff gages should be employed at each water level recorder site to provide a reference and check on the recorder trace. Water stage should be recorded to the nearest 0.01 foot where possible.

Tape downs provide instantaneous water stage as referenced to a known elevation. An engineering tape is fashioned with a plumb bob to measure from a bridge deck or other reference point to the water surface. The plumb bob provides weight for the tape as well as providing a discernible contact with the water surface. All measurements should be to the nearest 0.05 foot accompanied by a date, time, and station location. The exact reference or point from which a tape down is measured shall be permanently marked on the reference (wing wall or bridge rail by etching a reference with a chisel, etc.) and a complete description of the reference shall be made in the field records.

Both of these procedures (water stage and tape downs) are predicated upon accurate references to established measuring points. As mentioned above, the NGVD is an established datum that provides correlation of water surface recordings to engineering structures (bridge, wing walls, sea wall caps, clarifier cat walks, etc.). When recording water level dynamics in relation to a particular flow device, the datum is established in relation to the flow device reference point. Rectangular and V-notch weirs, for instance, are proportional to the water level referenced to the weir crest or, in the case of partially filled pipes, the flow rate is proportional to the depth of flow. Therefore, when employing a water level recorder or tape down on primary flow devices the reference or datum is the weir crest or in the case of pipes, the invert (see Section 5, Flow Measurement).

7.6.2 Equipment Available

The following Branch equipment is available for surface water stage/tape down measurements:

- Model F Stevens Stage Recorder(s);
- Model A-71 Stevens Stage Recorder(s);
- Model 1152 SSM ENDECO Stage Recorder(s);
- ISCO Flow Meter(s) and Recorder(s);
- USGS Staff Gage(s); and
- Weighted steel measuring tapes.

7.6.3 Specific Equipment Quality Control Procedures

A log book will be kept of all equipment used for making water stage/ tape down measurements. The following maintenance and calibration procedures shall be used and recorded in the log book for all equipment using for water stage and tape down measurements.

7.6.3.1 Stevens Model A-71 and Model F Stage Recorders -- These stage recorders shall:

- Be maintained according to the manufacturer's instructions. Once yearly, each unit shall be operated, and the time scale shall be adjusted to read within two percent of full scale. Once yearly, the recorders shall be bench checked by moving the recording mechanism vertically. The units must be accurate and record to within 0.01 foot of the Invar steel surveyor's chain.

- Be checked in the field by comparison with a staff gage. During field measurements, the vertical accuracy shall check within 0.05 foot, and

- Be cleaned and maintained before storage.

7.6.3.2 <u>ENDECO Model 1152 SSM Stage Recorder(s)</u> -- This instrument has no moving parts and uses solid state memory. In addition to water level data, the instrument also measures and stores conductivity and temperature data. The stage recorder shall:

- Be maintained according to manufacturer's instructions and checked in the field by comparison with a staff gage. The vertical accuracy shall check within 0.05 foot.

- Be within $\pm$ 0.55 m^2/cm and $\pm$ 0.2°C of prepared conductivity standards and an NBS thermometer, respectively.

- Be cleaned and maintained before storage.

7.6.3.3 <u>ISCO 1870, 2870 Flow Meter and Recorder(s)</u> -- See specific quality control procedures for this equipment in Section 5, Flow Measurement.

7.6.3.4 <u>USGS Staff Gage(s)</u> -- USGS staff gages shall:

- Be checked on receipt from the vendor. Any staff gage not accurate to within 0.01 foot when compared with the Invar steel surveyor's chain shall be discarded. Gages will be appropriately marked upon calibration.

- Be checked for damage, warpage, legibility, etc., before use. Any damaged or illegible staff gages shall be discarded.

- Be cleaned after use before being stored.

7.6.3.5 <u>Weighted Steel Measuring Tapes</u> -- Weighted steel measuring tapes shall:

- Be calibrated against the Invar steel surveyor's chain. The calibration shall be within 0.01 foot per 10 feet of length.

- Be checked for damage before use; damaged tapes shall be recalibrated or discarded.

- Be cleaned after use before being stored.

7.7 GROUND WATER LEVEL MEASUREMENT

7.7.1 General

The measurement of ground water level in wells is frequently conducted in conjunction with ground water sampling. Data from such measurements are needed to determine the "free" water surface and can be used to establish ground water flow direction and gradients. Specific techniques used by Branch personnel are presented in Appendix E.

Total well depth measurements, along with ground water level measurements, are necessary to determine the volume of water in a well casing prior to purging the well during ground water sampling.

All ground water level measurements, as well as total depth measurements, shall be made in reference to an established reference point on the well casing. This reference point shall be documented in field records. To be useful for establishing ground water gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. An arbitrary datum common to all wells in a group may be used for an isolated group of wells, if necessary.

7.7.2 Specific Ground Water Level Measuring Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods (8). Method accuracies are noted below for each of the specific methods described.

7.7.2.1 Popper or Bell Sounder -- A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight barely strikes the water. Measurements shall be recorded to the nearest 0.1 foot.

7.7.2.2 Weighted Tape -- This method is similar to the "bell sounder" method, except that any suitable weight, not necessarily one designed to create an audible pop, can be used to suspend the tape. The weight should, ideally, be made of a relatively inert material and should be easily cleaned. Measurements shall be made and recorded to the nearest 0.1 foot.

7.7.2.3 Chalked Tape -- Chalk rubbed on a weighted steel tape will discolor or be removed when in contact with water. Distance to the water surface can be obtained by subtracting the wet chalked length from the total measured length. The tape should be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. Measurements shall be made and recorded to the nearest 0.01 foot. This method is not recommended if samples are to be collected for analyses of organic or inorganic contaminants.

7.7.2.4 Electric Water Level Indicators -- This instrument consists of a spool of dual conductor wire, a probe attached to the end, and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter

light and/or buzzer attached to the spool will signal the contact. Penlight or 9-volt batteries are normally used for a power source. Measurements shall be made and recorded to the nearest 0.01 foot.

7.7.2.5 Other Methods -- There are other types of water level indicators and recorders available on the market such as the sliding float method, air line pressure method, and electrical and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells. Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot shall not be used.

7.7.3. Total Well Depth Measurement Techniques

The bell sounder, weighted tape, or electric water level indicators described in Section 7.7.2 can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well. Care must be taken in these situations to ensure accurate measurements. All total well depth measurements must be made and recorded to the nearest 0.1 foot.

7.7.4 Equipment Available

The following Branch equipment is available for ground water level and total well depth measurements:

- weighted steel measuring tapes, and
- electric water level indicators.

7.7.5 Specific Quality Control Procedures

All devices used to measure ground water levels shall be calibrated against the Invar steel surveyor's chain. These devices shall be calibrated to 0.01 foot per 10 feet length. Before each use, these devices shall be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. These devices should be decontaminated according to the procedures specified in Appendix B.7.1 prior to use at the next well. All calibration and maintenance data shall be recorded in a log book.

7.8 TIME-OF-TRAVEL

7.8.1 General

Three principal methods are used to determine travel time in streams, i.e., surface floats, measurements of cross sectional velocity, and tracers such as dye.

A very rough method for preliminary estimates of time-of-water travel con

sists of dropping sticks or other buoyant objects from bridges in the stream reach under observation, and noting the time required for them to float an estimated 10 feet or some other convenient distance. The velocity estimates are too inaccurate for use in interpretation of data or final reporting, but can be useful in preliminary planning of studies and in subsequent more precise measurements of time-of-water-travel.

Stream velocities at gaging stations, measured by the U. S. Geological Survey in developing rating curves, may be applied to the entire reach under observation to estimate time-of-water travel. This is somewhat more refined than the floating objects estimates, but can still be far from accurate. There rarely are more than one or two gaging stations in most stream reaches being studied. Stream channels generally are restricted at gaging stations and velocities there are generally higher than average velocities throughout the reach. Cross sectional velocities can also be determined at locations designated for a particular study.

Tracer dyes provide a direct and highly accurate method of determining time-of-travel. This is the preferred method if resources are available.

7.8.2 Procedures

7.8.2.1 Floats -- Surface floats may be followed downstream and timed for known distances to determine time-of-water-travel. This requires the use of considerable judgment, for floats tend to travel into quiet or eddy areas, or to become stuck on tree limbs, the stream bank, or other obstacles. The floats must frequently be retrieved and returned to the stream current. The principal judgment factors are how long the floats should be left in quiet areas before retrieval and where they should be placed in the current.

Surface water velocity is greater than the average for the entire stream, and a correction factor must be applied to the surface velocity. An average velocity of about 85 percent of that of the surface velocity is a reasonable rule-of-thumb value.

7.8.2.2 Cross Section Measurements -- The measurement of cross sectional velocities at frequent longitudinal intervals and the calculation of average velocity in the stream constitutes a time consuming method of obtaining time-of-water-travel.

The longitudinal intervals at which cross sections should be measured vary with the characteristics of the stream channel. One cross section per mile may be adequate for streams with reasonably uniform channels. Cross sections at every tenth of a mile may be desirable for streams with irregular channels.

Cross section measurement methods are described in detail in Section 5.

7.8.2.3 Tracers -- The most accurate method of measuring time-of-travel involves following a tracer. Some conservative industrial waste constituents, salt, or radioisotopes may serve as tracers; however, dye is most common. The most frequently used dye is Rhodamine WT that can be detected in concentrations as low as 0.01 ppb by a fluorometer.

Prior to injection into the stream, the concentrated dye should be diluted with the stream water. This will help insure immediate maximum dispersion. Addition of concentrated dye without dilution may result in incomplete dispersion, particularly in shallow streams. Calibration curves should be developed for each study with particular emphasis on accounting for natural background fluorescence.

The dye should be distributed across the stream at the upstream point, as nearly instantaneously as possible. The ideal distribution produces a narrow band of tracer in a uniform concentration across the stream. The band of tracer mixes with water ahead of and behind it by diffusion, or longitudinal mixing, as it moves downstream to produce an increasingly wider band. The peak concentration remains near, but somewhat downstream of, the center line of the band and decreases as longitudinal mixing proceeds. The times-of-water-travel to downstream points are the differences between the time the dye was added to the stream and the times the centroid of the dye mass arrives at downstream points. The length of the dye cloud and the peak concentrations produces a measure of instream dispersion.

If Rhodamine WT dye is used as the tracer, peak concentrations from 1.0 to 50 ppb allow satisfactory definition of the dye concentration curve.

Most methods of calculating the dosage of dye needed at the upstream point involve estimates of one or more stream characteristics, such as flow, velocity, length of reach, volume in the reach, cross-sectional area, average depth, and the roughness coefficient, "n", of Manning's formula. The USGS has produced excellent publications regarding to time-of-travel techniques, i.e., "Measurement of Time-of-Travel and Dispersion by Dye Tracing" (9) and "Fluorometric Procedures for Dye Tracing" (10).

The stream should be sampled frequently as the dye arrives at the downstream point to define the tracer concentration versus time curve with special emphasis on the peak. The frequency may be varied from once each minute to once every 10 to 15 minutes, depending on how wide the band of dye has become at the sampling point. The dye may be missed altogether by overestimating the time required for it to travel downstream. Much time may be wasted, on the other hand, waiting for it to arrive if the time-of-travel is underestimated. All information that will contribute to the best possible preliminary estimate of the time required should be used.

There are two primary methods by which the stream water can be sampled and analyzed for dye. A submersible pump can be used to pump dye continuously through a fluorometer or the stream samples can be grabbed (either by hand or by automatic sampler) at specified frequencies and then placed into the fluorometer individually. With the "flow-through" version, a strip chart recorder connected to the fluorometer can be used to plot the tracer concentration versus time. Readings directly from the fluorometer scale or conversion to dye concentration can be manually plotted against time when the grab sampling technique is used.

A version of the grab sampling technique would be to use an automatic water sampler which discharges into separate bottles. The sampler is pre-set to collect samples at certain intervals; at the end of the sample collection time,

the discrete samples shall be analyzed and the concentration determined for each. The concentrations are then plotted against time.

For proper determination of travel time, samples should continue to be analyzed until the stream background concentration following the peak is measured. With a time versus concentration plot from background level to peak to background level, the centroid, and thus actual travel time, can be determined.

The Water Supply Branch of the Water Management Division should be contacted prior to conducting tracer studies in freshwater systems to insure that tracer concentrations do not impart color to downstream public or private water supplies.

7.8.3 Equipment Available

The following Branch equipment is available for time-of-travel studies:

- fluorometers,
- tracer standards,
- automatic samplers,
- pumps,
- recorders,
- flow meters, and
- floats.

7.8.4 Specific Equipment Quality Control Procedures

All of the quality control procedures for equipment utilized in time-of-travel studies has been discussed in Section 4 (Sampling Procedures), 5 (Flow Measurement), or 6 (Field Analyses).

7.9 DILUTION STUDIES

7.9.1 Procedures

A great deal of the previous section (time-of-travel studies) applies to this section and USGS publications provide references to techniques, in particular "Measurement of Discharge by Dye-Dilution Methods" (11).

Dilution studies using tracer dyes evolve from "mass conservation" principles. That is, a known mass of tracer is introduced at an upstream point, and after mixing with the water to be traced, this mass should be accountable at downstream locations. Rhodamine WT provides an adequate tracer for such investigations. This dye is slightly photoreactive and reaction rates are available in the literature (generally K rate is 0.034/day). Other tracers either introduced into an upstream point or in some instances occurring at the upstream point are often used. The high degree of accuracy and detection ability of fluorometers plus the solubility properties of tracer dyes make them the technique of choice.

In dilution studies, the tracer dye is precisely metered into the waters to be traced and then monitored after mixing via a fluorometer at downstream

stations. This series of events requires highly controlled metering rates and very accurate fluorometric analyses. State-of-the-art fluorometers make the dilution study program a valuable assessment tool.

7.9.2 Equipment Available

The following Branch field equipment is available for dilution studies:

- fluorometer,
- metering pump,
- tracer standards, and
- pumps.

7.9.3 Specific Equipment Quality Control Procedures

See previous section. The metering pump shall be calibrated before and during use. Field calibration data shall be recorded in the field records.

The principal of superposition as developed by Kilpatrick and Yotsukura of the USGS is a reliable method to determine dilution levels of wastewaters in the receiving estuary (12). A tracer dye is metered into the wastewater stream during a tidal cycle. Successive slack tide measurements of dye concentrations in the estuary at selective distances from the outfall produce a series of concentration curves. By superposition, the accumulative concentration at each station provides a determination of the ultimate concentrations or steady-state concentration of a continuous discharge. By simple proportioning, with due regard to tracer photo decay, the dilution levels of the discharge can be produced for selective points in the estuary.

Calculation Procedure:

$$C_w = (C_t)(e^{kt})\left(\frac{Vw}{Vt}\right)$$

Where:

C_w = Ultimate concentration of wastewater at point of interest

C_t = Ultimate concentration of tracer (by superposition) at point of interest

e^{kt} = Photo decay of tracer

k = 0.034 tidal day

t = tidal days to ultimate concentration

Vw = Wastewater discharge per tidal day

Vt = Volume dye released in tidal day

For example:

Assume: C_t = 100 ppb

e^{kt} = 1.2 (ultimate concentration obtained in 5 tidal days

Vw = 100,000 gal/tidal day

Vt = 10 gal/for one tidal day

Then: C_w = 1,000,000 ppb
= 0.10% wastewater

Investigations of industrial and municipal facilities for NPDES permit compliance require measurements of discharge rates. Often encountered during these investigations are flow measuring devices such as orifices and magnetic meters which are inaccessible for measurements of flow by standard equations relating to hydraulic head and structure size. The following provides a direct technique for measurement of flow through the above devices using dye tracers.

Discharge rate through any structure can be defined by the following mass balance equation:

MASS BALANCE EQUATION

Q_2

C^2 @ (Q_2+q_1)

q_1, @ C_1

$$(C_1)\ (q_1) = (C_2)\ (Q_2 + q_1)$$

$$Q_2 = \frac{(C_1)\ (q_1) - (C_2)\ (q_1)}{C_2}$$

Where:

Q_2 = pipe flow rate

The following is brief description of the methods available and their applications.

7.10.3.1 Metal Detection -- Metal detectors are used to detect changes in electrical conductivity caused by the presence of metallic materials, both ferrous and non-ferrous. Metal detectors: (1) are limited to shallow depths (0 to 8 feet), (2) can detect large metallic objectives such as buried drums and metallic laden wastes, (3) are light weight and economical, and (4) are insensitive to soil moisture and small metallic objects.

7.10.3.2 Magnetometry -- Magnetometers are designed to detect and accurately measure changes in the earth's magnetic field. The major feature of the magnetometer is ease of operation and reliability.

The magnetometer's primary design function is detection of magnetic objects such as buried drums or large bodies of ore which alter the earth's magnetic field. Magnetometers should not be calibrated or used in or around buildings, near powerlines, or directly on the ground.

7.10.3.3 Electromagnetic Induction (EM) -- A transmitter induced coil directs induced current loops into the ground, which produce secondary fields. These secondary fields are then sensed or detected by the receiver coil, and then amplified and stored on a strip chart recorder or magtape, if desired.

EM instruments measure true soil conductivity in uniform, homogeneous subsurface conditions. EM units also measure apparent soil conductivity in layered soils.

Measurements can be obtained from depths to 60 meters with these instruments. EM units are very effective for rapid site reconnaissance and detection of buried drums, pipes, and metallic type conductors. EM's are not limited by frozen ground, or wet or dry soils.

7.10.3.4 Ground Penetrating Radar (GPR)

Ground penetrating radar (GPR) units radiate short duration electromagnetic pulses directly into the ground from an antenna near the surface. The pulses are reflected back to the receiver from subsurface structures and are plotted on a strip chart recorder.

The depth of GPR penetration is site specific ranging from as little as 3 feet in clay to as much as 100 feet in dry quartz sand. Depths are further reduced if ground water electrical conductivity is high. GPR may be useful in defining boundaries of buried trenches and other subsurface disturbances, but is difficult to use in silty or clay soils.

7.10.3.5 Seismic Refraction Devices (SRD)

Field operation is accomplished by transmitting sound waves into the ground by means of a sound source (hammer, drop weight, explosives, etc.). Reflected sound waves are then detected by receivers or geophones which automatically

translate them into electrical signals, which are recorded and displayed in graph form on a seismograph. Stratigraphic profiles can then be determined based on travel time of the sound waves through the different earth strata.

7.10.3.6 Resistivity

Resistivity is used to measure the electrical resistance of the soil, rock, and ground water. The resistivity method requires that a electrical current be injected into the ground through a pair of surface electrodes. The resulting potential field (voltage) is measured at the surface by a second pair of electrodes. The electrical current flows from the electrodes into the ground through the moisture-filled pore spaces in the soils and rocks. Resistivity is controlled by the amount of pore water present in the soil and rock strata. The resistivity method can be used to locate and map contaminant plumes, locate and define trenches, and determine natural geohydrologic conditions such as depth to ground water, and depth to bedrock. The resistivity method is limited in areas where soils contain little or no moisture, since dry soils will not permit current to flow. Very hard or compacted soils or frozen ground impede the use of resistivity because the electrodes cannot be driven into the ground. Resistivity surveys are costly and time consuming which make the resistivity method unfavorable for a short reconnaissance trip or a quick screening investigation.

7.10.3.7 Very Low Frequency (VLF) Ground Conductivity

The VLF instrument uses the magnetic components of the electromagnetic field generated by already-existing radio transmitters that use the VLF band (Very Low Frequency, 15-30 kHz). Such transmitters are now operating in a number of countries, and are used primarily for long-distance submarine communication.

Electrically conductive structures on the surface or underground, even when covered with thick overburden, locally affect the direction and strength of the field generated by the transmitted radio signal. A weak secondary field is generated around the geological structure, which is most commonly a water-filled fracture or ore body. This field is measured by the instrument. Different VLF instruments available vary in the degree of useful output produced by each instrument. Some merely quantify the secondary field measurement, while others provide real-time current density profiles and structure interpretation of identified anomalies.

7.10.3 Equipment Available

The following Branch equipment is available for geophysical studies:

- EM-31D Non-Contacting Terrain Conductivity Meter,
- Unimag II Portable Proton Magnetometer Model G-846,
- Pipe Seeker 5 metal detector, and
- ABEM Wadi VLF Instrument

7.10.4 Specific Equipment Quality Control Procedures

All geophysical instruments used by Hazardous Waste Section personnel or EPA contractors shall be calibrated in accordance with the manufacturers' specified calibration procedures, and shall only be calibrated by personnel that have been trained to do so. The calibration shall be checked periodically to insure accurate readings, especially on re-entering the study area after having left for a period of time. All calibration procedures and pertinent information shall be documented in the field logbook as outlined in Section 3.5.

Personnel using the geophysical equipment shall be trained in the use and maintenance of such equipment, and shall be able to interpret and present the gathered data in an easily understood manner in charts, graphs, maps, and formal reports. It is the responsibility of each Hazardous Waste Section project leader to insure that the personnel designated to use the geophysical equipment are qualified in the calibration and use of the equipment, and able to gather and interpret the data.

Training on the calibration and use of geophysical equipment that is currently available will be conducted by qualified Hazardous Waste Section personnel and will be given to all Hazardous Waste Section personnel during in-house training sessions scheduled throughout the year.

7.10.4.1 <u>EM-31 Non-Contacting Terrain Conductivity Meter</u>

7.10.4.1.1 <u>Assembly and Calibration Procedure</u>

- Align and connect transmitter tube to control box.
- Check batteries by setting mode switch to operate position and range switch to +B position and then to -B position. The needle should read in the battery mark. If not, replace batteries.
- Align and connect receiver tube to control box.
- Set range switch to 30 millimhos/meter position.
- Set mode switch to comp. position.
- Adjust meter to zero using coarse and fine comp. controls.
- Check phasing, set mode switch to phase position.
- Note meter reading.
- Rotate coarse control to original position. No further adjustments are needed.
- If there is a difference in meter readings, an adjustment is needed.

- Put coarse control in original position.
- Rotate phase potentiometer 1/4 turn clockwise and note meter reading.
- Rotate coarse control one step clockwise and note meter reading.
- If meter reading does not change, no further adjustment is needed. Return coarse control to original position.
- If meter reading changes - repeat above adjustments until meter reading remains the same when coarse control is rotated one step clockwise.
- Meter should read between 75 - 85 percent of full scale (in Black Mark).
- Return coarse control to original position.
- EM-31 is ready for operation!

Note: When calibrating the EM-31 over ground with higher conductivity than 30 millimhos/meter, the range switch should be set at the appropriate range level.

7.10.4.1.2 <u>EM-31 Operating Procedure - Measuring Soil Conductivity</u>

- Adjust the shoulder strap so that the instrument rests comfortably on the hip.
- Switch the mode switch to OPER position and rotate range switch so that meter reads in upper 2/3 of the scale.
- EM-31 can be operated continuously while moving from one measuring station to the other or the EM-31 can be turned off while walking from station to station and then turned on when taking a reading. The latter saves battery life.
- Dismantle EM-31 and clean before storage.

7.10.4.1.3 <u>EM-31 Operating Procedure - Buried Metal Detection</u>

- Set the mode switch to the COMP position.
- Set the range switch to 30 millimhos/meter.
- Adjust the COARSE and FINE compensation controls so that a meter deflection of about 20 percent of full scale is obtained.

- Operate the EM-31 while continuously moving to determine the exact location of the buried objects.

- Dismantle EM-31 and clean before storage.

7.10.4.2 Unimag II Portable Proton Magnetometer Model G-846

7.10.4.2.1 Calibration and Operating Procedure

The Unimag II is completely self-contained and ready for field operation. A few simple procedures should be observed to obtain optimum results.

- Check the sensor for sensor fluid: Shake the instrument gently and listen for a "sloshing" sound. If the fluid is not present or cannot be heard, it will be necessary to fill the sensor with strained kerosene or unleaded gasoline. This procedure is outlined in the operator's manual furnished with the instrument.

- Check the battery: Simply depress the black push bottom and observe the readout. If the readout flashes on/off during the display period, the battery is not fully charged. Refer to the operators manual for battery recharging instructions.

- Lift the Unimag II out of the carrying case and adjust the shoulder strap for a comfortable fit.

- Adjust the "tuning-kilograms" knob to a position that correlates with the earth's magnetic field. The earth's field can be estimated by referring to the world intensity map located in front of the operators manual.

- Depress the black button on top of the instrument and release. The center digit on the readout will, briefly flash. This indicates that the cycle has started. It will take two seconds for the display to illuminate and give the earth's magnetic field in gammas.

- When operating, hold the Unimag II waist high. When depressing black button for reading, hold instrument as still as possible.

- The instrument should exhibit one count stability. If one count stability is not possible, a ferromagnetic object is present or a steep magnetic gradient is being encountered. Verify the one count stability by repeating the measurement with the instrument held in the same position.

  Note: If the earth's magnetic field is 40,000 gammas or less (low magnetic latitudes-equator area), the sensor should be rotated 90°. See operator's manual for the correct procedure. The sensor rotation

is not necessary in Region IV. If problems arise with the instrument, refer to the operator's manual.

- Do not operate the Unimag II in buildings, near high energy sources (powerlines, etc.), or directly on the ground. Hold instrument waist high. Do not wear magnetic objects such as jewelry, keys, watches, zippers, pocket knives, belt buckles, etc.

- Become familiar with the instrument and it's operation before attempting a field survey.

7.10.4.3 Metal Detector - The Tracer Metallic Pipe & Liner Locator

This instrument is a very sensitive piece of equipment and has to be fine tuned (nulled) in order to detect buried objects. The operators's manual should be read and understood before any field operation is attempted.

7.10.4.3.1 Operating Procedure

- Test the battery voltage on the transmitter and receiver (refer to the instructions in the operators manual). Make sure that batteries are fully charged.

- Assembly of the transmitter to the receiver should be accomplished according to the instructions in the operator's manual.

- Null the instrument prior to use. "Nulling" should take place in an area similar to the area of concern but where there are no buried metal objects. Refer to the instructions.

- Practical with the instrument over objects of known size and depth.

- For highest sensitivity, adjust the sensitivity control for an approximately half scale meter reading with the instruments nulled.

- Store instrument in a secure, dry place when not in use.

7.10.4.4 ABEM Wadi VLF Instrument

See owners manual for detailed instructions. The following is a summary of the basic steps for routine operation of the Wadi for site reconnaissance for location of water-filled fractured geologic terrain.

7.10.4.4.1 Operating Procedure

- Turn instrument on.

- Select suitable transmitter. Face the direction of anticipated profile and press STATION key. Wadi will display current radio frequency and signal strength indicator. Turn 360 degrees and observe the indicator. The length of the bar should be longest (or more nearly so) when facing the direction of the profile. If not, and if the numerical value displayed with the bar is less than 10 or greater than 50, a new transmitter must be selected. If a new transmitter is required, enter 0, 0, 0, and press the STATION key again. After about three minutes a frequency scan will appear. After the scan is completed, select strongest signal with large arrows on key pad and check for orientation of transmitter, as before.

- Select profile start point and specify grid. Press COORDINATE key and select starting coordinate, profile separation, and measurement separation distance.

- Conduct measurements along profile. Press MEASURE key. Wait for prompt to press MEASURE key again. Observe inclinometer in lower right portion of screen. A straight line is best, although measurements can be obtained with the open-carrot symbol. If inclination of antenna is too great, instrument will not measure and will indicate this condition. Re-orient antenna and try again. Remain steady while Wadi conducts measurement. Move to next measurement point and conduct next measurement.

- For any additions profiles in the same grid, using large arrows, make turn as required at end of each profile to continue measurements along successive profiles. Wadi automatically stores data for proper interpretation.

- To interpret any anomaly identified on profile, press MEASUREMENT key once and, using small arrows, move cursor to top of selected anomaly. Press INTERPRETATION key. After several seconds, interpretation will appear above anomaly. Identical vertical and horizontal scales allow for estimates to be made of depth of anomaly.

7.11 REFERENCES

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2. Breed, C. B., and G. L. Hosmer, The Principles and Practices of Surveying Volume II, Higher Surveying, Eighth Edition, John Wiley and Sons, Inc.: New York, New York.

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4. 18 U.S.C. Section 1385 provides, in pertinent part, "whoever, except in

cases and under circumstances expressly authorized by the Constitution or Art of Congress, willfully uses any part of the Army or Air Force ... to execute the laws of the United States shall be fined not more than $10,000 or imprisoned not more than two (2) years, or both."

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9. Kilpatrick, F. A., L. A. Martens, and J. F. Wilson, "Measurement of Time of Travel and Dispersion by Dye Tracing," Chapter A9, Applications of Hydraulics, Book 3, United States Geological Survey, 1968.

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12. "Tracer Simulation of Soluble Waste Concentrations," Journal of the Environmental Engineering Division, Proceedings of the ASCE, Volume 99, No. EE4, August 1973.