352SERBSF10,620

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Site Name (Subject):	SOUTHERN WOOD PIEDMONT COMPANY
Site ID (Document ID):	NCD058517467
Document Name (DocType):	Preliminary Assessment/Site Inspection (PA/SI)
Report Segment:	
Description:	Site Inspection Prioritization: References 34 - 60
Date of Document:	1/31/1995
Date Received:	
Box: *Enter SF and # with no spaces*	SF10,620
Access Level:	PUBLIC
Division:	WASTE MANAGEMENT
Section:	SUPERFUND
Program (Document Group):	SERB (SERB)
Document Category:	FACILITY

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THE SOIL CHEMISTRY OF HAZARDOUS MATERIALS

James Dragun, Ph.D.

458 pages
1988

Hazardous Materials Control Research Institute
Silver Spring, Maryland

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a]

Chemical	*Source*[b]
acenaphthalenes	fo
acenaphthenes	fo
acetic acid	co
adamantane	co
alkanes	fo
aniline	fo
anthracene	fo
benzene	co, fo, g, hog, ug
1,2-benzofluorene	co
benzoic acid	fo
benzothiophenes	fo
bicyclic sesquiterpanes	co
bicyclo-[3.2.1] octane	co
cis-bicyclo-[3.3.0]-octane	co
biphenyl	co, fo, k
1,3-butadiene	g
n-butane	co, g, hog, ug
1-butanethiol	co
2-butanethiol	co
butanoic acid	co
trans-2-butene	g, hog
1-butene	g
cis-2-butene	g
trans-2-butene	g
t-butyl alcohol	g
n-butylbenzene	co, g
sec-butylbenzene	co, g
t-butylbenzene	co, g
sec-butylcyclohexane	g
t-butylcyclohexane	g
d1-2-sec-butyl-4,5-dimethylpyridine	co
butylthiophane	co
carbazole	co
m-cresol	co
o-cresol	co
p-cresol	co
cycloalkanes	fo
cyclobutane	co
cycloheptane	co, g
cyclohexane	co, g, hog
cyclohexanecarboxylic acid	co
cyclohexanethiol	co
cyclohexene	g
cyclopentane	co, g

no benz a anth
no benz o b fluoranth
no benzo a pyrene
SFP 12/94

no chrysene
SFP 12/94

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

cyclopentaneacetic acid	co
cyclopentanecarboxylic acid	co
cyclopentanethiol	co
cyclopentene	g
3-cyclopentylpyridine	co
4-cyclopentylpyridine	co
m-cymene	fo, g
o-cymene	fo, g
p-cymene	fo, g
trans-decahydronaphthalene	co
n-decane	co, g, k
decanoic acid	fo
1-decene	g
cis-2-decene	g
trans-2-decene	g
decylthiophane	co
diasteranes	co
1,2-dibromoethane	g
1,2-dichloroethane	g
1,2-diethylbenzene	co, fo, g
1,3-diethylbenzene	g
1,4-diethylbenzene	co, g
diethylphenol	co
2,6-dimethylanthracene	co
2,7-dimethylanthracene	co
2,3-dimethylbenzo-[h]-quinoline	co
2,4-dimethylbenzo-[h]-quinoline	co
2,2-dimethylbutane	co, g, hog
2,3-dimethylbutane	co, g, hog, ug
2,3-dimethyl-1-butene	g
2,3-dimethyl-2-butene	g
3,3-dimethyl-1-butene	g
2,3-dimethyl-2-butenedioic acid	co
1,3-dimethyl-5-t-butylbenzene	g
2,4-dimethyl-8-sec-butylquinoline	co
1,1-dimethylcyclohexane	co, g
cis-1,2-dimethylcyclohexane	co, g, hog
cis-1,3-dimethylcyclohexane	co, hog
cis-1,4-dimethylcyclohexane	co, hog
trans-1,2-dimethylcyclohexane	co, g, hog
trans-1,3-dimethylcyclohexane	co, hog
trans-1,4-dimethylcyclohexane	co, hog
1,1-dimethylcyclopentane	co, g, hog
cis-1,2-dimethylcyclopentane	co, g
trans-1,2-dimethylcyclopentane	co, g
cis-1,3-dimethylcyclopentane	co, g, hog, ug
trans-1,3-dimethylcyclopentane	co, g, hog, ug

no dibenz & h anthracenes

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TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

2,4 no dimethyl phenol

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2,2-dimethylcyclopentanecarboxylic acid	co
2,3-dimethylcyclopentylacetic acid	co
dimethylcyclopropane	g
1,8-dimethyldibenzothiophene	co
2,3-dimethyl-4-8-diethylquinoline	co
1,2-dimethyl-3-ethylbenzene	co, g, k
1,2-dimethyl-4-ethylbenzene	co, fo, g, k
1,3-dimethyl-2-ethylbenzene	co, g, k
1,3-dimethyl-4-ethylbenzene	co, g, k
1,3-dimethyl-5-ethylbenzene	co, fo, g, k
1,4-dimethyl-2-ethylbenzene	co, g
2,2-dimethyl-3-ethylpentane	g
2,4-dimethyl-3-ethylpentane	g
2,3-dimethyl-4-ethyl-8-n-propylquinoline	co
2,3-dimethyl-8-ethylquinoline	co
2,4-dimethyl-8-ethylquinoline	co
2,3-dimethyl-4-ethylthiophene	co
2,4-dimethyl-3-ethylthiophene	co
3,4-dimethyl-2-ethylthiophene	co
2,2-dimethylheptane	g, hog
2,3-dimethylheptane	co, g
2,4-dimethylheptane	g
2,5-dimethylheptane	g
2,6-dimethylheptane	co, g
3,3-dimethylheptane	g
3,4-dimethylheptane	g
3,5-dimethylheptane	g
2,2-dimethylhexane	co, g, hog
2,3-dimethylhexane	co, g, hog
2,4-dimethylhexane	co, g, hog
2,5-dimethylhexane	co, g, hog
3,3-dimethylhexane	co, g
3,4-dimethylhexane	co, g, hog
2,2-dimethyl-trans-3-hexene	g
2,3-dimethyl-1-hexene	g
2,3-dimethyl-2-hexene	g
2,3-dimethyl-trans-3-hexene	g
2,5-dimethyl-trans-3-hexene	g
1,2-dimethyl-4-hydroxybenzene	fo
1,3-dimethyl-5-hydroxybenzene	fo
2,4-dimethyl-1-hydroxybenzene	fo
1,1-dimethylindan	g
1,6-dimethylindan	g
1,2-dimethyl-3-isopropylbenzene	g
2,3-dimethyl-6-isopropylpyridine	co
dimethylmaleic anhydride	co
1,2-dimethylnaphthalene	co, fo, k
1,3-dimethylnaphthalene	fo

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

TAB

n-dotriacontane	co
n-eicosane	co, fo
eicosanoic acid	co
ethane	co
ethanethiol	co
ethanol	fo
ethylbenzene	co, fo, g, hog, ug
2-ethyl-1-butene	g
ethylcyclohexane	co, g
ethylcyclopentane	co, g, hog
3-ethylcyclopentene	g
3-ethylheptane	g
4-ethylheptane	g
3-ethylhexane	co, g
2-ethyl-1-hexene	g
3-ethyl-3-hexene	g
1-ethyl-3-isopropylbenzene	g
1-ethyl-4-isopropylbenzene	g
1-ethyl-4-methylbenzene	fo
1-ethylnaphthalene	fo
2-ethylnaphthalene	fo
4-ethyloctane	g
3-ethylpentane	co, g, hog
3-ethylpentanoic acid	co
2-ethyl-1-pentene	g
3-ethyl-l-pentene	g
3-ethyl-2-pentene	g
1-ethyl-2-n-propylbenzene	g
1-ethyl-3-n-propylbenzene	g
ethylstyrene	g
2-ethylthiacyclopentane	co
formic acid	co
n-heneicosane	co, fo
n-hentriacontane	co
heptacosane	co, fo
n-heptadecane	co, fo
n-heptane	co, g, hog
heptanoic acid	co,
l-heptene	g
cis-2-heptene	g
cis-3-heptene	g
trans-2-heptene	g
trans-3-heptene	g
heptylthiophane	co
hexacosane	co, fo

no fluoranthene
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TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

n-hexadecane	co, fo, k
hexadecanoic acid	co
hexadecylthiophane	co
n-hexane	co, g, hog, ug
2-hexanethiol	co
3-hexanethiol	co
n-hexanoic acid	co
1-hexene	g, hog
cis-2-hexene	g
cis-3-hexene	g
trans-2-hexene	g
trans-3-hexene	g
hexylthiophane	co
hopanes	co
indan	co, g
indans	fo
indanol	fo
indene	g
isobutane	co, g
isobutylbenzene	co, g
isobutylcyclohexane	g
isobutylcyclopentane	g
isooctylthiophane	co
isopentylbenzene	g
isoprenoids	co
isopropyl alcohol	g
isopropylbenzene	co, fo, g
isopropylcyclohexane	g
isopropylcyclopentane	co, g
isoquinoline	fo
2-isopropylphenol	fo
methane	co
methanethiol	co
methanol	fo
8-methyl-1,2-benzofluorene	co
methylbicyclo-[2.2.1]-heptane	co
3-methylbiphenyl	co
2-methyl-1,3-butadiene	g
2-methylbutane	co, g
3-methylbutanoic acid	co
2-methyl-1-butanethiol	co
2-methyl-2-butanethiol	co
3-methyl-1-butanethiol	co
3-methyl-2-butanethiol	co
2-methyl-1-butene	g
2-methyl-2-butene	g

no indene
123 cd pyrene
SFP
12/94

(cont.)

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

2-methyl-trans-3-hexene	g
3-methyl-1-hexene	g
3-methyl-cis-2-hexene	g
3-methyl-trans-2-hexene	g
3-methyl-cis-3-hexene	g
3-methyl-trans-3-hexene	g
4-methyl-1-hexene	g
4-methyl-cis-2-hexene	g
4-methyl-trans-2-hexene	g
5-methyl-1-hexene	g
5-methyl-cis-2-hexene	g
1-methyl-2-isopropylbenzene	co, g
1-methyl-3-isopropylbenzene	co, g
1-methyl-4-isopropylbenzene	co, g
1-methyl-cis-4-isopropylcyclohexane	g
1-methyl-trans-4-isopropylcyclohexane	g
1-methylindan	co, g, k
2-methylindan	co, g, k
4-methylindan	co, g, k
5-methylindan	g
1-methylnaphthalene	co, fo, k
2-methylnaphthalene	co, fo, g, k
methylnaphthalenes	fo
2-methylnonane	co, g
3-methylnonane	co, g
4-methylnonane	co, g
5-methylnonane	co, g
2-methyl-1-nonene	g
2-methyloctane	co, g, ug
3-methyloctane	co, g, ug
4-methyloctane	co, g, ug
2-methyl-1-octene	g
2-methyl-2-octene	g
2-methylpentane	co, g, hog, ug
3-methylpentane	co, g, hog, ug
2-methylpentanoic acid	co
3-methylpentanoic acid	co
4-methylpentanoic acid	co
2-methyl-2-pentanethiol	co
2-methyl-3-pentanethiol	co
3-methyl-3-pentanethiol	co
4-methyl-2-pentanethiol	co
2-methyl-1-pentene	g, ug
2-methyl-2-pentene	g, ug
3-methyl-1-pentene	g
3-methyl-2-pentene	g
cis-3-methyl-2-pentene	g
trans-3-methyl-2-pentene	g

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

4-methyl-1-pentene	g
4-methyl-cis-2-pentene	g
4-methyl-trans-2-pentene	g
2-methylpropane	g, hog
2-methyl-1-propanethiol	co
2-methyl-2-propanethiol	co
2-methylpropanoic acid	co
2-methylpropene	g
1-methyl-2-n-propylbenzene	co, g, k
1-methyl-3-n-propylbenzene	g
1-methyl-4-n-propylbenzene	co, g, k
1-methylpyrene	co
3-methylpyridine	co
2-methylquinoline	co
2-methylstyrene	g
2-methyl-1,2,3,4-tetrahydronaphthalene	co
5-methyl-1,2,3,4-tetrahydronaphthalene	co
6-methyl-1,2,3,4-tetrahydronaphthalene	co
1-methyltetralin	k
2-methyltetralin	k
4-methyl-2-thia[0.3.3]-bicyclononane	co
3-methyl-2-thia[0.3.3]-bicyclooctane	co
methyl-8-thia[3.2.1]-bicyclooctane	co
3-methyl-2-thiabutane	co
2-methylthiacyclopentane	co
3-methylthiacyclopentane	co
4-methylthiacyclopentane	co
2-methyl-3-thiahexane	co
4-methyl-3-thiahexane	co
2-methyl-3-thiapentane	co
2-methylthiophene	co
3-methylthiophene	co
naphthalene	co, fo, g, k
naphthalenes	fo
2-naphthol	co
n-nonacosane	co
n-nonadecane	co, fo
n-nonane	co, fo, g, k
nonanoic acid	co, fo
nonanol	g
1-nonene	g
nonhopanes	co
nonylthiophane	co
n-octacosane	co
n-octadecane	co, fo
octadecanoic acid	co

TABLE 9.16 (

octadecyl
n-octane
n-octano
2-octanet
octanoic
1-octene
cis-2-octe
trans-2-o
trans-4-o
octylthio
pentacos
n-pentad
1,4-penta
pentamet
n-pentan
1-pentan
2-pentan
3-pentan
pentanoi
1-pentene
cis-2-pent
trans-2-p
n-pentylb
n-pentylc
n-pentylc
pentylthi
perylene
phenanth
phenol
polynaph
porphyri
propane
1-propan
2-propan
propanoi
n-propylb
propylcyc
n-propylc
4-n-propy
quinoline
steranes
n-tetracos
n-tetradec
tetradecan
tetradecyl
1,2,3,4-tet
5,6,7,8-tet
tetralin

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

octadecylthiophane	co
n-octane	co, fo, g, hog, k
n-octanoic acid	co
2-octanethiol	co
octanoic acid	fo
1-octene	g
cis-2-octene	g
trans-2-octene	g
trans-4-octene	g
octylthiophene	co
pentacosane	co, fo
n-pentadecane	co, fo, k
1,4-pentadiene	g
pentamethylbenzene	g
n-pentane	co, fo, g, hog, ug
1-pentanethiol	co
2-pentanethiol	co
3-pentanethiol	co
pentanoic acid	co
1-pentene	g, hog, ug
cis-2-pentene	g, hog, ug
trans-2-pentene	g, hog, ug
n-pentylbenzene	g
n-pentylcyclohexane	g
n-pentylcyclopentane	g
pentylthiophane	co
perylene	co
phenanthrene	fo
phenol	co, fo
polynaphthenes	fo
porphyrins	co
propane	co, g, hog
1-propanethiol	co
2-propanethiol	co
propanoic acid	co
n-propylbenzene	co, g
propylcyclohexane	g
n-propylcyclopentane	co, g
4-n-propylheptane	g
quinoline	fo
steranes	co
n-tetracosane	co, fo
n-tetradecane	co, fo, k
tetradecanoic acid	co
tetradecylthiophane	co
1,2,3,4-tetrahydronaphthalene	co, g
5,6,7,8-tetrahydroquinoline	co
tetralin	g, k

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

tetralins	fo
1,3,5,7-tetramethylanthracene	co
1,3,6,7-tetramethylanthracene	co
2,3,6,7-tetramethylanthracene	co
1,2,3,4-tetramethylbenzene	co, g, k
1,2,3,5-tetramethylbenzene	co, fo, g, k
1,2,4,5-tetramethylbenzene	co, fo, g, k
2,2,3,3-tetramethylbutane	co
1,1,3,3-tetramethylcyclopentane	co
1,1-cis-2-cis-3-tetramethylcyclopentane	co
1,1-cis-2-trans-3-tetramethylcyclopentane	co
1,1-cis-2-trans-4-tetramethylcyclopentane	co, g
1,1-cis-3-trans-4-tetramethylcyclopentane	co
1-cis-2-trans-3-cis-4-tetramethylcyclopentane	co
1-trans-2-cis-3-trans-4-tetramethylcyclopentane	co
1-trans-2-trans-3-cis-4-tetramethylcyclopentane	co
2,2,3,3-tetramethylhexane	g
2,6,10,14-tetramethylhexadecane	fo
1,4,5,7-tetramethylnaphthalene	co
2,3,6,7-tetramethylnaphthalene	co
2,6,10,14-tetramethylpentadecane	fo
2,2,3,4-tetramethylpentane	g
2,2,4,4-tetramethylpentane	co
2,3,4,8-tetramethylquinoline	co
2,3,4,5-tetramethylthiophene	co
thiaadamantane	co
6-thia[0.3.4]bicyclononane	co
9-thia[3.3.1]bicyclononane	co
2-thia[2.2.2]bicyclooctane	co
2-thia[3.3.0]bicyclooctane	co
cis-3-thia[3.3.0]bicyclooctane	co
2-thia[3.2.1]bicyclooctane	co
3-thia[3.2.1]bicyclooctane	co
6-thia[3.2.1]bicyclooctane	co
8-thia[3.2.1]bicyclooctane	co
2-thiabutane	co
thiacyclohexane	co
thiacyclopentane	co
5-thiadecane	co
3-thiaheptane	co
2-thiahexane	co
3-thiahexane	co
cis-1-thiahydrindane	co
trans-1-thiahydrindane	co
thianaphthene	co
5-thianonane	co
3-thiaoctane	co
2-thiapentane	co

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

3-thiapentane	co
2-thiapropane	co
7-thiatridecane	co
6-thiaundecane	co
thiophene	co
toluene	co, fo, g, hog, ug
n-triacontane	co
n-tricosane	co, fo
tricyclic terpanes	co
n-tridecane	co, fo, k
triethylphenol	co
2,3,6-trimethylanthracene	co
1,2,3-trimethylbenzene	co, g, k
1,2,4-trimethylbenzene	co, g, k, ug
1,3,5-trimethylbenzene	co, g, k
2,2,3-trimethylbutane	co, g, hog
2,3,3-trimethyl-1-butene	g
1,1,2-trimethylcyclohexane	g
1,1,3-trimethylcyclohexane	co, g
1,1,4-trimethylcyclohexane	g
1-cis-2-trans-3-trimethylcyclohexane	g
1-trans-2-cis-3-trimethylcyclohexane	g
1-trans-2-cis-4-trimethylcyclohexane	co, g
1-trans-2-trans-4-trimethylcyclohexane	co, g
1-cis-3-cis-5-trimethylcyclohexane	g
1-cis-3-trans-5-trimethylcyclohexane	g
cis-2,2,6-trimethylcyclohexanecarboxylic acid	co
trans-2,2,6-trimethylcyclohexanecarboxylic acid	co
2-(2,2,6-trimethylcyclohexyl)-4,6-dimethylpyridine	co
1,1,2-trimethylcyclopentane	co, g
1,1,3-trimethylcyclopentane	co, g
1-cis-2-cis-3-trimethylcyclopentane	co, g
1-cis-2-cis-4-trimethylcyclopentane	co, g
1-cis-2-trans-3-trimethylcyclopentane	co, g
1-cis-2-trans-4-trimethylcyclopentane	co, g
1-trans-2-cis-3-trimethylcyclopentane	co, g
1-trans-2-cis-4-trimethylcyclopentane	co, g
1,1,2-trimethylcyclopentanecarboxylic acid	co
1,2,2-trimethylcyclopentane-1,3-dicarboxylic acid	co
3,3,4-trimethylcyclopentylacetic acid	co
2,6,10-trimethyldodecane	fo
1,2,3-trimethyl-4-ethylbenzene	g
1,2,3-trimethyl-5-ethylbenzene	g
1,2,4-trimethyl-3-ethylbenzene	g
1,2,4-trimethyl-5-ethylbenzene	g
1,2,5-trimethyl-3-ethylbenzene	g
1,3,5-trimethyl-2-ethylbenzene	g
2,3,8-trimethyl-4-ethylquinoline	co

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

2,3,4-trimethyl-8-ethylquinoline	co
2,3,4-trimethyl-5-ethylthiophene	co
2,2,4-trimethylheptane	g
2,2,5-trimethylheptane	g
2,2,5-trimethylheptane	g
2,2,6-trimethylheptane	g
2,4,4-trimethylheptane	g
2,4,5-trimethylheptane	g
2,5,5-trimethylheptane	g
3,3,4-trimethylheptane	g
3,3,5-trimethylheptane	g
3,4,4-trimethylheptane	g
3,4,5-trimethylheptane	g
2,2,3-trimethylhexane	g
2,2,4-trimethylhexane	co, g
2,2,5-trimethylhexane	co, g
2,3,3-trimethylhexane	g
2,3,5-trimethylhexane	co, g
2,4,4-trimethylhexane	g
3,4,4-trimethyl-2-hexene	g
2,3,4-trimethyl-8-isopropylquinoline	co
1,2,5-trimethylnaphthalene	co
1,2,6-trimethylnaphthalene	co
1,2,7-trimethylnaphthalene	co
1,2,8-trimethylnaphthalene	co
1,3,5-trimethylnaphthalene	co
1,3,7-trimethylnaphthalene	co
1,3,8-trimethylnaphthalene	co
1,6,7-trimethylnaphthalene	co
2,3,6-trimethylnaphthalene	co
2,2,3-trimethylpentane	g, hog, ug
2,2,4-trimethylpentane	co, g, hog, ug
2,2,5-trimethylpentane	g, hog, ug
2,3,3-trimethylpentane	co, g, hog, ug
2,3,4-trimethylpentane	co, g, hog, ug
2,3,6-trimethylphenol	fo
2,4,6-trimethylphenol	fo
2,4,4-trimethyl-1-pentene	g
2,4,4-trimethyl-2-pentene	g
1,2,8-trimethylphenanthrene	co

TABLE 9.16

2,3,4-tri
2,3,4-tri
2,3,5-tri
2,3,8-tri
2,4,8-tri
2,3,5-tri
2,3,4-tri
triterpan

n-undeca
undecylth

vinyl-2-et

m-xylene
o-xylene
p-xylene
1,2,3-xyle
1,2,4-xyle
1,3,4-xyle
1,3,5-xyle

a - compil
b - abbrevi

TABLE 9.16 Organic Chemicals Identified in Various Petroleum Hydrocarbons[a] (cont.)

2,3,4-trimethyl-8-n-propylquinoline	co
2,3,4-trimethylpyridine	co
2,3,5-trimethylpyridine	co
2,3,8-trimethylquinoline	co
2,4,8-trimethylquinoline	co
2,3,5-trimethylthiacyclopentane	co
2,3,4-trimethylthiophene	co
triterpanes	co
n-undecane	co, fo, g, k
undecylthiophane	co
vinyl-2-ethylhexylether	g
m-xylene	co, fo, g, hog, ug
o-xylene	co, fo, g, hog, ug
p-xylene	co, fo, g, hog, ug
1,2,3-xylenol	co
1,2,4-xylenol	co
1,3,4-xylenol	co
1,3,5-xylenol	co

a - compiled from information in references 104, 105, 106, 107, & 108.
b - abbreviations: co = crude oil
fo = fuel oil
g = gasoline
hog = high octane gasoline
k = kerosene
ug = unleaded gasoline

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar.

acenaphthene	
1-acenaphthol	
acenaphthylene	
acephenanthrene	
acephenanthrylene	
acetaldehyde	
acetic acid	
acetone	
acetonitrile	
acetophenone	
acridine	
adipate esters	
aliphatic esters >C−9	
alkanes >C−6	
alkyl acenaphthols	
alkyl acridines	
alkyl alcohols >C−6	
1-aminonaphthalene	
2-aminonaphthalene	
aminotetralin	
aminotoluene	
aniline	
anisoles	
anthanthrene	
anthracene	
9,10-anthraquinone	
aza-acenaphthylene	
azabenzofluorene	
1-azacarbazole	
1-azafluoranthene	
7-azafluoranthene	
4-azafluorene	
7-azaindole	
4-azapyrene	
azulene	
benz(e)acephenanthrylene	
benz(a)acridine	
benz(c)acridine	
benzanilide	
benz(a)anthracene	
benzathrone	
benzene	
benzidine	
benzindole	

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

benzo(a)carbazole
11H-benzo(a)carbazole
benzo(b)carbazole
5H-benzo(b)carbazole
7H-benzo(c)carbazole
4H-benzo(def)carbazole
benzo(b)chrysene
benzo(b)fluoranthene
benzo(ghi)fluoranthene
benzo(j)fluoranthene
benzo(k)fluoranthene
benzo(a)fluorene
11H-benzo(a)fluorene
benzo(b)fluorene
11H-benzo(b)fluorene
benzo(c)fluorene
7H-benzo(c)fluorene
benzofluoreneamine
2,3-benzofuran
7-benzo(b)furanol
benzoic acid
benzo(a)naphthacene
benzo(b)naphtho(2,1-d)furan
benzo(b)naphtho(2,3-d)furan
benzo(b)naphtho(1,2-d)thiophene
benzo(b)naphtho(2,1-d)thiophene
benzo(b)naphtho(2,3-d)thiophene
benzonitrile
benzo(a)pentacene
benzo(rst)pentaphene
benzo(ghi)perylene
benzo(c)phenanthrene
benzo(c)picene
benzo(a)pyrene
benzo(e)pyrene
2,3-benzopyridine
3,4-benzopyridine
benzo(f)quinoline
benzo(h)quinoline
benzo(b)thiophene
benzo(k)xanthene
bicyclohexyl
2,2'-binaphthalene
2,2'-binaphthyl
biphenyl
3-(biphenyl)-4H-4-pyranone
1,2-butadiene

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

1,3-butadiene
butane
butanoic acid
2-butanone
1-butene
2-butene
t-butylhydroquinone
3-n-butylphenol
4-n-butylphenol
4-sec-butylphenol
1-butyne
2-butyne

carbon disulfide
carbazole
9H-carbazole
chrysene
coronene
m-cresol
o-cresol
p-cresol
cyano-11H-benzo(b)fluorene
cyanofluorene
1-cyanonaphthalene
2-cyanonaphthalene
2-cyanotoluene
3-cyanotoluene
4-cyantoluene
4H-cyclopenteno(d,e,f)phenanthrene
1,3-cyclohexadiene
cyclohexane
cyclohexene
cyclopentadiene
cyclopentane
4H-cyclopenta(d,e,f)phenanthrene
cyclopentene

n-decane
dibenz(ac)anthracene
dibenz(ah)anthracene
dibenz(aj)anthracene
dibenzo(b,def)chrysene
13H-dibenzo(a,h)fluorene
dibenzo(b,d)furan

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

1,4-dimethylcyclohexane
1,1-dimethylcyclopentane
4,6-dimethyldibenzo(b,d)furan
4,6-dimethyldibenzo(b,d)thiophene
2,3-dimethyl-6-ethylpryidine
dimethyl-4-indanol
4,5-dimethylindene
4,6-dimethylindene
4,7-dimethylindene
5,6-dimethylindene
5,7-dimethylindene
6,7-dimethylindene
1,3-dimethylisoquinoline
1,2-dimethylnaphthalene
1,3-dimethylnaphthalene
1,4-dimethylnaphthalene
1,5-dimethylnaphthalene
1,6-dimethylnaphthalene
1,7-dimethylnaphthalene
2,3-dimethylnaphthalene
2,6-dimethylnaphthalene
2,7-dimethylnaphthalene
3,6-dimethylphenanthrene
2,3-dimethylphenol
2,4-dimethylphenol
2,5-dimethylphenol
2,6-dimethylphenol
3,4-dimethylphenol
3,5-dimethylphenol
4,11-dimethylpicene
2,7-dimethylpyrene
2,3-dimethylpyridine
2,4-dimethylpyridine
2,5-dimethylpyridine
2,6-dimethylpyridine
3,4-dimethylpyridine
3,5-dimethylpyridine
2,3-dimethylquinoline
2,4-dimethylquinoline
2,6-dimethylquinoline
2,7-dimethylquinoline
2,8-dimethylquinoline
4,6-dimethylquinoline
4,7-dimethylquinoline
5,8-dimethylquinoline
6,8-dimethylquinoline

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

dimethylsulfide
2,5-dimethylthiophene
3,5-dimethylxanthene
dinaphthofuran
dinaphtho(2,1-b:1',2'-d)thiophene

eicosane
ethanethiol
ethanol
ethylbenzene
ethylene glycol
ethylisocyanide
2-ethylnaphthalene
3-ethylpentane
2-ethylphenol
3-ethylphenol
4-ethylphenol
2-ethylpyridine
3-ethylpyridine
4-ethylpyridine
2-ethyltoluene
3-ethyltoluene
4-ethyltoluene

fluoranthene
fluorene
9H-fluorene
9H-fluorene-2-carbonitrile
2-fluorenol
heptadecane
n-heptane
1-heptene
hexadecane
hexadecanoic acid
hexamethylbiphenyl
n-hexane
1-hexene
1-hexyne
2-hexyne
3-hexyne
hydroxyanthracene
hydroxybenzofluorene
2-hydroxybenzoic acid
3-hydroxybenzoic acid

ar. (cont.)

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

4-hydroxybenzoic acid
2-hydroxybiphenyl
9-hydroxy-4-methylfluorene
5-hydroxy-1-methyl-3-isopropylbenzene
2-hydroxy-7-methylquinoline
2-hydroxyphenanthrene
4-hydroxyphenanthrene
2-hydroxypropanoic acid
4-hydroxythionaphthene
6-hydroxythionaphthene

indan
indano(2,1-a)indan
4-indanol
5-indanol
indene
indenofluoranthene
indenole
indeno(1,2,3-cd)pyrene
11H-indeno(1,2-b)quinoline
indole
6H-indolo(2,3-b)quinoline
2-isopropylphenol
3-isopropylphenol
4-isopropylphenol
isoquinoline

methanethiol
4-methoxybenzophenone
methylacenaphthene
methylacenaphthylene
methylacenaphthol
methylacetylene
2-methylacridine
methylaminoacenaphthylene
2-methylaniline
3-methylaniline
4-methylaniline
1-methylanthracene
2-methylanthracene
9-methylanthracene
methylbenzindole
1-methylbenzo(a)anthracene
6-methylbenzo(a)anthracene
9-methylbenzo(a)anthracene

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

2-methyl-1-phenylpropane
2-methyl-4-propylphenol
1-methylpyrene
2-methylpyrene
4-methylpyrene
2-methylpyridine
3-methylpyridine
4-methylpryidine
2-methylquinoline
3-methylquinoline
4-methylquinoline
5-methylquinoline
6-methylquinoline
7-methylquinoline
8-methylquinoline
2-methyltetrahydrothiophene
2-methylthionaphthene
2-methylthiophene
3-methylthiophene
methyltriphenylene
1-methyl-2-vinylbenzene
1-methyl-4-vinylbenzene

naphthacene
naphthalene
naphtho(1,2-b)chrysene
2',1':1,2-naphthofluorene
naphtho(1,2-b)furan
naphtho(2,1-b)furan
naphthoindole
1-naphthol
2-naphthol
naphtho(1,2-a)pyrene
naphthopyrrole
naphtho(1,2-b)thiophene
naphtho(2,1-b)thiophene
naphtho(2,3-b)thiophene
naphtho(2,1,8,7-klmn)xanthene
o-(2-naphthyl)-phenol
nonadecane
nonane

Tar. (cont.)

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

octadecane
octadecanoic acid
cis-9-octadecenoic acid
octahydroanthracene
n-octane
5-oxo-4,5-dihydro-4-azapyrene

pentacene
1,3-pentadiene
n-pentane
pentanoic acid
pentaphene
1-pentene
2-pentene
1-pentyne
2-pentyne
perylene
phenanthrene
phenanthridine
5H-phenanthridin-6-one
phenanthrobenzpyrene
phenanthro(4,5-bcd)thiophene
phenol
1-phenylbenzanthrone
2-phenylbutane
1-phenylnaphthalene
2-phenylnaphthalene
2-phenylphenanthrene
1-phenylpropane
2-phenylpropane
1-phenyl-1-propanone
2-phenylpyridine
4-phenylpyridine
phthalate esters
phthalic esters
phytane
picene
pristane
propadiene
propanoic acid
propionamide
2-n-propylphenol
3-n-propylphenol
4-n-propylphenol
pyrene

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

pyridine
2-pyridinecarboxylic acid
pyrrole
pyrrolo(def)phenanthrene
quinoline
styrene
tetradecane
1,2,3,4-tetrahydroacridine
1,2,3,4-tetrahydrofluoranthene
1,2,3,4-tetrahydronaphthalene
1,2,3,4-tetrahydroquinoline
1,2,3,4-tetramethylbenzene
1,2,3,5-tetramethylbenzene
1,2,4,5-tetramethylbenzene
tetramethylbiphenyl
1,2,3,5-tetramethylcyclohexane
2,3,6,7-tetramethylnaphthalene
2,3,5,6-tetramethylphenol
2,3,4,5-tetramethylpyridine
2,3,4,6-tetramethylpyridine
2,3,5,6-tetramethylpyridine
thiophene
thiophenol
thiopheno(def)phenanthrene
toluene
tri-n-butylamine
1,2,3-trihydroxybenzene
1,2,4-trihydroxynaphthalene
1,4,5-trihydroxynaphthalene
1,2,3-trihydroxypropane
1,2,3-trimethylbenzene
1,2,4-trimethylbenzene
1,3,5-trimethylbenzene
1,2,3-trimethylcyclohexane
1,2,4-trimethylcyclohexane
1,3,5-trimethylcyclohexane
1-trans-2-cis-trimethylcyclopentane
1,3,7-trimethylnaphthalene
1,6,7-trimethylnaphthalene
2,3,6-trimethylnaphthalene
2,2,4-trimethylpentane

TABLE 9.21 Organic Chemicals Identified as Components of Coal Tar. (cont.)

1,2,8-trimethylphenanthrene
2,3,4-trimethylphenol
2,3,5-trimethylphenol
2,4,5-trimethylphenol
2,4,6-trimethylphenol
3,4,5-trimethylphenol
2,3,4-trimethylpyridine
2,3,5-trimethylpyridine
2,3,6-trimethylpyridine
2,4,5-trimethylpyridine
2,4,6-trimethylpyridine
3,4,5-trimethylpyridine
2,4,6-trimethylquinoline
2,4,8-trimethylquinoline
2,6,8-trimethylquinoline
trimethylthiophenes
triphenylene

xanthene
9H-xanthene
m-xylene
o-xylene
p-xylene
xylenol

Compiled from data in references 138, 139, 140, 141, & 142.

TABLE 9.22 Concentrations of Metals in Municipal Sludges.

Metal	*Concentration (mg/kg)*		
	Range	*Mean*	*No. Samples*
Al	300 - 110,000	24,435	397
Ag	0.13 - 150	11.4	234
As	0.007 - 109	10.7	272
B	<1 - 1400	105	266
Ba	2.25 - 2797	619	41
Be	<1 - 23	1.5	226
Cd	0.04 - 1200	57	404
Co	<1 - 250	20	396
Cr	0.36 - 15,167	596	406
Cu	0.03 - 13,380	998	406
Fe	52 - 116,000	23,838	402
Hg	0.006 - 1690	15	274
Mn	0.6 - 3800	519	398
Mo	6.0 - 3700	60	225
Ni	0.18 - 1300	138	405
Pb	2.1 - 7627	596	406
Sb	<1 - 1303	18	270
Se	0.07 - 390	12	44
Sn	25.4 - 492	205	17
Tl	0.13 - 89	26	4
Zn	4.4 - 24,000	2,243	406
pH	3.1 - 13.0	7.05	355

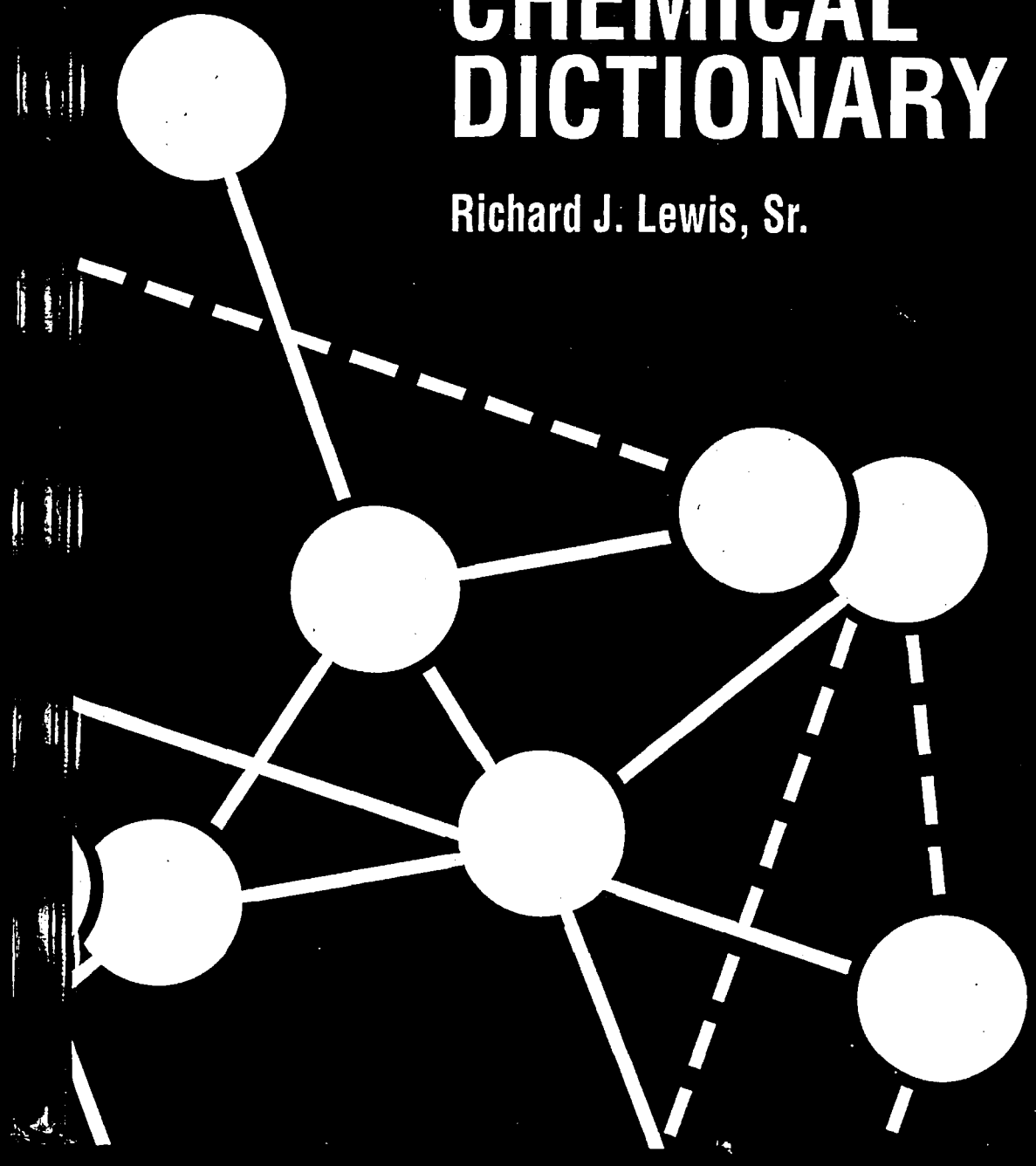
Compiled from data from References 143, 144, and 145.

Ref. 35

Twelfth Edition

Hawley's CONDENSED CHEMICAL DICTIONARY

Richard J. Lewis, Sr.



Hawley's

Condensed Chemical

Dictionary

TWELFTH EDITION

Revised by

Richard J. Lewis, Sr.

VNR VAN NOSTRAND REINHOLD COMPANY
New York

fuming sulfuric acid at low temperature followed by separation from the 1,6-isomer.
Use: Dye intermediate.

Arndt-Eistert synthesis. Procedure for converting an acid to its next higher homolog.

"Arnel" [*Hoechst Celanese*]. TM for an acetate fiber made from cellulose triacetate. It has a higher melting point, and is less soluble than cellulose acetate.
See acetate fiber, cellulose triacetate.

aromatic. (arene). A major group of unsaturated cyclic hydrocarbons containing one or more rings, typified by benzene, which has a 6-carbon ring containing three double bonds. The vast number of compounds of this important group, derived chiefly from petroleum and coal tar, are rather highly reactive and chemically versatile. The name is due to the strong and not unpleasant odor characteristic of most substances of this nature. Certain 5-membered cyclic compounds such as the furan group (heterocyclic) are analogous to aromatic compounds.
Note: The term "aromatic" is often used in the perfume and fragrance industries to describe essential oils which are not aromatic in the chemical sense.

aromaticity. A stable electron shell configuration in organic molecules, especially those related to benzene.
See resonance, orbital theory.

aromatization. See hydroforming.

"Arosurf TA100" [*Sherex*]. (distearyldimethylammonium chloride). CAS: 107-64-2. TM for powder cationic-quaternary fabric softener.
Use: For retail powdered detergent-softener, industrial laundry and pap-softening formulas, and cosmetic formulations.

arrack. An oriental distilled liquor which is obtained from palm or rice juice.

arrest point. The temperature at which a system of more than one component being heated or cooled absorbs or yields heat without changing temperature.

Arrhenius, Svante. (1859–1927). A native of Sweden, he won the Nobel prize in chemistry in 1903. He is best known for his fundamental investigations on electrolytic dissociation of compounds in water and other solvents, and for his basic equation stating the increase in the rate of a chemical reaction with rise in temperature:

$$\frac{d \ln k}{dT} = \frac{A}{RT^2}$$

in which k is the specific reaction velocity, T is the absolute temperature, A is a constant usually referred to as the energy of activation of the reaction, and R is the gas-law constant.

arrowroot. (maranta). The starch which is obtained from the roots of the maranta plant, which has many uses, including food ingredients, cosmetics, glues, and starches.

arsacetin. (sodium acetylarsanilate; sodium p-acetyl aminophenylarsonate).
$CH_3CONHC_6H_4AsO(OH)ONa$.
Properties: White, crystalline powder; odorless; tasteless; free of arsenous or arsenic acid; solutions will admit of thorough sterilization. Soluble in cold water, but more so in warm water.
Use: Medicine (antisyphilitic).

arsanilic acid. (atoxylic acid; p-aminobenzenearsonic acid; p-aminophenylarsonic acid).
$C_6H_4{\cdot}C_6H_8AsNO_3$.
Properties: White, crystalline powder; practically odorless; soluble in hot water; slightly soluble in cold water, alcohol, and acetic acid; insoluble in acetone, benzene, chloroform, and ether. Mp 232C.
Derivation: By condensing aniline with arsenic acid, removing the excess of aniline by steam distillation in alkaline solution, and setting the acid free using hydrochloric acid.
Hazard: A poison. Yields flammable vapors on heating above melting point.
Use: Arsanilates, manufacture of arsenical medicinal compounds such as arsphenamine, veterinary medicine, grasshopper bait.

arsenic. As. CAS: 7440-38-2. A nonmetallic element of atomic number 33, group Va of periodic table, aw 74.9216, valences of 2,3,5; no stable isotopes.
Properties: Silver-gray, brittle, crystalline solid that darkens in moist air. Allotropic forms: black, amorphous solid (β-arsenic); yellow, crystalline solid, d 5.72 (commercial product ranges from 5.6 to 5.9), mp 814C (36 atm), sublimes at 613C (1 atm), Mohs hardness 3.5, insoluble in water and in caustic and nonoxidizing acids. Attacked by hydrochloric acid in presence of oxidant. Reacts with nitric acid. Low thermal conductivity; a semiconductor.
Derivation: Flue dust of copper and lead smelters from which it is obtained as white arsenic (arsenic trioxide) in varying degrees of purity. This is reduced with charcoal. The commercial grade is not made in the U.S.
Grade: Technical, crude (90–95%), refined

bonyl compounds containing an asymmetric center. The diastereomer which is formed by approach of the reagent from the less hindered side of the carbonyl group predominates in the product. The α-substituents are schematically represented as S (small), M (medium), and L (large).

crazing. Development of minute cracks in the surface of a material, such as ceramic glaze, varnish, paint, etc., often as a result of exposure to sunlight or weathering.

cream of tartar. See potassium bitartrate.

creatine. (N-methyl-N-guanylglycine; (α-methylguanido)acetic acid).
$HN{:}C(NH_2)N(CH_3)CH_2COOH$. A nitrogenous acid widely distributed in the muscular tissue of the body.
Properties: (monohydrate) Prisms from water, anhydrous at 100C, decomposes 303C, slightly soluble in water, insoluble in ether.
Source: Commercially isolated from meat extracts.
Grade: Technical, CP.
Use: Biochemical research.

creatinine. $C_4H_7N_3O$. The anhydride of creatine, a metabolic waste product.
Properties: Colorless to yellow liquid; d 1.092 (25C); mp 5.5C; bp 220C; slightly soluble in water, alcohol, benzene, chloroform, ether, acetic acid.

Creighton process. Electrochemical reduction of sugars, e.g., reduction of glucose, xylose, and galactose to sorbitol, xylitol, and dulcitol.

creosote, coal-tar. (creosote oil; liquid pitch oil; tar oil).
Properties: Yellowish to dark-green-brown, oily liquid; clear at 38C or higher; naphthenic odor; frequently contains substantial amounts of naphthalene and anthracene; distilling range 200–400C; flash p 165F (74C) (CC). Soluble in alcohol, benzene, and toluene; immiscible with water. Autoign temperature 637F (335C), d 1.06–1.10.
Derivation: Fractional distillation of coal tar.
Method of purification: Rectification.
Grade: Technical, crude, refined.
Hazard: Toxic by inhalation of fumes, skin and eye irritant. Use may be restricted.
Use: Wood preservative (ties, telephone poles, marine pilings, etc.), disinfectants, fungicide, biocide.

p-cresidine. See 5-methyl-o-anisidine.

"Creslan" [*American Cyanamid*]. TM for an acrylic fiber.

cresol. (methylphenol; hydroxymethylbenzene; cresylic acid). CAS: 1319-77-3.
$CH_3C_6H_4OH$. A mixture of isomers obtained from coal tar or petroleum.
Properties: Colorless, yellowish, or pinkish liquid; phenolic odor; d 1.030–1.047; wt/gal 8.66–8.68 lb; flash p approximately 180F (82C); mp 11–35C; bp 191–203C. Soluble in alcohol, glycol, dilute alkalies, and water.
Derivation: Coal tar (from coke and gas works), also from toluene by sulfonation or oxidation.
Grade: Various, depending on phenol content or other properties. NF grade contains not more than 5% phenol.
Hazard: Irritant, corrosive to skin and mucous membranes, absorbed via skin. TLV: 5 ppm in air.
Use: Disinfectant, phenolic resins, tricresyl phosphate, ore flotation, textile scouring agent, organic intermediate, manufacture of salicylaldehyde, coumarin, and herbicides, surfactant, synthetic food flavors (para isomer only).
See also cresylic acids.

m-cresol. (m-cresylic acid; 3-methylphenol).
CAS: 108-39-4. $CH_3C_6H_4OH$.
Properties: Colorless to yellowish liquid, phenol-like odor. Soluble in alcohol ether, and chloroform; soluble in water. D 1.034, mp 12C, bp 203C, wt/gal 8.66 lb, flash p 187F (86C), autoign temperature 1038F (558C).
Derivation: By fractional distillation of crude cresol (from coal tar), also synthetically.
Method of purification: Rectification.
Grade: Technical (95–98%).
See cresol.

o-cresol. (o-cresylic acid; 2-methylphenol).
CAS: 95-48-7. $CH_3C_6H_4OH$.
Properties: White crystals, phenol-like odor. Soluble in alcohol, ether, chloroform, and hot water; d 1.047; mp 30.9C; flash p 178F (81C); autoign temperature 1110F (598C); bp 191C; wt/gal 8.68 lb.
Derivation: (1) By fractional distillation of crude cresol from coal tar. (2) Interaction of methanol and phenol.
Method of purification: Crystals.
Grade: According to fp: 25, 29, 30, 30.5C, etc.
See cresol.

p-cresol. (p-cresylic acid; 4-methylphenol).
CAS: 106-44-5. $CH_3C_6H_4OH$.

rather than the random and varying arrangement that characterizes an amorphous polymer. Achievement of this specific steric (three-dimensional) structure (also called tacticity) requires use of special catalysts such as those developed by Ziegler and Natta about 1950. Such polymers are wholly or partially crystalline. Synthetic natural rubber, *cis*-polyisoprene, is an example of a stereospecific polymer made possible by this means. There are five types of stereospecific (or stereoregular) structures: *cis*, *trans*, isotactic, syndiotactic, and tritactic.
See also catalyst, stereospecific.

polymer, syndiotactic. See syndiotactic polymer.

polymer, synthetic. See polymer.

polymer, water-soluble. Any substance of high molecular weight that swells or dissolves in water at normal temperature. These fall into several groups, including natural, semisynthetic, and synthetic products. Their common property of water solubility makes them valuable for a wide variety of applications as thickeners, adhesives, coatings, food additives, textile sizing, etc. See specific entries.

(1) *Natural.* This type is principally comprised of gums, which are complex carbohydrates of the sugar group. They occur as exudations of hardened sap on the bark of various tropical species of trees. All are strongly hydrophilic. Examples are arabic, tragacanth, karaya.

(2) *Semisynthetic.* This group (sometimes called water-soluble resins) includes such chemically treated natural polymers as carboxymethylcellulose, methylcellulose, and other cellulose ethers, as well as various kinds of modified starches (ethers and acetates).

(3) *Synthetic.* The principal members of this class are polyvinyl alcohol, ethylene oxide polymers, polyvinyl pyrrolidone, polyethyleneimine.

polymethacrylate resin. See acrylic resin; methyl methacrylate.

polymethylbenzene. See durene and pseudocumene, the two members of this group with some commercial production and use.

polymethylene polyphenylisocyanate. A polymer of diphenylmethane-4,4′-diisocyanate.

polymethylene wax. See wax, polymethylene.

poly-4-methylpentene-1.
Properties: High resistance to all chemicals except carbon tetrachloride and cyclohexane, excellent heat resistance, high clarity and light transmittance. Temperature limit 170C, d 0.83.
Use: Laboratory ware (beakers, graduates, etc.), electronic and hospital equipment; food packaging, especially types subject to high temperature such as trays for TV dinners, etc.; light reflectors.

poly(methyl vinyl ether). See polyvinyl methyl ether.

polymorphism. See allotropy.

polymyxin. CAS: 1406-11-7. Generic term for a series of antibiotic substances produced by strains of *Bacillus polymyxa*. Various polymyxins are differentiated by the letters A, B, C, D, and E. All are active against certain gram-negative bacteria. Polymyxin B is most used.
Properties: All are basic polypeptides, soluble in water; the hydrochlorides are soluble in water and methanol, insoluble in ether, acetone, chlorinated solvents, and hydrocarbons. Permissible food additives.
Use: Medicine (antibiotic), beer production.

"Poly-N" [*Monsanto*]. (ammonium polyphosphate) CAS: 68333-79-9. TM for chemical used as a phosphorus-based catalyst in organic as well as latex-based products.
Use: In fire-retardant intumescent paints, mastics, and polymers.

polynuclear. Descriptive of an aromatic compound containing three or more closed rings, usually of the benzenoid type, e.g., sterols.
See also polycyclic; nucleus (3).

polyol. A polyhydric alcohol, i.e., one containing three or more hydroxyl groups. Those having three hydroxyl groups (trihydric) are glycerols, those with more than three are called sugar alcohols, with general formula $CH_2OH(CHOH)_nCH_2OH$, where n may be from 2 to 5. These react with aldehydes and ketones to form acetals and ketals.
See also alcohol, glycerol.

polyolefin. A class or group name for thermoplastic polymers derived from simple olefins; among the more important being polyethylene, polypropylene, polybutenes, polyisoprene, and their co-polymers. Many are produced in the form of fibers. This group comprises the largest tonnage of all thermoplastics produced.

polyorganosilicate graft polymer. An organoclay to which a monomer or an active polymer has been chemically bonded, often by the use of ionizing radiation. An example is the bonding of styrene to a polysilicate containing vinyl radicals, resulting in the growth of polystyrene chains from the surface of the silicate. Such complexes are stable to organic solvents. They

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THE MERCK INDEX

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TENTH EDITION

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Published by
MERCK & CO., INC.
RAHWAY, N.J., U.S.A.

1983

3-3-86 $28.50 E.H. Smith (M.G.)
(32.84)

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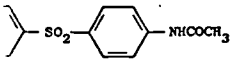
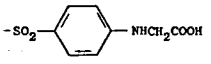
c.3

4',4'''-Sulfonylbisfacetanilide]; bis-
fone; 4,4'-diacetyldiaminodiphenyl
modiphenyl sulfone; *N,N'*-diacetyl-
ulfone; DADDS; diacetyldapsone;
556; Hansolar; Rodilone. $C_{16}H_{16}$-
C 57.82%, H 4.85%, N 8.43%, O
:: Fromm, Wittmann, *Ber.* **41**, 2270
'. *Am. Chem. Soc.* **61**, 2763 (1939);
Chem. **12**, 357 (1969). Properties:
· 206, 630 (1965).



289-92°. uv max (methanol): 256,
0). Soly in water: 0.003 mg/ml; in
% castor oil: 0.026 mg/ml.
arial; antibacterial (leprostatic).

. *N-[4-[(4-Aminophenyl)sulfonyl]-*
lfanilylphenylglycine; p-amino-*p'*-
iphenyl sulfone; 4-carboxymethyl-
vlsulfone; diaminodiphenylsulfone-
$_2O_4S$; mol wt 306.35. C 54.89%, H
89%, S 10.47%. Prepn: Jackson, *J.*
80 (1948); Swiss pats. 254,803 and
to Cilag Ltd.); Rawlins, U.S. pat.
ce, Davis).

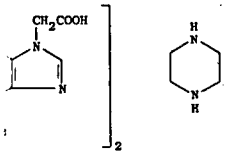


l in methanol, dil sodium hydroxide,

$_2NaO_4S$, *Sulfon-Cilag.* Ingredient of

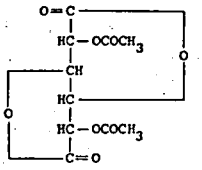
$_{18}H_{23}N_3O_5S$, *Bentrofene.* Glittering
decomp). Prepn: Martin, Habicht,
56 to Cilag Ltd.).
robial.

perazine. *1,2,3,6-Tetrahydro-1,3-di-*
-7-acetic acid piperazine salt; acepi-
ophylline-7-acetate; 7-theophylline-
lt; piperazine theophylline ethanoate;
el; Etaphylline; Etophylate. $C_{22}H_{30}$-
C 46.97%, H 5.38%, N 24.90%, O
. *Bull. Soc. Chim. France* **1949**, 769.



tonic, diuretic, smooth muscle re-

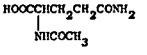
D-*Glucaric acid 1,4:6,3-dilactone di-*
l-D-glucaro-1,4:6,3-dilactone; 2,5-di-
naro-1,4:6,3-dilactone; Aceglaton;
ol wt 258.19. C 46.52%, H 3.90%, O
ucture: Hirasaka, Umemoto, *Chem.*
965), *C.A.* **63**, 3024h (1965); Ishidate
,956('67) (to Tokyo Biochem. Res.
m (1968). Pharmacological studies:
armacol. **15**, 88 (1965), *C.A.* **63**, 5961g
n. Med. Gaz. **8**(8), 15 (1971).



White, odorless and tasteless crystalline powder. mp 185-186° (Hirasaka) from 2:1 ethanol-ethyl acetate; 192° (dec) *(Japan. Med. Gaz.).* Sol in dimethylformamide, sparingly sol in acetone, slightly sol in dioxane, methanol and ethanol. Practically insol in water. LD_{50} in mice, rats: >20, >10 g/kg orally; >20, >10 g/kg s.c.; 5.80-6.35, 6.10-6.15 g/kg i.p.

THERAP CAT: Antineoplastic (to inhibit relapse after surgery for carcinoma of bladder).

20. Aceglutamide. *N^2-Acetyl-L-glutamine; α-N*-acetyl-L-glutamine; Acutil-S. $C_7H_{12}N_2O_4$; mol wt 188.18. C 44.68%, H 6.43%, N 14.88%, O 34.01%. Prepn: P. Karrer *et al., Helv. Chim. Acta* **9**, 301 (1926); Brit. pat. 792,576 (1958 to Merck & Co.), *C.A.* **53**, 2109a (1959); I. J. Maschler, N. Lichtenstein, *Biochim. Biophys. Acta* **57**, 252 (1962). Stability study: G. Sekules, G. Guadagnini, *Farmaco Ed. Prat.* **21**, 22 (1966). NMR study: W. Voelter *et al., Z. Naturforsch. B* **26**, 213 (1971). Fermentation study: T. Nakanishi, *J. Ferment. Technol.* **56**, 573 (1978). Prepn of the aluminum complex: T. Kagawa *et al.*, Ger. pat. 2,127,176 corresp to U.S. pat. 3,787,466 (1971, 1974 both to Kyowa). Effect on exptl chronic gastric ulcer: H. Tanaka *et al., Oyo Yakuri* **7**, 1035 (1973), *C.A.* **81**, 33283v (1974). Physicochemical properties: E. Hayakawa *et al., Yakugaku Zasshi* **97**, 731 (1977), *C.A.* **87**, 141198 (1977).

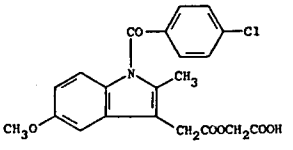


Cryst from ethanol, mp 197°. $[\alpha]_D^{20}$ −12.5° (c = 2.9 in water).

Aluminum complex, $C_{35}H_{59}Al_3N_{10}O_{24}$, *pentakis (N²-acetyl-L-glutaminato)tetrahydroxytrialuminum, aceglutamide aluminum, KW-110, Glumal.* White powder, mp 221° (dec). Sol in water; practically insol in methanol, ethanol, acetone. LD_{50} in male mice, rats (g/kg): 14.3, >14.5 orally; 5.0, 4.2 i.p.; 0.46, 0.40 i.v., T. Kagawa *et al.*, U.S. pat. 3,787,466.

THERAP CAT: Free acid as psychostimulant; aluminum complex as anti-ulcerative.

21. Acemetacin. *1-(4-Chlorobenzoyl)-5-methoxy-2-methyl-1H-indole-3-acetic acid carboxymethyl ester;* [[1-(4-chlorobenzoyl)-5-methoxy-2-methylindol-3-yl]acetoxy]-acetic acid; TV 1322; Rantudil. $C_{22}H_{18}ClNO_6$; mol wt 425.91. C 59.22%, H 6.63%, Cl 8.32%, N 3.29%, O 22.54%. Deriv of indomethacin, *q.v.* Prepn: K. H. Boltze *et al.*, Ger. pat. 2,234,651 corresp to U.S. pat. 3,910,952 (1972, 1975 both to Troponwerke). Series of articles on chemistry, analysis, pharmacodynamics, toxicology and clinical trials: *Arzneimittel-Forsch.* **30**, 1313-1468 (1980).

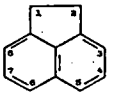


Very fine pale yellow cryst from petr ether, mp 150-153°. LD_{50} in mice, rats: 55.5, 24.2 mg/kg orally (males); 18.42, 30.1 mg/kg orally (females); 34.1, 38.1 mg/kg i.v. (males); 51.1, 28.3 mg/kg i.v. (females), H. Jacobi, H.-D. Dell, *Arzneimittel-Forsch.* **30**, 1398 (1980).

THERAP CAT: Anti-inflammatory.

22. Acenaphthene. *1,2-Dihydroacenaphthylene; peri*-ethylenenaphthalene; 1,8-ethylenenaphthalene. $C_{12}H_{10}$; mol

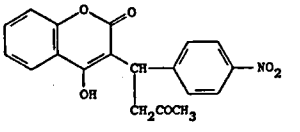
wt 154.21. C 93.46%, H 6.54%. Occurs in coal tar. Isoln: Ges. f. Teerverwertung, Ger. pat. 277,110; *Chem. Zentr.* **1914, II**, 597. In petroleum residues: Orloff *et al., C.A.* **31**, 2800⁹ (1937). By passing ethylene and benzene or naphthalene though a red hot tube: Berthelot, *Bull. Soc. Chim.* [2] **7**, 274; **8**, 226, 245 (1867). By heating tetrahydroacenaphthene with sulfur to 180°: Braun *et al., Ber.* **55**, 1694 (1922). From acenaphthenone or acenaphthenequinone by high pressure hydrogenation in decalin with nickel at 180-240°: Braun, Bayer, *Ber.* **59**, 921, 923 (1926). From acenaphthenone oxime: Morgan, Stanley, *J. Soc. Chem. Ind. (London)* **44**, 494T (1925).



Orthorhombic bipyramidal needles from alcohol. d 1.189. mp 95°. bp 279°. uv spectrum: Seshan, *Proc. Indian Acad. Sci.* **A3**, 148 (1936). Factors influencing the uv spectrum: Jones, *J. Am. Chem. Soc.* **67**, 2127 (1945). Insol in water. One gram dissolves in 31 ml alcohol, 56 ml methanol, 25 ml propanol, 2.5 ml chloroform, 5 ml benzene or toluene. 3.2 g are sol in 100 ml glacial acetic acid. Forms water-sol, cryst complexes with desoxycholic acid, containing two molecules of the bile acid as a rule. The complexes crystallize when concentrated solns of the proper amount of the components in alcohol or dioxane are allowed to cool slowly.

USE: Dye intermediate; manuf plastics; insecticide; fungicide.

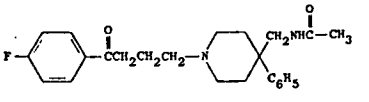
23. Acenocoumarol. *4-Hydroxy-3-[1-(4-nitrophenyl)-3-oxobutyl]-2H-1-benzopyran-2-one; 3-(α-acetonyl-p-nitrobenzyl)-4-hydroxycoumarin;* 3-(α-*p*-nitrophenyl-β-acetylethyl)-4-hydroxycoumarin; acenocoumarin; nicoumalone; G-23350; Sinthrome; Sintrom. $C_{19}H_{15}NO_6$; mol wt 353.32. C 64.58%, H 4.28%, N 3.96%, O 27.17%. Prepn: Stoll, Litvan, U.S. pat. 2,648,682 (1953 to Geigy). Pharmacology: Jindal, Shah, *Arzneimittel-Forsch.* **16**, 878 (1966).



Crystals, mp 196-199°. Almost insol in water or organic solvents. Forms water-sol salt with alkalies. LD_{50} in mice: 114.7 mg/kg i.p.

THERAP CAT: Anticoagulant.

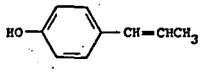
24. Aceperone. *N-[[1-[4-(4-Fluorophenyl)-4-oxobutyl]-4-phenyl-4-piperidinyl]methyl]acetamide; N-[[1-[3-(p-fluorobenzoyl)propyl]-4-phenyl-4-piperidyl]methyl]acetamide;* 1-(*p*-fluorophenyl)-4-(4-phenyl-4-acetamidomethylpiperidino)-1-butanone; 1-[γ-(4-fluorobenzoyl)propyl]-4-acetamidomethyl-4-phenylpiperidine; *N*-[1-[3-(*p*-fluorobenzoyl)propyl]-4-phenylpiperidin-4-ylmethyl]acetamide; 4'-fluoro-4-(4-acetamidomethyl-4-phenylpiperido)butyrophenone; acetabutone; acetobuton; R 3248. $C_{24}H_{29}FN_2O_2$; mol wt 396.51. C 72.70%, H 7.37%, F 4.79%, N 7.07%, O 8.08%. Prepd by reacting γ-chloro-4-fluorobutyrophenone with 4-acetamidomethyl-4-phenylpiperidine: Janssen, Belg. pat. 606,849 (1961), *C.A.* **56**, 12862c (1962). Crystal structure: N. Van Opdenbosch *et al., Acta Crystallogr.* **33B**, 171 (1977).



Crystals, mp 97-100°.

Brilliant prisms from chloroform + methanol, mp 232°. Sol in chloroform, dil HCl. Sparingly sol in methanol.

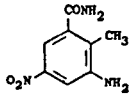
698. p-Anol. *4-(1-Propenyl)phenol; p-propenylphenol;* 4-hydroxy-1-propenylbenzene. $C_9H_{10}O$; mol wt 134.17. C 80.56%, H 7.51%, O 11.93%. Prepn from anethole: Stoermer, Kahlert, *Ber.* 34, 1812 (1901); from 4-propenylphenylmagnesium bromide: Quelet, *Bull. Chim. Soc.* [4] 45, 268 (1929).



Leaflets from boiling water. Weak odor of cloves, resembling that of eugenol. Spicy, pungent taste. mp 93-94°. bp_{760} 250° (dec); bp_{14} 138-140°. Slightly sol in hot water. Freely sol in dimethylformamide, other organic solvents. Sol in aq solns of KOH and NaOH.

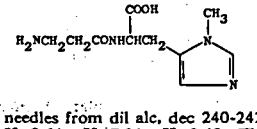
USE: Intermediate in the synthesis of estrogens.

699. Anot. *3-Amino-2-methyl-5-nitrobenzamide; 3-amino-5-nitro-o-toluamide.* $C_8H_9N_3O_3$; mol wt 195.18. C 49.23%, H 4.65%, N 21.53%, O 24.59%. Major metabolite of chickens on a zoalene diet. Isoln procedure: Thiegs *et al., J. Agr. Food Chem.* 9, 201 (1961).



Golden-yellow crystals, mp 198.5-199.5°. Slightly sol in water (less than 1%).

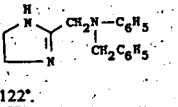
700. Anserine. *N-β-Alanyl-3-methyl-L-histidine; α-(β-*aminopropionylamino)-β-(1-methyl-5-imidazolyl)propionic acid; 3-methyl-*N,α*-(β-alanyl)-L-histidine. $C_{10}H_{16}N_4O_3$; mol wt 240.26. C 49.99%, H 6.71%, N 23.32%, O 19.98%. First found in muscles of geese, later in many more animals, but not in man, beef, horse, or dog. Isoln: Ackermann, *Z. Physiol. Chem.* 183, 1 (1929); Wolff, Wilson, *J. Biol. Chem.* 109, 565 (1935). Synthesis: Behrens, du Vigneaud, *J. Biol. Chem.* 120, 517 (1937); Rinderknecht *et al., J. Org. Chem.* 29, 1968 (1964). *Review:* M. Guggenheim, *Die biogenen Amine* (Karger, Basel—New York, 4th ed., 1951) pp 439-446, 502.



L-Form, needles from dil alc, dec 240-242°. $[\alpha]_D^{20}$ +12.3° (c = 5). pK_1 2.64; pK_2 7.04; pK_3 9.49. The dried material is very hygroscopic. Freely soluble in water. Slightly sol in methanol, even less in ethanol.

Nitrate, $C_{10}H_{16}N_4O_3 \cdot HNO_3$, needles from dil methanol, mp 226-228°.

701. Antazoline. *4,5-Dihydro-N-phenyl-N-(phenylmethyl)-1H-imidazole-2-methanamine; 2-(N-benzylanilinomethyl)-2-imidazoline;* phenazoline; 2-(*N*-phenyl-*N*-benzylaminomethyl)imidazoline; imidamine; 5512-M; Antistine; Antistin; Histostab; Antastan; Antasten; Antihistal; Azalone; Ben-a-hist. $C_{17}H_{19}N_3$; mol wt 265.35. C 76.94%, H 7.22%, N 15.84%. Prepd by the condensation of benzylaniline with 2-(chloromethyl)imidazoline: Miescher, Klarer, U.S. pat. 2,449,241 (1948 to Ciba).



Crystals, mp 120-122°.

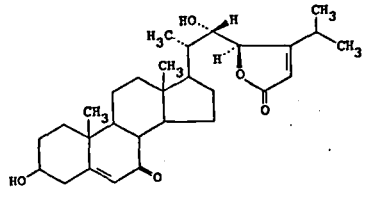
Hydrochloride, $C_{17}H_{20}ClN_3$, *Fenazolina, Histazine.* Bitter crystals producing temporary numbness of the tongue. mp 237-241°. uv max: 242 nm ($E^{1\%}_{1cm}$ 495 to 515); min 222 nm. One gram dissolves in 40 ml water, in 25 ml alc. Practically insol in ether, benzene, chloroform. pH (1% aq soln): 6.3.

Phosphate, $C_{17}H_{19}N_3 \cdot H_3PO_4$, crystals. Bitter taste. mp 194-198°. Sol in water. Sparingly sol in methanol. Practically insol in benzene, ether. pH (2% aq soln): 4.5.

THERAP CAT: Antihistaminic.

THERAP CAT (VET): Antihistaminic.

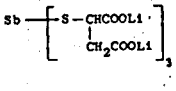
702. Antheridiol. *3,22,23-Trihydroxy-7-oxostigmasta-5,24(28)-dien-29-oic acid γ-lactone;* 3β,22,23-trihydroxy-24-(carboxymethylene)cholest-5-en-7-one 23,24-lactone; Hormone A. $C_{29}H_{42}O_5$; mol wt 470.66. C 74.01%, H 8.99%, O 17.00%. The first specific functioning sex hormone to be identified in the plant kingdom. A diffusible substance secreted by the female mycelium of the filamentous water molds *Achlya bisexualis* and *A. ambisexualis,* which induces the growth of antheridial hyphae in the male plant, thereby initiating sexual reproduction in the species. Isoln and preliminary chemical data: Raper, Haagen-Smit, *J. Biol. Chem.* 143, 311 (1942). Isoln of crystalline material: McMorris, Barksdale, *Nature* 215, 320 (1967). Structure: Arsenault *et al., J. Am. Chem. Soc.* 90, 5635 (1968). Synthesis: Edwards *et al., ibid.* 91, 1248 (1969); Fried, Edwards, U.S. pat. 3,547,911 (1970 to Syntex). Stereochemical proposal: Green *et al., Tetrahedron* 27, 1199 (1971). Absolute stereochemistry and alternate syntheses: Edwards *et al., Tetrahedron Letters* 1972, 791; T. C. McMorris *et al., ibid.* 2673; *eidem, J. Org. Chem.* 39, 669 (1974). *Reviews:* Barksdale, *Ann. N.Y. Acad. Sci.* 144, 313-319 (1967); *idem, Science* 166, 831-837 (1969); T.C. McMorris, *Lipids* 13, 716-722 (1978).



Colorless crystals from methanol, mp 250-255°. uv max (ethanol): 220 nm (ε 17,000). Sol in hot methanol. Slightly sol in chloroform; very slightly sol in water. Has extremely high specific biological activity even at conc of 2×10^{-8} mg/ml (McMorris, Barksdale, *loc. cit.*).

USE: Control and regulation of plant fertility: Fried, Edwards, *loc. cit.*

703. Anthiolimine. *2,2',2''-[Stibilidynetris(thio)]tris-butanedioic acid hexalithium salt; mercaptosuccinic acid antimonate(III) hexalithium salt;* mercaptosuccinic acid *S*-antimony derivative lithium salt; lithium antimoniothiomalate; lithium antimony thiomalate; Anthiomaline. $C_{12}H_9Li_6O_{12}S_3Sb$; mol wt 604.78. C 23.83%, H 1.50%, Li 6.88%, O 31.75%, S 15.91%, Sb 20.13%. Prepn: Delepine, Gaillot, U.S. pat. 2,060,181 (1937 to Rhône-Poulenc).

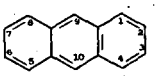


Enneahydrate, hygroscopic powder. Very soluble in water; very slightly sol in alcohol, ether.

THERAP CAT: Anthelmintic.

704. Anthracene. $C_{14}H_{10}$; mol wt 178.22. C 94.34%, H 5.66%. Obtained from coal tar: Dumas, Laurent, *Ann.* 5, 10 (1833); Laurent, *Ann.* 34, 287 (1840); Anderson, *Ann.* 122, 294 (1862); *J. Chem. Soc.* 15, 44 (1862); Auerbach, *Das Anthracen und seine Derivate* (Braunschweig, 1880); Perkin, *J. Soc. Arts* 27, 572 (1879); Lunge, *Coal Tar and Ammonia* (1916); Barnett, *Anthracene and Anthraquinone* (London, 1921); Nanson, *Textile Colorist* 48, 605, 678, 751 (1926); 49, 19, 246, 557, 593 (1927); Houben, Fischer, *Das Anthracen und die Anthrachinone* (Leipzig, 1929); Borrmann, *Der Teer*

(Leipzig, 1940); Schumann, *Kokereiteer* (Stuttgart, 1940). Extensive patent literature on purification. Prepn of very pure anthracene from synthetic anthraquinone: Clar, *Ber.* 72, 1645 (1939). *Review:* E. Clar, *Polycyclic Hydrocarbons* 2 vols. (Academic Press, New York, 1964).

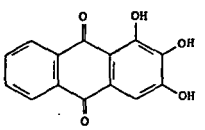


Monoclinic plates from alc. Sublimes. When pure, colorless with violet fluoresence; when impure (due to tetracene, naphthacene), yellow with green fluorescence. Strongly triboluminescent and triboelectric. d_4^{17} 1.25. mp 218°. bp_{760} 342°. Absorption spectrum: Clar, *Ber.* 65, 506 (1932). Less soluble than the isomeric phenanthrene. Insol in water; one gram dissolves in 67 ml abs alcohol, 70 ml methanol, 62 ml benzene, 85 ml chloroform, 200 ml ether, 31 ml carbon disulfide, 86 ml carbon tetrachloride, 125 ml toluene. Anthracene darkens in sunlight. According to Downs, U.S. pat. 1,303,639 (1919), when solns of crude anthracene in coal tar naphtha are exposed to ultraviolet irradiation, the anthracene is precipitated as dianthracene (*para*-anthracene) which is reconverted to anthracene by sublimation.

Forms molecular addn products with nitro compounds. Picric acid complex, mp 139°; *sym*-trinitrobenzene complex, mp 164°; trinitrotoluene complex, mp 162°.

USE: Important source of dyestuffs (manuf anthraquinone, alizarin dyes).

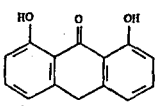
705. Anthragallol. *1,2,3-Trihydroxy-9,10-anthracenedione;* 1,2,3-trihydroxyanthraquinone; anthragallic acid; anthracene brown. $C_{14}H_8O_5$; mol wt 256.20. C 65.63%, H 3.15%, O 31.22%. From gallic acid and benzoic acid with sulfuric acid at 125° or from phthalic anhydride and pyrogallol with sulfuric acid at 160°: Seuberlich, *Ber.* 10, 39 (1877). Other methods: Kubota, Perkin, *J. Chem. Soc.* 127, 1889 (1925); Perkin, Story, *ibid.* 1929, 1399; Cross, Perkin, *ibid.* 1930, 292.



Brown crystals, mp 312-313°. Sublimes 290°. Absorption spectrum: Meyer, Fischer, *Ber.* 46, 85 (1913). Slightly sol in water, chloroform; sol in alcohol, ether, glacial acetic acid. Its soln in concd H_2SO_4 is reddish-brown. Greenish-brown soln in ammonia water changes to blue on heating. Forms salts with Na, K, Ba, Tl, Pb, La, Ce, Nd, Co.

Trimethyl ether, $C_{17}H_{14}O_5$, yellow needles from benzene + petr ether, mp 168°. Insol in water solns of alkalies.

706. Anthralin. *1,8-Dihydroxy-9(10H)-anthracenone; 1,8-dihydroxyanthrone;* dithranol; Anthra-Derm; Antraderm; Batidrol; Cignolin; Cigthranol; Dithrocream; Psoradrate; Psoriacide. $C_{14}H_{10}O_3$; mol wt 226.22. C 74.33%, H 4.45%, O 21.22%. Prepd from chrysazin by reduction with hydrogen and nickel catalyst at high pressure: Zahn, Koch, *Ber.* 71B, 172 (1938). Revised structure: H. M. Avdovich, G. A. Neville, *Can. J. Spectrosc.* 25, 110 (1980); F. R. Ahmed, *Acta Crystallogr.* B36, 3184 (1980).



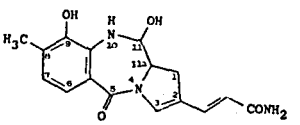
Lemon yellow leaflets or needles from ligroin, mp 176-181°. Practically insol in water. Freely sol in chloroform. Sol in acetone, benzene, pyridine, oils. Slightly sol in alcohol, ether, glacial acetic acid. Sol in dil NaOH with yellow color and green fluorescence. Under the influence of air, alkaline solns turn red and lose their fluorescence.

Triacetate, $C_{20}H_{16}O_6$, *1,8,9-anthracenetriol triacetate, 1,8,9-triacetoxyanthracene, Exolan.*

THERAP CAT: Antipsoriatic.

THERAP CAT (VET): Antifungal.

707. Anthramycin. *3-(5,10,11,11a-Tetrahydro-9,11-dihydroxy-8-methyl-5-oxo-1H-pyrrolo[2,1-c][1,4]benzodiazepin-2-yl)-2-propenamide; 5,10,11,11a-tetrahydro-9,11-dihydroxy-8-methyl-5-oxo-1H-pyrrolo[2,1-c][1,4-]benzodiazepin-2-acrylamide.* $C_{16}H_{17}N_3O_4$; mol wt 315.32. C 60.94%, H 5.43%, N 13.33%, O 20.30%. From *Streptomyces refuineus* var *thermotolerans*, NRRL 3143: Leimgruber *et al.*, *J. Am. Chem. Soc.* 87, 5791 (1965); Berger *et al.*, U.S. pat. 3,361,742 (1968 to Hoffmann-La Roche). Also produced by *Streptomyces spadicogriseus:* N. Komatsu *et al.*, *J. Antibiot.* 33, 54 (1980). Structure: Leimgruber *et al.*, *J. Am. Chem. Soc.* 87, 5793 (1965). Synthesis: *eidem, ibid.* 90, 5641 (1968); Batcho, Leimgruber, U.S. pat. 3,524,849 (1970 to Hoffmann-La Roche). Activity studies: Horwitz, Grollman, *Antimicrob. Ag. Chemother.* 1968, 21. Biosynthesis: L. H. Hurley *et al.*, *J. Am. Chem. Soc.* 97, 4372 (1975). *Review:* Kohn in *Antibiotics* vol. 3, J. W. Corcoran, F. E. Hahn, Eds. (Springer-Verlag, New York, 1975) pp 3-11.

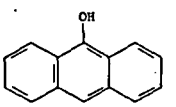


Yellow prisms from acetone + water, dec 188-194°. uv max (acetonitrile): 235, 333 nm (ε 18,200, 31,800). $[\alpha]_D$ +930° (DMF).

Methyl ether hydrate, $C_{17}H_{19}N_3O_4 \cdot H_2O$, pale yellow needles from methanol + water, dec above 120°.

THERAP CAT: Antineoplastic.

708. Anthranol. *9-Anthracenol; 9-anthrol;* 9-hydroxyanthracene. $C_{14}H_{10}O$; mol wt 194.22. C 86.57%, H 5.19%, O 8.24%. Prepd by dissolving anthrone in 5 to 10% boiling NaOH soln, cooling to −5° and pouring in cooled 5% H_2SO_4: Meyer, *Ann.* 379, 56 (1911). Also prepared from anthraquinone.



Needles from glacial acetic acid, plates from dil alcohol. Orthorhombic, mp 120° (if bath is heated to 110°). Sinters at 120°, mp 152° (if bath is cold at start). Absorption spectrum (of acetate): Barnett *et al.*, *J. Chem. Soc.* 1928, 885. Sol in most solvents with blue fluorescence. The solid is fairly stable when kept dry. In solution it changes quickly to anthrone. Recrystallizations of anthranol may lead to a less pure compound.

Acetate, $C_{16}H_{12}O_2$, crystals from petr ether, mp 134°.

Benzoate, $C_{21}H_{14}O_2$, crystals from pyridine + alcohol, mp 170-172°.

Methyl ether, $C_{15}H_{12}O$, crystals from alcohol, mp 97-98°.

Ethyl ether, $C_{16}H_{14}O$, crystals from methanol, mp 73°.

USE: In the manuf of dyes.

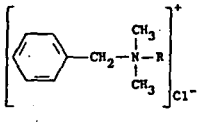
709. Anthraquinone. *9,10-Anthracenedione;* 9,10-anthraquinone; 9,10-dioxoanthracene; Morkit. $C_{14}H_8O_2$; mol wt 208.20. C 80.76%, H 3.87%, O 15.37%. Produced industrially from phthalic anydride and benzene in the presence of aluminum chloride by a Friedel-Crafts reaction: Klipstein, *Ind. Eng. Chem.* 18, 1327 (1926). From anthracene with vanadium pentoxide, sodium chlorate, glacial acetic and sulfuric acids: *Org. Syn.* coll. vol. II, 554 (1943). Convenient lab procedure: L. F. Fieser, *Organic Experiments* (Heath & Co., Boston, 1964) pp 195-200. *Reviews:* de Barry, Bar-

Strongly refractive liquid, becoming yellowish on keeping; characteristic odor of volatile oil of almond; burning aromatic taste. Oxidizes in air to benzoic acid; volatile with steam. d_4^{15} 1.050; 1.043 at 25°. bp 179°. Solidif −56.5°. Flash pt 62°. n_D^{20} 1.5456. Sol in 350 parts water; miscible with alcohol, ether, oils. It reduces ammoniacal $AgNO_3$, but not Fehling's soln. *Keep tightly closed and protected from light.* LD_{50} orally in rats, guinea pigs: 1300, 1000 mg/kg, P. M. Jenner *et al., Food Cosmet. Toxicol.* 2, 327 (1964).

Note: Benzaldehyde FFC designates a grade of benzaldehyde free from chlorine.

USE: Manufacture of dyes, perfumery, cinnamic and mandelic acids, as solvent; in flavors. *Caution:* Narcotic in high concns. May cause contact dermatitis.

1055. Benzalkonium Chloride. Zephiran Chloride; Zephirol; BTC; Roccal; Benirol; Enuclen; Germitol; Drapolene; Drapolex; Cequartyl; Paralkan; Germinol; Rodalon; Osvan. A mixture of alkyldimethylbenzylammonium chlorides of the general formula in which R represents a mixture of the alkyls from C_8H_{17} to $C_{18}H_{37}$.



White or yellowish-white, amorphous powder or gelatinous pieces. Aromatic odor, very bitter taste. Very sol in water, alcohol, acetone; slightly sol in benzene. Almost insol in ether. The aq soln is slightly alkaline to litmus and foams strongly when shaken. LD_{50} orally in rats: 400 mg/kg, L. M. Cummins, E. T. Kimura, *Toxicol. Appl. Pharmacol.* 20, 89 (1971).

Incompatible with anionic detergents, such as soap, and with nitrates. A white precipitate is formed in a 1:3000 aq soln of benzalkonium chloride when nitrates are present in concns greater than the equiv. of 0.5% ammonium nitrate.

Dibromide, *Callusolve.* Adduct of benzalkonium chloride with bromine which is insol in water and non-ionized.

USE: Cationic surface active agent and germicide.

THERAP CAT: Topical anti-infective.

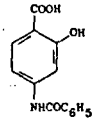
THERAP CAT (VET): Antiseptic for skin preoperatively or for wounds, burns, etc. Udder wash.

1056. Benzamide. Benzoylamide. C_7H_7NO; mol wt 121.13. C 69.41%, H 5.82%, N 11.56%, O 13.21%. $C_6H_5CONH_2$. Prepd from benzoyl chloride and ammonium carbonate. Lab prepn: Gattermann-Wieland, *Praxis des organischen Chemikers* (de Gruyter, Berlin, 40th ed., 1961) p 119. Alternate procedure using concd ammonia soln: A. I. Vogel, *Practical Organic Chemistry* (Longmans, London, 3rd ed., 1959) p 797.

Crystals. d^4 1.341. mp 130°. bp 288°. One gram dissolves in 74 ml water, more sol in boiling water, in 6 ml alc, 3.3 ml pyridine. Sol in hot benzene, slightly in ether; sol in ammonia with formation of a small quantity of benzonitrile.

N-chloro deriv, mp 116°. Sol in water; insol in alcohol or benzene.

1057. 4-Benzamidosalicylic Acid. *4-(Benzoylamino)-2-hydroxybenzoic acid; N*-benzoyl-*p*-aminosalicylic acid; benzoylpas. $C_{14}H_{11}NO_4$; mol wt 257.25. C 65.36%, H 4.31%, N 5.45%, O 24.88%. Prepn: Drain *et al., J. Chem. Soc.* 1949, 1498; Brit. pat. 676,363 (1952 to Wander). Prepn of sodium and calcium salts: Suddaby, Sumpter, Brit. pat. 711,163 (1954 to Herst).



Crystals, mp 260-261°.

Sodium salt, $C_{14}H_{10}NNaO_4$, *BPAS*, white powder.

Calcium salt, $C_{28}H_{20}CaN_2O_8$, *benzoylpas calcium, Benzapas, Benzacyl, B-Paracipan, Therapas.* Pentahydrate, white powder or crystals. *Iso-Benzacyl* is a mixture of the calcium salt and isoniazid, *q.v.*

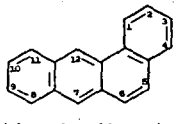
THERAP CAT: Antibacterial (tuberculostatic).

1058. Benzanilide. *N-Phenylbenzamide; N*-benzoylaniline. $C_{13}H_{11}NO$; mol wt 197.23. C 79.16%, H 5.62%, N 7.10%, O 8.11%. $C_6H_5CONHC_6H_5$. Prepd by the treatment of aniline with benzoic acid: Hübner, *Ann.* 208, 291 (1881); Nägeli, *Bull. Soc. Chim.* [3] 11, 892 (1894); Webb, *Org. Syn.* 7, 6 (1927); coll. vol. I (2nd ed., 1941) p 82.

Leaflets from alc. d 1.315. mp 163°. Sublimes. Distills without decompn. bp_{10} 117-119°. Absorption spectrum: Crymble, *J. Chem. Soc.* 99, 459 (1911). Insoluble in water. One gram dissolves in 60 ml alc, 7 ml boiling alc. Slightly sol in ether.

USE: Manuf dyes and perfumes.

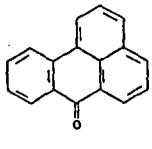
1059. 1,2-Benzanthracene. *Benz[a]anthracene;* 2,3-benzphenanthrene; tetraphene; benzanthrene; naphthanthracene. $C_{18}H_{12}$; mol wt 228.28. C 94.70%, H 5.30%. Occurs in coal tar: Cook *et al., J. Chem. Soc.* 1933, 395. Synthesis from naphthalene and phthalic anhydride: Elbs, *Ber.* 19, 2209 (1886). From *o*-toluylnaphthalene: Fieser, Dietz, *Ber.* 62, 1827 (1929). From phenanthrene and succinic anhydride: Haworth, Mavin, *J. Chem. Soc.* 1933, 1012. *Review:* E. Clar, *Polycyclic Hydrocarbons* (Academic Press, New York, 1964) 2 vols.



Plates from glacial acetic acid or alc. Greenish-yellow fluorescence. Sublimes. mp 155-157° (Fieser, Dietz); mp 160° [Fieser, Hershberg, *J. Am. Chem. Soc.* 59, 2502 (1937)]; mp 167° (I. G. Farbenind., Ger. pats. 481,819; 486,766). Absorption spectrum: Capper, Marsh, *J. Chem. Soc.* 1926, 726; Clar, *Ber.* 65, 507 (1932); Mayneord, Roe, *Proc. Roy. Soc. London* A152, 299 (1935). Difficultly sol in boiling alc; sol in most other organic solvents; insol in water.

Note: This substance has been listed as a carcinogen by the EPA: *Second Annual Report on Carcinogens* (NTP 81-43, Dec. 1981) pp 44-46.

1060. Benzanthrone. *7H-Benz[de]anthracen-7-one.* $C_{17}H_{10}O$; mol wt 230.25. C 88.67%, H 4.38%, O 6.95%. Prepd by heating a reduction product of anthraquinone with sulfuric acid and glycerol: Macleod, Allen, *Org. Syn.* 14, 4 (1934); *cf.* U.S. pat. 1,626,392 (1927).



Pale yellow needles from alcohol or xylene. mp 170°. Absorption spectrum: Clar, *Ber.* 65, 846 (1932). Solubility at 20° = 0.52 g in 100 g glacial acetic acid; 1.61 g in 100 g benzene; 2.05 g in 100 g chlorobenzene. Solution in H_2SO_4 is orange with green fluorescence.

1061. Benzarone. *(2-Ethyl-3-benzofuranyl)(4-hydroxy-*

Liquid, odor of volatile oil of almond. bp_{760} 190.7°, bp_{100} 123.5°, bp_{10} 69.2°, bp_1 28.2°. fp −12.75°. d_{15}^{15} 1.010. n_D^{20} 1.5289. Fire pt, 167°F. Slightly sol in cold water; sol to the extent of 1% in water at 100°; miscible with common organic solvents. LD s.c. in mice: 180 mg/kg.

USE: Solvent.

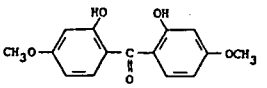
1101. Benzophenone. *Diphenylmethanone;* diphenyl ketone; benzoylbenzene. $C_{13}H_{10}O$; mol wt 182.21. C 85.69%, H 5.53%, O 8.78%. $C_6H_5COC_6H_5$. Prepd by the Friedel-Crafts ketone synthesis from benzene and benzoyl chloride in the presence of $AlCl_3$: Marvel, Sperry, *Org. Syn.* coll. vol. I (Wiley, New York, 2nd ed., 1941) p 95. By decarboxylation of *o*-benzoylbenzoic acid in the presence of copper catalyst: L. F. Fieser, *Organic Experiments* (D. C. Heath & Co., Boston, 1964) pp 201-203.

Stable form (there are two other labile forms), orthorhombic bisphenoidal prisms from alcohol or ether. Geranium-like odor. d_4^{18} 1.1108. d_4^{50} 1.0869. $n_D^{45.2}$ 1.5975. Absorption spectrum: Purvis, McCleland, *J. Chem. Soc.* **101**, 1516 (1912). mp 48.5°. bp_{760} 305.4°; bp_{400} 276.8°; bp_{200} 249.8°; bp_{100} 224.4°; bp_{60} 208.2°; bp_{40} 195.7°; bp_{20} 175.8°; bp_{10} 157.6°; bp_5 141.7°; $bp_{1.0}$ 108.2°. Insoluble in water. One gram dissolves in 7.5 ml alcohol, 6 ml ether; sol in chloroform.

Oxime. $C_{13}H_{11}NO$, for prepn *see Org. Syn.* **10**, 10. Crystals from ligroin, mp 143-144°. Freely sol in ether, acetone.

USE: Fixative for heavy perfumes, such as geranium, new-mown hay, especially when used in soaps. In the manuf of antihistamines, hypnotics, insecticides.

1102. Benzophenone-6. *Bis(2-hydroxy-4-methoxyphenyl)methanone; 2,2'-dihydroxy-4,4'-dimethoxybenzophenone;* Uvinul D49. $C_{15}H_{14}O_5$; mol wt 274.26. C 65.69%, H 5.15%, O 29.16%. Preparation: Grover *et al., J. Chem. Soc.* **1955**, 3982; Hardy, Forster, U.S. pat. 2,773,903 (1956 to Am. Cyanamid); Dayan, Roberts; Hahn, Stanley, U.S. pats. 2,853,522 and 2,853,523 (both 1958 to Gen. Aniline); Hosler, Storfer, U.S. pat. 2,928,878 (1960 to Am. Cyanamid).



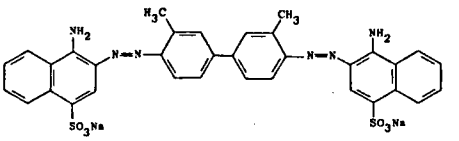
Crystals, mp 139-140°. uv max: 284, 340 nm (log ε 4.12, 4.12).

USE: As ultraviolet light absorber, esp in paints, plastics.

1103. Benzopinacol. *1,1,2,2-Tetraphenyl-1,2-ethanediol;* benzpinacone; tetraphenylethylene glycol. $C_{26}H_{22}O_2$; mol wt 366.44. C 85.22%, H 6.05%, O 8.73%. $(C_6H_5)_2C(OH)$-$C(OH)(C_6H_5)_2$. Prepd by photochemical reduction of benzophenone: Bachmann, *Org. Syn.* coll. vol. II, 71 (1943); L. F. Fieser, *Organic Experiments* (D. C. Heath & Co., Boston, 1964) p 203. By the action of phenylmagnesium bromide on benzil: Acree, *Ber.* **37**, 2761 (1904).

Monoclinic prisms, may contain 1 mol C_6H_6 when crystallized from benzene. mp 197° (open capillary, rapid heating); mp 222° (copper block). On heating to mp it dec to benzophenone and benzohydrol. Soluble in 11.5 parts boiling glacial acetic acid; in 26 parts boiling benzene; in 39 parts boiling 95% alcohol. Freely sol in ether, carbon bisulfide, chloroform.

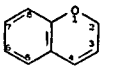
1104. Benzopurpurine 4B. *3,3'-[(3,3'-Dimethyl[1,1'-biphenyl]-4,4'-diyl)bis(azo)]bis[4-amino-1-naphthalenesulfonic acid] disodium salt; C.I. Direct Red 2;* disodium *o*-tolidinediazobis(1-naphthylamine-4-sulfonate); azamin 4B; C.I. 23500; cotton red 4B; eclipse red; fast scarlet. $C_{34}H_{26}N_6Na_2O_6S_2$; mol wt 724.74. C 56.35%, H 3.62%, N 11.60%, Na 6.34%, O 13.25%, S 8.85%. Prepd from diazotized *o*-tolidine and sodium 4-amino-1-naphthalenesulfonate: Ger. pat. 35,615 (1885 to A. G. für Anilinfabrikation Berlin), *Frdl.* **1**, 473; F. J. Welcher, *Organic Analytical Reagents* vol. 4 (Van Nostrand Co., New York, 1948) pp 338-339; *Colour Index* vol. 4 (3rd ed., 1971) p 4189. *See also H. J. Conn's Biological Stains* (Williams & Wilkins, Baltimore, 1969) pp 114-115.



Brown powder. Soluble in water, sodium hydroxide, sulfuric acid, ethanol, acetone, Cellosolve; practically insol in other organic solvents.

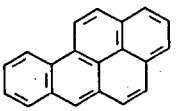
USE: For dyeing primarily cotton and viscose rayon: *Colour Index* vol. 2 (3rd ed., 1971) p 2101. As an analytical reagent in detection of Al, Mg, Hg, Ag, U; as a biological stain; as pH indicator, violet 1.2 to red 4.0.

1105. 1,2-Benzopyran. *2H-1-Benzopyran; α-5:6-benzopyran;* 1,2-chromene; 3-chromene. C_9H_8O; mol wt 132.15. C 81.79%, H 6.10%, O 12.11%. Prepn from *cis-o*-hydroxycinnamyl alcohol: Chatterjea, *J. Indian Chem. Soc.* **36**, 76 (1959), *C.A.* **54**, 519b (1960); from phenyl propargyl ether in diethylphenylamine: Iwai, Ide, *Chem. Pharm. Bull.* **11**, 1042 (1963); Iwai, Iwade, Japan. pat. 22,587('63) (to Sankyo), *C.A.* **60**, 2901e (1964). Earlier prepns: Maitte, *Ann. Chim. (Paris)* **9**, 431 (1954); Normant, Maitte, *Compt. Rend.* **234**, 1787 (1952).



Liquid; bp_{102} 132°, bp_{15} 92-92.5°, bp_{13} 91°, bp_9 77°. d^{16} 1.0993. n_D^{24} 1.5869; n_D^{16} 1.5923 (Maitte, *loc. cit.*); also reported as 1.5837 (Japan. pat. *see above*).

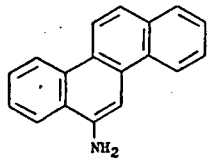
1106. Benzo[*a*]pyrene. 3,4-Benzpyrene. $C_{20}H_{12}$; mol wt 252.30. C 95.21%, H 4.79%. Formerly called *1,2-benzpyrene.* Occurs in coal tar. Isoln by fractionation: Cook *et al., J. Chem. Soc.* **1933**, 395; by adsorption and fluorimetric determination: Hieger, *Am. J. Cancer* **29**, 705 (1937); Winterstein *et al., Z. Physiol. Chem.* **230**, 158, 169 (1934); *Naturwiss.* **22**, 237 (1934). Synthesis from pyrene and succinic anhydride: Cook, Hewett, *J. Chem. Soc.* **1933**, 398; Fieser, Fieser, *J. Am. Chem. Soc.* **57**, 782 (1935); Winterstein *et al., Ber.* **68**, 1079 (1935); Fieser *et al., J. Am. Chem. Soc.* **57**, 1509 (1935). *Review:* Clar, *Polycyclic Hydrocarbons* (Academic Press, New York, 1964), 2 vols. Review of carcinogenicity studies: *IARC Monographs* **3**, 91-136 (1973). Inhibition of the mutagenicity of the ultimate carcinogenic metabolite of benzo[*a*]pyrene by ellagic acid: A. W. Wood *et al., Proc. Nat. Acad. Sci. USA* **79**, 5513 (1982). Study of the reaction between this metabolite (*benzo[a]pyrene-7,8-diol 9,10-epoxide*) and ellagic acid: J. M. Sayer *et al., J. Am. Chem. Soc.* **104**, 5562 (1982).



Yellowish plates, needles from benzene + methanol, mp 179-179.3°. Crystals may be monoclinic or orthorhombic. bp_{10} 310-312°. Absorption spectrum: Mayneord, Roe, *Proc. Roy. Soc. London* **A152**, 299 (1935). Violet fluorescence of dil benzene solns: Hieger, *loc. cit.* Soluble in benzene, toluene, xylene; sparingly sol in alc, methanol; practically insol in water.

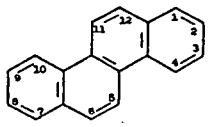
Note: This substance has been listed as a carcinogen by the EPA: *Second Annual Report on Carcinogens* (NTP 81-43, Dec. 1981) pp 55-57.

1107. Benzo[*e*]pyrene. 1,2-Benzpyrene; 4,5-benzpyrene. $C_{20}H_{12}$; mol wt 252.30. C 95.21%, H 4.79%. Constituent of coal tar. Isoln: Cook *et al., J. Chem. Soc.* **1933**, 396. Synthesis: Cook, Hewett, *ibid.* 398; Clar, *Ber.* **76**, 609 (1943); Buchta, Kröger, *Ann.* **705**, 190 (1967). NMR spectra:



Leaflets from alc, mp 210-211°. Slightly sol in alcohol, benzene, ethyl acetate.
USE: In biochemical research to produce leukopenia.

2235. Chrysene. 1,2-Benzphenanthrene. $C_{18}H_{12}$; mol wt 228.28. C 94.70%, H 5.30%. Occurs in coal tar. Is formed during distillation of coal, in very small amount during distillation or pyrolysis of many fats and oils. Isoln from coal tar: Liebermann, *Ann.* **158**, 299, 307 (1871). Purification by chromatography: Winterstein, Schön, *Z. Physiol. Chem.* **230**, 146 (1934); Winterstein *et al., ibid.* 158. Synthesis by heating H_2 and acetylene to 800°: Meyer, *Ber.* **45**, 1633 (1912). From cholesterol on heating with palladium charcoal or activated charcoal: Schmid, Zentner, *Monatsh.* **49**, 96 (1928).

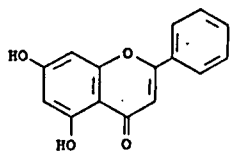


Orthorhombic bipyramidal plates from benzene. d_4^{20} 1.274. mp 254°. Sublimes easily *in vacuo.* bp 448°. Strong fluorescence under ultraviolet light. Absorption spectrum: Marchlewski, Moroz, *Bull. Soc. Chim. France* [4] **33**, 1406 (1923). Slightly sol in alc, ether, carbon bisulfide, glacial acetic acid. At 25° one gram dissolves in 1300 ml abs alc, 480 ml toluene. About 5% is sol in toluene at 100°. Moderately sol in boiling benzene. Insol in water. Chrysene is generally only slightly sol in cold organic solvents, but fairly sol in these solvents when hot, including glacial acetic acid.

2236. Chrysergonic Acid. $C_{32}H_{30}O_{14}$; mol wt 638.59. C 60.19%, H 4.74%, O 35.08%. Yellow pigment from ergot. Diastereoisomer of secalonic acids, *q.v.* For isoln and structure *see* secalonic acids.

Pale yellow needles from chloroform, mp 268-270°; pale yellow plates from glacial acetic acid, mp 250-257°. $[\alpha]_D^{20}$ $-3° \rightarrow +34°$ (c = 1.11 in pyridine). uv max (glacial acetic acid): 335 nm (log ε 4.57). One part sol in 1000 parts boiling chloroform; in 800-1000 parts boiling glacial acetic acid.

2237. Chrysin. *5,7-Dihydroxy-2-phenyl-4H-1-benzopyran-4-one; 5,7-dihydroxyflavone;* chrysidenon 1438. $C_{15}H_{10}O_4$; mol wt 254.23. C 70.86%, H 3.96%, O 25.17%. From heartwood of *Pinus monticola* Dougl., *P. excelsa* Wall., and *P. aristata* Engelm., *Pinaceae:* Linstedt, *Acta Chem. Scand.* **3**, 1147, 1375 (1949); **4**, 55 (1950); from bark of *Dolichandrone falcata* Seem., *Bisnomiaceae:* Kincl, *Naturwiss.* **42**, 646 (1955). Synthesis: Seka, Prosche, *Monatsh.* **69**, 284 (1936); Hutchins, Wheeler, *J. Chem. Soc.* **1939**, 91; Teoule *et al., Bull. Soc. Chim. France* **1961**, 546.



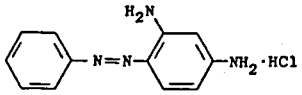
Light yellow prisms from methanol, mp 285°. uv max: 270, 329 nm (log ε 4.40, 3.90). Practically insol in water; sol in alkali hydroxide solns; slightly sol in alcohol, chloroform, ether.

Diacetoxychrysin, $C_{19}H_{14}O_6$, crystals from ethanol, mp 194-195°.

Methylchrysin, $C_{16}H_{12}O_4$, *tectochrysin.* Yellow needles, mp 163°. Sol in alcohol, benzene, chloroform. It is present as such or in the form of a glucoside in buds of *Populus* spp., *Salicaceae.* Use of tectochrysin as diuretic: Perrault, U.S. pat. **3,155,579** (1964 to Laroche Navarron).

2238. Chrysocolla. $CuSiO_3.2H_2O$—copper silicate.

2239. Chrysoidine. *4-(Phenylazo)-1,3-benzenediamine monohydrochloride;* 4-phenylazo-*m*-phenylenediamine hydrochloride; 2,4-diaminoazobenzene hydrochloride; chrysoidine orange; chrysoidine Y; C.I. 11270; C.I. Basic Orange 2. $C_{12}H_{13}ClN_4$; mol wt 248.71. C 57.95%, H 5.27%, Cl 14.26%, N 22.53%. Prepn: Hofmann, *Ber.* **10**, 213 (1877); Maximoff, U.S. pat. **2,053,095** (1935 to Azodal Co.); *Colour Index* vol. 4 (3rd ed., 1971) p 4019.



Reddish-brown cryst powder, mp 118-118.5°. Solubility at 15°: water 5.5%; abs ethanol 4.75%; cellosolve 6.0%; anhydr ethylene glycol 9.5%; xylene 0.005%; slightly sol in acetone; practically insol in benzene. Gives yellow soln in concd H_2SO_4, orange soln in dil H_2SO_4 and in HNO_3.

Free base, $C_{12}H_{12}N_4$, *C.I. Solvent Orange 3.*
USE: Dyeing silk and cotton.

2240. Chrysoidine Hydrochloride Citrate. 4-Phenylazo-*m*-phenylenediamine hydrochloride citrate; 2,4-diaminoazobenzene hydrochloride citrate; Azoangin; Azohel. $C_{18}H_{21}ClN_4O_7$; mol wt 440.84. $C_{12}H_{12}N_4.HCl.C_6H_8O_7$. Prepn: Ger. pat. **562,392** (1933 to Chem.-pharm. Fabrik Hubold & Bartsch).

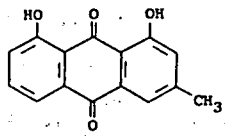
Sol in alcohol, water; soly in water: up to 4%.
THERAP CAT: Antiseptic.

2241. Chrysoidine Thiocyanate. Chrysoidine monothiocyanate; 4-phenylazo-*m*-phenylenediamine thiocyanate; 2,4-diaminoazobenzenemonothiocyanate; Azorhodan. $C_{13}H_{13}N_5S$; mol wt 271.34. $C_{12}H_{12}N_4.HSCN$. Prepn: Ger. pat. **643,343** (1938 to Chem.-pharm. Fabrik Hubold & Bartsch). Properties: Riedel, *Arch. Exp. Path. Pharmakol.* **194**, 190; **195**, 75 (1940).

Dark red elongated needles from alc, mp 178°. Soly in water 1:1500 at 25°. Freely sol in methanol, ethanol, acetone; sparingly sol in chloroform; practically insol in benzene, petr ether; sol in warm olive oil, glycerol.
THERAP CAT: Antiseptic.

2242. Chrysolite. $(Mg,Fe)_2SiO_4$—iron magnesium silicate.

2243. Chrysophanic Acid. *1,8-Dihydroxy-3-methyl-9,10-anthracenedione; 1,8-dihydroxy-3-methylanthraquinone;* 3-methylchrysazin; chrysophanol. $C_{15}H_{10}O_4$; mol wt 254.23. C 70.86%, H 3.96%, O 25.17%. Occurs in the free state and as glucoside in cascara sagrada, senna and various species of *Rumex* and *Rheum* (rhubarb). Isoln from rhubarb root: Tutin, Clewer, *J. Chem. Soc.* **99**, 946 (1911); Siesto, Bartoli, *Farmaco Ed. Prat.* **12**, 517 (1957); Carelli, Giuliano, *ibid.* 184; from *Penicillium islandicum* Sopp.: Howard, Raistrick, *Biochem. J.* **46**, 49 (1950); from *Chaetonium affine* Corda: Arkley *et al., Croat. Chem. Acta* **29**, 141 (1957), *C.A.* **53**, 1287h (1959). Synthesis: Eder, Widmer, *Helv. Chim. Acta* **5**, 3 (1922); **6**, 419 (1923); Ayyangar *et al., J. Sci. Ind. Res. (India)* **20B**, 493 (1961). Total synthesis: M. E. Jung, J. A. Lowe, *Chem. Commun.* **1978**, 95.



Hexagonal or monoclinic crystals from alcohol or benzene, mp 196°. Sublimes. Absorption max: 226, 256, 278, 288, 436 nm (ε × 10^{-3} 41, 28, 14, 14, 11.8). Practically insol in water; slightly sol in cold, freely in boiling alc; sol in

if alcohols or water are present. Copper powder causes active decompn with the evolution of nitrogen and the formation of insol white flakes of polymethylene $(CH_2)_x$. Solid calcium chloride or boiling stones have the same effect. This phenomenon appears to occur always during the action of diazomethane on solid substances.

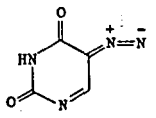
USE: Powerful methylating agent for acidic compds such as carboxylic acids, phenols, enols. For syntheses with diazomethane *see* the reviews by Smith, *Chem. Revs.* **23**, 193 (1938); Eistert, *Z. Angew. Chem.* **54**, 99, 124 (1941) translated by Spangler in *Newer Methods of Preparative Organic Chemistry* (New York, 1948) p 513; J. S. Pizey, *Synthetic Reagents* vol. 2 (John Wiley, New York, 1974) pp 65-142. *Caution:* Explosive (use safety screen), insidious poison (a well-ventilated hood is absolutely necessary), avoid vapor. Strong irritant. Does not cause discernible reaction at the time of contact, but later, even in minute amounts, produces an inflammatory reaction. Hypersensitivity results which makes it impossible to work with diazomethane without attacks of asthma and associated symptoms.

2973. 6-Diazo-5-oxo-L-norleucine. DON. $C_6H_9N_3O_3$; mol wt 171.16. C 42.10%, H 5.30%, N 24.55%, O 28.05%. $N_2CHCOCH_2CH_2CH(NH_2)COOH$. Antitumor antibiotic produced by an unidentified species of *Streptomyces* from Peruvian soil: Dion *et al.*, *J. Am. Chem. Soc.* **78**, 3075 (1956); Ehrlich *et al.*, *Antibiot. & Chemother.* **6**, 487 (1956). Several methods of synthesis: De Wald, Moore, *ibid.* **80**, 3941 (1958); *eidem*, U.S. pat. 2,965,634 (1960 to Parke, Davis). *Review:* Pittillo, Hunt, *Antibiotics* vol 1, D. Gottlieb, P. D. Shaw, Eds. (Springer-Verlag, New York, 1967) pp 481-493.

Pale yellow crystals from dil ethanol, dec 145-155°. $[\alpha]_D^{26}$ +21° (c = 5.4). uv max (phosphate buffer): 244, 275 nm ($E_{1cm}^{1\%}$ 376, 683). Freely sol in water. The pH of aq solns should be maintained between 4.5 and 6.5. Also sol in aq solns of methanol, ethanol, acetone. Sparingly sol in absolute alcs.

THERAP CAT: Antineoplastic.

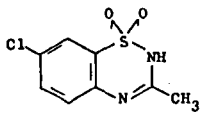
2974. 5-Diazouracil. *5-Diazo-2,4(1H,3H)-pyrimidinedione;* DU; 2,4-dioxo-5-diazopyrimidine; 5-diazo-2,4-dioxopyrimidine. $C_4H_2N_4O_2$; mol wt 138.09. C 34.79%, H 1.46%, N 40.58%, O 23.17%. Prepd by diazotization of 5-aminouracil: Johnson *et al.*, *Ber.* **64**, 2629 (1931). Revised structure: Thurber, Townsend, *J. Heterocycl. Chem.* **9**, 629 (1972). Has significant activity against gram-positive and gram-negative bacteria *in vivo:* Hunt, Pittillo, *Appl. Microbiol.* **16**, 1792 (1968).



Crystals, conflagrates at 198°. The stout prisms obtained from ice water should be white, not yellow or red. Sensitive to light, temp and air. Best stored in evacuated, refrigerated ampuls. Acid reactions. IR spectrum: Band at 4.57 μ. Forms alcoholates, also a red monohydrate, $C_4H_4N_4O_3$, from which a potassium salt, $KC_4H_3N_4O_3$, is obtained which is slightly sol in water with neutral reaction.

USE: In cancer research.

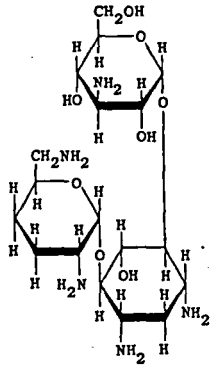
2975. Diazoxide. *7-Chloro-3-methyl-2H-1,2,4-benzothiadiazine 1,1-dioxide;* 3-methyl-7-chloro-1,2,4-benzothiadiazine 1,1-dioxide; SRG 95213; Eudemine Injection; Proglicem; Hyperstat; Hypertonalum; Mutabase; Proglycem. $C_8H_7ClN_2O_2S$; mol wt 230.70. C 41.65%, H 3.06%, Cl 15.37%, N 12.15%, O 13.87%, S 13.90%. Prepn: Rubin *et al.*, *Science* **133**, 2067 (1961); Topliss *et al.*, U.S. pat. 2,986,573 (1961 to Schering); Raffa, Monzani, *Farmaco Ed. Sci.* **17**, 244 (1962). Crystal and molecular structure: G. Bandoli, M. Nicolini, *J. Cryst. Mol. Struct.* **7**, 229 (1978).



Crystals from dil alc, mp 330-331°. uv max (methanol): 268 nm (ε 11,300). Sol in alcohol and alkaline solns. Insol in water.

THERAP CAT: Antihypertensive.

2976. Dibekacin. *O-3-Amino-3-deoxy-α-D-glucopyranosyl-(1→6)-O-[2,6-diamino-2,3,4,6-tetradeoxy-α-D-erythrohexopyranosyl-(1→4)]-2-deoxy-D-streptamine;* DKB; 3',4'-dideoxykanamycin B; debecacin; Orbicin. $C_{18}H_{37}N_5O_8$; mol wt 451.54. C 47.88%, H 8.26%, N 15.51%, O 28.35%. Antibiotic showing activity against kanamycin-resistant bacteria. Prepn: Umezawa *et al.*, *J. Antibiot.* **24**, 485 (1971); *eidem*, *Bull. Chem. Soc. Japan* **45**, 3624 (1972); Umezawa *et al.*, Ger. pat. 2,135,191 (1972 to Microbiochem. Res. Found.). Improved synthesis: T. Yoneta *et al.*, *Bull. Chem. Soc. Japan* **52**, 1131 (1979). Metabolic studies: Shimizu, *Japan. J. Antibiot.* **26**, 522 (1973). Toxicology: Koeda *et al.*, *ibid.* 221.



$[\alpha]_D^{20}$ +132° (c = 0.65). LD_{50} i.v. in mice, rats: 63-72 mg/kg, 140-177 mg/kg.

Sulfate, *Débékacyl, Panimycin,* white or yellowish-white powder. Slightly bitter taste. Sol in water. Practically insol in ethanol, acetone, other org solvents.

THERAP CAT: Antibacterial.

2977. Dibenzalacetone. *1,5-Diphenyl-1,4-pentadien-3-one;* dibenzylidene acetone; distyryl ketone. $C_{17}H_{14}O$; mol wt 234.28. C 87.15%, H 6.02%, O 6.83%. $C_6H_5CH{=}CH{-}COCH{=}CHC_6H_5$. Prepn from benzaldehyde + acetone: Conrad, Dolliver, *Org. Syn.* **12**, 22 (1939); Haslam, U.S. pat. 2,719,863 (1955 to du Pont); Tokár *et al.*, *Acta Chim. Acad. Sci. Hung.* **19**, 83 (1959). Prepn of geometrical isomers: Dinwiddie *et al.*, *J. Org. Chem.* **27**, 327 (1962).

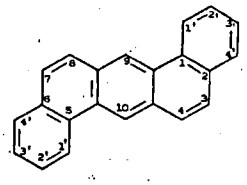
trans-trans-Form, crystals from hot ethyl acetate, mp 110-111°. uv max: 330 nm (ε 34,300). Practically insol in water; slightly sol in alc, ether; sol in acetone, chloroform.

cis-trans-Form, light yellow needles from ethanol, mp 60°. uv max 295 nm (ε 20,000).

cis-cis-Form, yellow oil, $bp_{0.02}$ 130°. uv max: 287 nm (ε 11,000).

USE: In sun protection preparations.

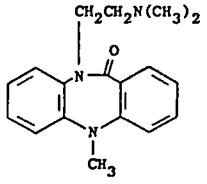
2978. 1,2:5,6-Dibenzanthracene. *Dibenz[a,h]anthracene.* $C_{22}H_{14}$; mol wt 278.33. C 94.93%, H 5.07%. From methyl dinaphthyl ketone: Clar, *Ber.* **62**, 350, 1378 (1929); Fieser, Dietz, *ibid.* 1827; Bachmann, *J. Org. Chem.* **1**, 347 (1937). Separation by chromatography: Winterstein, Schön, *Z. Physiol. Chem.* **230**, 146 (1934). Review: E. Clar, *Polycyclic Hydrocarbons,* 2 vols. (Academic Press, New York, 1964). Review of carcinogenicity studies: *IARC Monographs* **3**, 178-196 (1973).



Plates, leaflets from acetic acid. Crystals may be monoclinic or orthorhombic. Sublimes. mp 266°. Absorption spectrum: Mayneord, Roe, *Proc. Roy. Soc. London* A152, 299 (1935). Sol in petr ether, benzene, toluene, xylene, oils, other organic solvents; slightly sol in alcohol and ether; insol in water.

Note: This substance has been listed as a carcinogen by the EPA: *Second Annual Report on Carcinogens* (NTP 81-43, Dec. 1981) pp 101-102.

2979. Dibenzepin. *10-[2-(Dimethylamino)ethyl]-5,10-dihydro-5-methyl-11H-dibenzo[b,e][1,4]diazepin-11-one;* 5-methyl-10β-dimethylaminoethyl-10,11-dihydro-11-oxodibenzo[*b,e*][1,4]diazepine; HF 1927. $C_{18}H_{21}N_3O$; mol wt 295.37. C 73.19%, H 7.17%, N 14.23%, O 5.42%. Prepn: F. Hunziker *et al., Arzneimittel-Forsch.* 13, 324 (1963); Brit. pat. 961,106 corresp to J. Schmutz, F. Hunziker, U.S. pats. 3,312,689 and 3,419,547 (1964, 1967, 1968 all to Wander). Metabolism: H. Lehner *et al., Arzneimittel-Forsch.* 17, 185 (1967). Comprehensive description: A. Egli, W. R. Michaelis in *Analytical Profiles of Drug Substances* vol. 9, K. Florey, Ed. (Academic Press, New York, 1980) pp 181-206.



mp 116-117°. $bp_{0.01}$ 185°.

Hydrochloride, $C_{18}H_{22}ClN_3O$, *Neodalit, Noveril.* Cryst, mp 238°. uv max (0.1*N* HCl): 204, 220 nm (log ε 4.530, 4.458). pKa 8.25. Sol in water, alcohol, chloroform. LD_{50} orally in mice: 215 mg/kg, F. Hunziker *et al., loc. cit.*

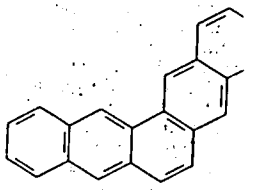
THERAP CAT: Antidepressant.

2980. Dibenzoylmethane. *1,3-Diphenyl-1,3-propanedione;* phenyl-α-hydroxystyryl ketone; ω-benzoylacetophenone; phenyl phenacyl ketone; γ-hydroxychalkone. $C_{15}H_{12}O_2$; mol wt 224.25. C 80.34%, H 5.39%, O 14.27%. C_6H_5CO-$CH_2COC_6H_5$. Prepd by the action of sodium methylate on benzylideneacetophenone dibromide: Allen *et al., Org. Syn.* coll. vol. I (2nd ed., 1941) p 205.

Orthorhombic plates, tablets from petr ether, mp 80°. bp_{18} 219-221°. 100 parts alc dissolve 4.43 parts at 19°. Sol in ether, chloroform, aq NaOH. Equilibrium mixtures in methanol, alcohol, and glacial acetic acid contain 96-98% of the enol form.

Monoxime, $C_{15}H_{13}NO_2$, prepd by adding 4 mols hydroxylamine to 1 mol dibenzoylmethane in alcohol. Prisms from ether, mp 165°. Sparingly sol in cold alcohol.

2981. 2,3:6,7-Dibenzphenanthrene. *Pentaphene;* dibenzo[*b,h*]phenanthrene; β,β'-dibenzphenanthrene; naphtho-2',3'-1,2-anthracene. $C_{22}H_{14}$; mol wt 278.33. C 94.93%, H 5.07%. Prepn by pyrolysis of 1,2- or 1,4-di-*o*-toluylbenzene: Clar *et al., Ber.* 62, 947 (1924); Clar, John, *Ber.* 64, 986 (1931); Winterstein, Schön, *Z. Physiol. Chem.* 230, 146 (1934); from phthalic anhydride + *o*-tolylmagnesium bromide: Clar, Stewart, *J. Chem. Soc.* 1951, 3215; from 2-benzoylbenzoic acid: Marsili, Isola, *Tetrahedron Letters* 1965, 3023; Franck, Zander, *Ber.* 99, 396 (1966).



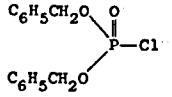
Yellowish-green needles or leaflets from
Absorption max (alc): 423.5, 412, 399, 3
314.5, 302, 289.5, 257.5, 245 nm. Sol in
sparingly sol in alcohol, ether. Solns exl
cence in daylight.

Dipicrate, $C_{22}H_{14}.2C_6H_3N_3O_7$, orange ne

2982. Dibenzylamine. *N-(Phenylmeth*
amine. $C_{14}H_{15}N$; mol wt 197.27. C 85.
7.10%. $C_6H_5CH_2NHCH_2C_6H_5$. Prepd by
holic ammonia on benzyl chloride: Mason,
1312 (1893).

Oil; ammoniacal odor. bp 300° with
Practically insol in water; sol in alcohol o
USE: Detection of cobalt, cyanate and ir

2983. Dibenzyl Chlorophosphonate. *P*
acid diphenylmethyl ester; benzyl phosphor
zylchlorophosphate; DBPCl; dibenzylpho
$C_{14}H_{14}ClO_3P$; mol wt 296.69. C 56.67
11.95%, O 16.18%, P 10.44%. Prepd b
chloride to dibenzyl phosphite at 17-19°
Atherton *et al., J. Chem. Soc.* 1948, 1106; b
to dibenzyl phosphite in CCl_4 at below 0°:
U.S. pat. 2,490,573 (1949 to Hoffmann-La



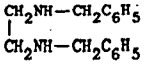
Thick oil, dec on standing or distillation.
reaction with ammonia or amines to form
benzyl aminophosphonates.

USE: In solns with inert solvents such as
bon tetrachloride, benzene and ether for the
of nucleosides and amino acids.

2984. Dibenzyl Disulfide. *Bis(phenyl*
benzyl disulfide; α-(benzyldithio)toluene;
disulfide. $C_{14}H_{14}S_2$; mol wt 246.37. C 68.
26.03%. $C_6H_5CH_2SSCH_2C_6H_5$. Prepd b
benzyl chloride with sodium disulfide or po
sma, *Rec. Trav. Chim.* 20, 137 (1901); Mora
pat. 2,113,092 (1938); Wojcik, U.S. pat.
Leaflets from alcohol, mp 71-72°. Ano
mp 69-70°. Dec >270°. Practically insol
ether, benzene, hot methanol, hot ethanol.

USE: Antioxidant in rubber compoundi
petr fractions, additive to silicone oils. T
increased by the presence of benzyl alcohol

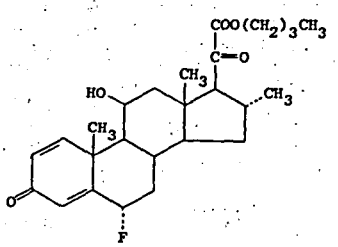
2985. *N,N'*-Dibenzylethylenediamine.
methyl)-1,2-ethanediamine; 1,2-bis(benz
DBED. $C_{16}H_{20}N_2$; mol wt 240.34. C 79.
11.66%. Prepd from *N,N'*-dibenzenesulfo
ylethylenediamine by heating with concd H
at 170-180°: Bleier, *Ber.* 32, 1829 (1899
chloride and benzylamine: Frost *et al., J.*
71, 3842 (1949); by reduction of *N,N'*-di
enediamine: Ger. pat. 98,031 (1898 to
Zentr. 1898, II, 743; Van Alphen, *Rec. T*
(1935); Lob, *ibid.* 55, 859 (1936); Szabo
Chemother. 1, 499 (1951); Rebenstorf, U.
(1956 to Upjohn).



Crystals from methanol. mp 308-311°. $[\alpha]_D$ +83° (chloroform). uv max: 237 nm (log ε 4.18).

THERAP CAT: Anti-inflammatory; glucocorticoid.

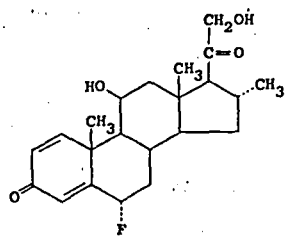
4052. Fluocortin Butyl. *6-Fluoro-11-hydroxy-16-methyl-3,20-dioxopregna-1,4-dien-21-oic acid butyl ester;* butyl 6α-fluoro-11β-hydroxy-16α-methyl-3,20-dioxopregna-1,4-dien-21-oate; SH K 203; Vaspit. $C_{26}H_{35}FO_5$; mol wt 446.57. C 69.93%, H 7.90%, F 4.25%, O 17.91%. The butyl ester deriv of fluocortolone-21-acid, a metabolite of fluocortolone *(q.v.)* in humans. Prepn: H. Laurent *et al.*, Ger. pats. 2,150,268, 2,150,270 corresp to U.S. pat. 3,824,260 (1973, 1973, 1974, all to Schering AG); H. Laurent *et al.*, *Angew. Chem.* 87, 70 (1975). Description of this new corticoid structure type, the pregnan-21-oic esters, their activity and methods for synthesis: H. Laurent *et al.*, *J. Steroid Biochem.* 6, 185 (1975). Series of articles on synthesis, pharmacology and clinical trials: *Arzneimittel-Forsch.* 27, 2185-2246 (1977).



Crystals from acetone/hexane, mp 195.1°. $[\alpha]_D^{25}$ +136° (c = 0.5 in chloroform). uv max (methanol): 242 nm (ε 16,800). Soluble in chloroform, ethanol; poorly sol in ethyl ether; insol in water. LD_{50} in mice, rats: >4 g/kg orally and s.c., P. Günzel *et al.*, *Arzneimittel-Forsch.* 27, 2217 (1977).

THERAP CAT: Anti-inflammatory.

4053. Fluocortolone. *6-Fluoro-11,21-dihydroxy-16-methylpregna-1,4-diene-3,20-dione;* 6α-fluoro-16α-methyl-1-dehydrocorticosterone; 6α-fluoro-16α-methyl-$\Delta^{1,4}$-pregnadiene-11β,21-diol-3,20-dione; Ultralan oral. $C_{22}H_{29}FO_4$; mol wt 376.47. C 70.19%, H 7.76%, F 5.05%, O 17.00%. Prepn: Belg. pat. 614,196 corresp to Kieslich *et al.*, U.S. pat. 3,232,839 (1962, 1966 to Schering A.G.); Doménico *et al.*, *Arzneimittel-Forsch.* 15, 46 (1965); Kieslich *et al.*, *Ann.* 726, 168 (1969). Pharmacology: Doménico *et al.*, *loc. cit;* Gillich *et al.*, *Int. Z. Klin. Pharmakol. Ther. Toxicol.* 1, 197 (1968); Von Schoening *et al.*, *Klin. Wochenschr.* 48, 1448 (1970). Metabolism: Gerhards *et al.*, *Acta Endocrinol. (Copenhagen)* 68, 98 (1971). Clinical studies: Breuer *et al.*, *Arzneimittel-Forsch.* 15, 50 (1965).



Crystals, mp 188-190.5°. Soly (mg/l): 295 in water (37°); 120 in ethanol (20°); 440 in toluene (20°). $[\alpha]_D^{20}$ +100° (dioxane). uv max (methanol): 242 nm (ε 16,300).

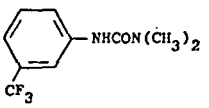
21-Acetate, $C_{24}H_{31}FO_5$, crystals, mp 237-239°. uv max (methanol): 240 nm (ε 15,860).

21-Hexanoate, $C_{28}H_{39}FO_5$, *fluocortolone 21-caproate, SH 770, Ficoid, Ultralanum.* Crystals, mp 242-245°. $[\alpha]_D^{20}$ +98.5° (dioxane). uv max (methanol): 242 nm (ε 16,200). Soly (mg/l): 7.8 in water (37°); 450 in ethanol (20°); 440 in toluene (20°).

21-Pivalate, $C_{22}H_{37}FO_5$, *fluocortolone trimethylacetate.* Crystals, mp 187°. Almost insol in water. Sol in chloroform, methanol. Slightly sol in ether.

THERAP CAT: Glucocorticoid.

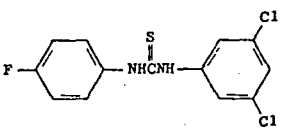
4054. Fluometuron. *N,N-Dimethyl-N'-[3-(trifluoromethyl)phenyl]urea; 1,1-dimethyl-3-(α,α,α-trifluoro-m-tolyl)urea; N-(3-trifluoromethylphenyl)-N',N'-dimethylurea;* Ciba 2059; Cotoran; Cottonex; Lanex. $C_{10}H_{11}F_3N_2O$; mol wt 232.21. C 51.72%, H 4.77%, F 24.55%, N 12.06%, O 6.89%. Made by the reaction of dimethylamine on 3-trifluoromethylphenyl isocyanate: Abel, *Chem. & Ind. (London)* 1957, 1106. Herbicidal preparations: Martin, Aebi, U.S. pat. 3,134,665 (1964 to Ciba).



Crystals, mp 163-164.5°. Soly in water at 25°: 80 ppm; sol in acetone, ethanol, isopropanol, DMF and other organic solvents. LD_{50} orally in male rats: 89 mg/kg, *RTECS* Vol. II, R. J. Lewis, R. L. Tatken, Eds. (1979) p 680.

USE: Herbicide.

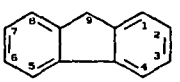
4055. Fluonilid®. *N-(3,5-Dichlorophenyl)-N'-(4-fluorophenyl)thiourea; 3,5-dichloro-4'-fluorothiocarbanilide.* $C_{13}H_9Cl_2FN_2S$; mol wt 315.21. C 49.53%, H 2.88%, Cl 22.50%, F 6.03%, N 8.89%, S 10.17%. Prepd from *p*-fluorophenyl isothiocyanate and 3,5-dichloroaniline or from 3,5-dichlorophenyl isothiocyanate and *p*-fluoroaniline: Belg. pat. 613,154 (1962 to Madan), *C.A.* 58, 474f (1963).



Crystals from ethanol, mp 148°. Soluble in ethyl oleate; isopropyl myristate.

THERAP CAT: Antifungal.

4056. Fluorene. *o*-Biphenylenemethane; diphenylenemethane; 2,2'-methylenebiphenyl. $C_{13}H_{10}$; mol wt 166.21. C 93.94%, H 6.06%. Occurs in coal tar (about 1.6%). Isoln: Kruber, *Ber.* 70, 1556 (1937). Also found in coke-oven tar: Weiss, Downs, *Ind. Eng. Chem.* 15, 1022 (1923). From acetylene and hydrogen in red-hot tube: Meyer, *Ber.* 45, 1609 (1912); Meyer, Taeger, *Ber.* 53, 1261 (1921). From charcoal by boiling with fuming HNO_3: Dimroth, Kerkovins, *Ann.* 399, 120 (1913). From 2,2'-dibromodiphenylmethane on boiling with hydrazine hydrate in presence of Pd: Busch, Weber, *J. Prakt. Chem.* [2] 146, 47 (1936). Reactions: Rieveschl Jr., Ray, *Chem. Rev.* 23, 287 (1938).



Dazzling white leaflets or flakes from alc. d 1.202. Sublimes easily in high vacuum. mp 116-117°. bp 295°. Absorption spectrum: Mayneord, Roe, *Proc. Roy. Soc. London* A158, 634 (1937). Freely sol in glacial acetic acid; sol in carbon disulfide, ether, benzene, hot alcohol. Soly data: Mortimer, *J. Am. Chem. Soc.* 45, 633 (1923).

Compound with 1,3,5-trinitrobenzene, $2C_{13}H_{10}\cdot 3C_6H_3N_3O_6$, golden yellow plates, mp 105° (also $3C_{13}H_{10}\cdot 4C_6H_3N_3O_6$, mp 105°).

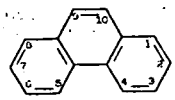
Compound with picryl chloride, $C_{13}H_{10}\cdot C_6H_2N_3O_6Cl$, orange crystals, mp 70°.

Compound with picric acid, $C_{19}H_{13}N_3O_7$, reddish-brown prisms (unstable), dec 80-82°.

4057. 2,7-Fluorenediamine. 2,7-Diaminofluorene. $C_{13}H_{12}N_2$; mol wt 196.24. C 79.56%, H 6.16%, N 14.28%. Prepd by nitrating fluorene and reducing the 2,7-dinitrofluorene.

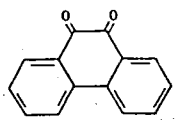
(−)-Hydrochloride, $C_{17}H_{27}ClN_2O$, levorotatory crystals from alcoholic HCl + ether, mp 201-202°.
Caution: Abuse leads to habituation or addiction.
THERAP CAT: Analgesic.

7075. Phenanthrene. $C_{14}H_{10}$; mol wt 178.22. C 94.34%, H 5.66%. Isomeric with anthracene. Occurs in coal tar. Isoln: Ostermayer, Fittig, *Ber.* 5, 933 (1872); Glaser, *ibid.* 982. Purification (from contaminating carbazole and anthracene): Clar, *Ber.* 65, 852 (1932). Formation from toluene: bibenzil, 9-methylfluorene or stilbene by passage through red-hot tube: Graebe, *Ber.* 7, 48 (1874); *Ann.* 167, 161 (1879); *Ber.* 37, 4145 (1904). Also from coumarone and benzene: Kraemer, Spilker, *Ber.* 23, 85 (1890). Pschorr synthesis from *o*-nitrobenzaldehyde and phenylacetic acid: *Ber.* 29, 500 (1896). From diphenylethylene: Cook, Hewett, *J. Chem. Soc.* 1933, 1098. Diene synthesis from 1-vinylnaphthalene and maleic anhydride: Cohen, Warren, *ibid.* 1937, 1315. From *o*-phenylbenzoic acid: Schönberg, Warren, *Chem. & Ind. (London)* 58, 199 (1939). By irradiation of stilbene: Mallory *et al.*, *J. Am. Chem. Soc.* 84, 4361 (1962). Synthesis by double succinoylation of benzene: Rahman *et al.*, *J. Org. Chem.* 28, 3571 (1963). Structure: Trotter, *Acta Cryst.* 16, 605 (1963).



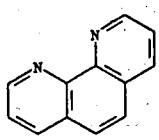
Monoclinic plates from alcohol. d^{25} 1.179; mp 100°; bp 340°. Sublimes in high vacuum. Absorption spectrum: Clar, Lombardi, *Ber.* 65, 1412 (1932); Mayneord, Roe, *Proc. Roy. Soc. London* A 152, 317 (1935). Practically insol in water; sol in organic solvents, especially in aromatic hydrocarbons. One gram dissolves in 60 ml cold, 10 ml boiling 95% alcohol, 25 ml abs alcohol, 2.4 ml toluene or carbon tetrachloride, 2 ml benzene, 1 ml carbon disulfide, 3.3 ml anhydr ether. Soluble in glacial acetic acid. Solns exhibit a blue fluorescence. Forms molecular compds with picric acid, picryl chloride, dinitrobenzene and similar nitro compounds. LD_{50} orally in mice: 700 mg/kg, *Toxic Substances List*, H. E. Christensen, Ed. (1973) p 708.
Caution: Can cause photosensitization of skin.

7076. Phenanthrenequinone. *9,10-Phenanthrenedione;* 9,10-phenanthraquinone. $C_{14}H_8O_2$; mol wt 208.20. C 80.76%, H 3.87%, O 15.37%. Prepn by oxidation of phenanthrene: Curtis *et al.*, U.S. pat. 2,956,065 (1960 to U.S. Steel); Binder, Koch, Ger. pat. 1,166,176 (1964).



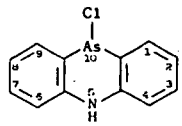
Orange-red crysts. mp 206-207°. bp about 360°. d 1.405. Sublimes. Practically insol in water; sol in benzene, ether, glacial acetic acid, hot alc. With concd H_2SO_4 gives a dark green color.

7077. *o*-Phenanthroline. *1,10-Phenanthroline;* 4,5-phenanthroline. $C_{12}H_8N_2$; mol wt 180.20. C 79.98%, H 4.48%, N 15.55%. Made by heating *o*-phenylenediamine with glycerol, nitrobenzene and concd H_2SO_4, or in the same manner from 8-aminoquinoline. Prepn: Madeja, *J. Prakt. Chem.* 17, 104 (1962). Crystal and molecular structure: S. Nishigaki *et al.*, *Acta Crystallogr.* B34, 875 (1978). Review of analytical uses: Vydra, Kopanica, *Chemist-Analyst* 52, 88-94 (1963).



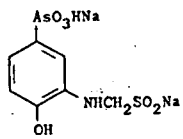
Monohydrate, white, cryst powder. mp 93-94°; anhydr, 117°. Soluble in about 300 parts water, 70 parts benzene; sol in alcohol, acetone.
USE: Forms a complex compound with ferrous ions which is used under the name of "*Ferroin*" as an indicator in oxidation reduction systems, *e.g.*, titration of ferrous salts. Also used in determination of nickel, ruthenium, silver and other metals.

7078. Phenarsazine Chloride. *10-Chloro-5,10-dihydrophenarsazine;* 5-aza-10-arsenaanthracene chloride; 10-chloro-5,10-dihydroarsacridine; diphenylaminechlorarsine; phenazarsine chloride; adamsite; DM. $C_{12}H_9AsClN$; mol wt 277.57. C 51.92%, H 3.27%, As 26.99%, Cl 12.77%, N 5.05%. Prepd by heating diphenylamine with arsenic trichloride: Ger. pat. 281,049 (1914 to I. G. Farben.); Wieland, Reinheimer, *Ann.* 423, 12 (1921); Lewis, Hamilton, *J. Am. Chem. Soc.* 43, 2222 (1921); Burton, Gibson, *J. Chem. Soc.* 1926, 450.



Canary-yellow crystals from carbon tetrachloride. *Poisonous.* Dimorphous. The stable form occurs as orthorhombic crystals; d 1.65; mp 195°; bp 410° (decompn). Sublimes readily. Vapor press. at 20° = 2×10^{-13} mm; volatility 0.02 mg/cu m; heat of volatilization 54.8 cal; spec heat 0.268 cal. Practically insol in water. Slightly sol in benzene, xylene, carbon tetrachloride. Corrodes iron, bronze, brass. [The metastable form melts at 186° if monoclinic, and at 182° if triclinic.]
USE: As war gas, dispersed in air in the form of minute particles. For riots in combination with tear gas (chloroacetophenone). In the formulation of wood-treating solns, against marine borers and similar pests. *Caution:* Irritating to skin and respiratory tract. Causes profuse watery nasal discharge; severe pain in nose, sinuses, chest; sneezing, coughing, nausea, vomiting, marked depression, weakness. Sensory disturbances may occur later.

7079. Phenarsone Sulfoxylate. *[(5-Arsono-2-hydroxyphenyl)amino]methanesulfinic acid disodium salt; 4-hydroxy-N-(sulfinomethyl)-m-arsanilic acid disodium salt;* Aldarsone. $C_7H_8AsNNa_2O_6S$; mol wt 355.10. C 23.67%, H 2.27%, As 21.10%, N 3.95%, Na 12.95%, O 27.03%, S 9.03%. Prepn: Raiziss, Kremens, U.S. pat. 2,074,757 (1937 to Abbott).



Amorphous, white powder. Sol in water, dil acids, alkali and alkali carbonates; slightly sol in methanol; practically insol in ether, chloroform, ethanol. pH of 5% aq soln: 7.0-7.5.
THERAP CAT: Anti-amebic.

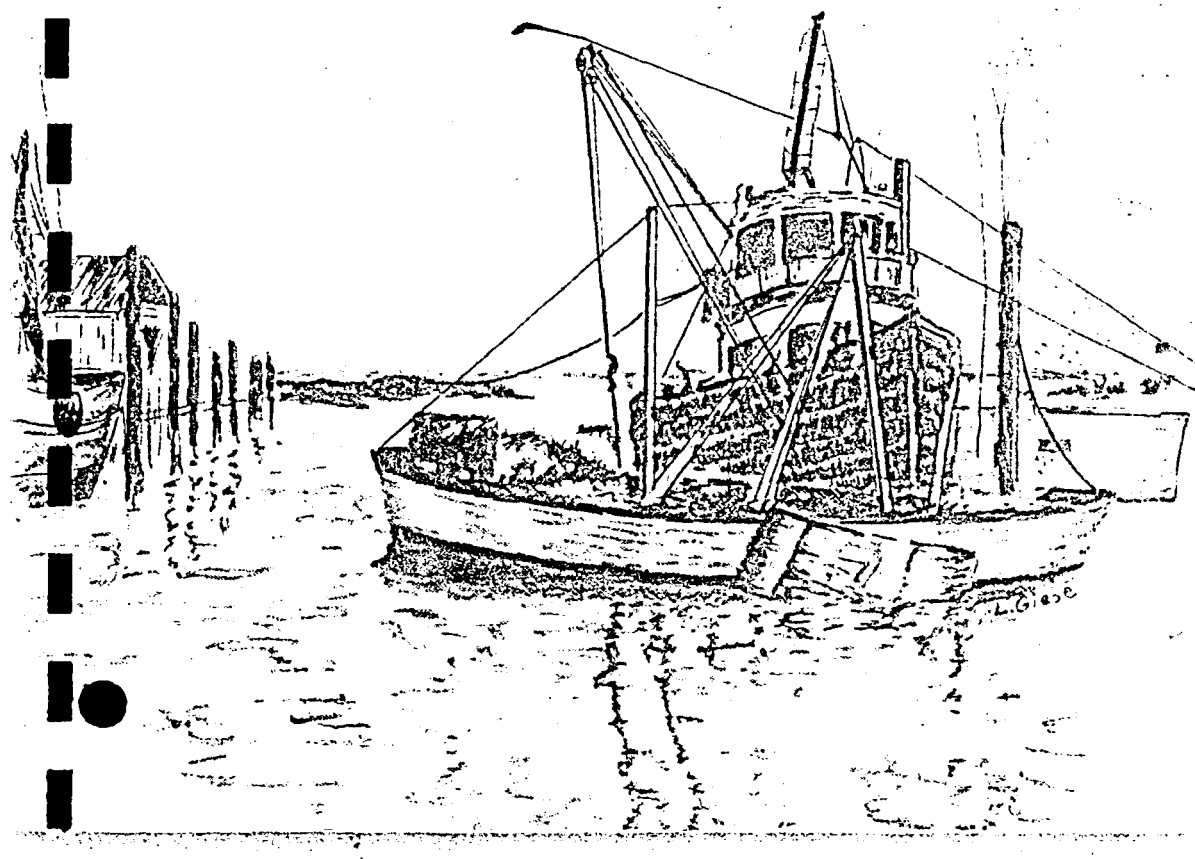
7080. Phenatine. *N-(1-Methyl-2-phenylethyl)-3-pyridinecarboxamide; N-(α-methylphenethyl)nicotinamide;* nicotinic acid β-phenylisopropylamide; nicotinoyl-β-phenylisopropylamine; fenatin; perviton. $C_{15}H_{16}N_2O$; mol wt 240.29. C 74.97%, H 6.71%, N 11.66%, O 6.66%. Synthesis from nicotinoyl chloride and $C_6H_5CH_2CH(CH_3)NH_2$: Arbuzov *et al.*, *Sb. Statei Obshch. Khim., Akad. Nauk SSSR* 1, 714 (1953), *C.A.* 49, 1072 (1955). Pharmacology: Arbuzov, *Farmakol. Toksikol.* 31, 373 (1968). Analysis: P. P. Suprun, *Farm. Zh. (Kiev)* 30, 49 (1975); O. N. Shcherbina *et al.*, *ibid.* 1979, 49.

CERCLA

Hydrology of Major Estuaries And Sounds of North Carolina

United States Geological Survey Water-Supply Paper 2221

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



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Hydrology of Major Estuaries And Sounds of North Carolina

By G. L. GIESE, H. B. WILDER, and G. G. PARKER, JR.

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

U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2221

2. Hydrology of the Cape Fear River Estuarine System

Together, the lower Cape Fear and Northeast Cape Fear Rivers comprise what we will term the Cape Fear River estuarine system. (See pl. 1.) Actually, the Northeast Cape Fear River basin (drainage area—1,740 mi^2) is a subbasin of the Cape Fear River basin (total drainage area—9,140 mi^2) and the Northeast Cape Fear River estuary may be thought of as a branch of the Cape Fear River estuary. Nevertheless, for ease of analysis the Northeast Cape Fear River estuary will be discussed separately.

The Cape Fear River and the Northeast Cape Fear River estuaries are the only major estuaries in North Carolina having a relatively free and direct access to the ocean, which results in significant tides and tide-affected flow within them. In the Cape Fear River estuary, tides extend up to Lock 1, about 65 miles upstream from the mouth near Southport. As shown in plate 1, the mouth is at a river cross section extending from Fort Caswell east to the western tip of Smith Island. Tide effects in the Northeast Cape Fear River estuary extend about 48 miles from its mouth at Wilmington, which in turn is located about 28 miles upstream from the mouth of the Cape Fear River estuary.

The lower reaches of the Cape Fear River and Northeast Cape Fear River estuaries are subject to saltwater intrusion, sometimes rendering the water unsuitable for some uses. Plate 1 shows the approximate extent of saltwater intrusion in both estuaries, that is, the furthest upstream advance of water containing 200 mg/L of chloride ever known and the furthest upstream advance that has a 50-percent chance of being equaled or exceeded in any year.

Rapid industrial growth has taken place along the banks of the two estuaries in recent years, and a number of industries use the water from them as process water and discharge industrial wastewater into them.

The Cape Fear River and Northeast Cape Fear River estuaries are important navigable waters, and navigation channels are maintained to various depths by the U.S. Army Corps of Engineers. The channel dimensions maintained for navigation will be discussed in more detail in following sections of this report.

The summaries of the hydrology of the Cape Fear River and Northeast Cape Fear River estuaries are based on data and other information from various sources, primarily the Geological Survey. Plate 1 shows the location of key flow and water-quality stations operated in the Cape Fear River basin by the Geological Survey. These stations include the Cape Fear River at Phoenix (sta. 02107570), where the Geological Survey generated records of volumes of water flowing upstream and downstream during each tidal phase for the period April 1966 through March 1969. Data from these stations are published annually in the U.S. Geological Survey water-data report series for North Carolina. Wilder and Slack (1971a and 1971b) summarized data on chemical quality of streams in North Carolina from 1943 through 1967. Wilder and Hubbard (1968) reported on saltwater encroachment in the Cape Fear River estuary; Hubbard and Stamper (1972) reported on the movement and dispersion of soluble pollutants in the Northeast Cape Fear River estuary; the U.S. Army Corps of Engineers (1976) discussed sedimentation and related aspects of hydrology in the lower Cape Fear River estuary. These and other sources of information are acknowledged in the text where appropriate.

THE CAPE FEAR RIVER ESTUARY

The Haw and Deep Rivers, two major tributaries of the Cape Fear River, originate in the Piedmont Province and flow southeast, joining at Moncure, to form the Cape Fear River (pl. 1). From Moncure, the Cape Fear River flows southeast through the Coastal Plain to its mouth near Southport. The Cape Fear River drains a larger part of North Carolina than any other river; the drainage area at the mouth is 9,140 mi^2, all of which is in North Carolina. Of this, the Deep River accounts for 1,422 mi^2 and the Haw River accounts for 1,705 mi^2. Other major tributaries include the Black River (1,563 mi^2) and the Northeast Cape Fear River (1,740 mi^2).

Prior to the construction of Lock 1 about 37 miles upstream from Wilmington, river stage was affected by ocean tides possibly as far as 50 to 75 miles upstream from Wilmington. The construction of Lock 1 eliminated the effect of ocean tides above this point and this lock, therefore, marks the upstream limit of tide effect at the present time. The total length of the estuary from its mouth to Lock 1 is about 65 miles.

The lower part of the estuary, beginning about three miles below Wilmington, averages about a mile in width and contains numerous scattered islands and a few tidal flats. It resembles an elongated bay only a few feet deep except along the ship channel which has been dredged and maintained in this reach to depths of 32–40 feet and widths of 300–500 feet. By comparison, the channel above Wilmington is narrow, with depths ranging from 20 to 60 feet. Tidal currents in the upper reach, particularly near the lower end are strong and velocities may exceed 3 ft/s.

Flow

Flow in the Cape Fear River estuary is strongly tide-affected. Except during periods of high freshwater inflow, regular reversals of flow occur with each tide. During periods of higher-than-average freshwater inflow, outflow at some or all locations in the estuary may be high enough to overwhelm incoming flood tides, resulting in periods when no flow reversal occurs. Because the freshwater inflow is such an important component of flow in the estuary, it will be discussed at length before further considering tide-affected flow.

Freshwater Inflow

The average discharge at the mouth of the Cape Fear River estuary is about 11,000 ft^3/s. Because of the difficulty of accurately measuring flows in the estuary portion of the river, values for discharges were arrived at by summation of flows for gaged areas within the basin and estimates of flows for ungaged areas.

The major part of the freshwater inflow is measured at the stream-gaging stations shown on plate 1. The stations closest to the estuary gage the runoff from 6,660 mi^2 or 73 percent of the total 9,140 mi^2 of drainage area above the mouth of the estuary. The three stations of greatest importance are the most downstream stations on the Cape Fear, Black, and Northeast Cape Fear Rivers. The runoff from 6,500 mi^2 of the Piedmont and the inner part of the Coastal Plain is measured at the three stations listed below:

Number	*Name*	*Drainage area*
02105769	Cape Fear River at Lock 1 near Kelly	5,220 mi^2
02106500	Black River near Tomahawk	680 mi^2
02108000	Northeast Cape Fear River near Chinquapin	600 mi^2

These stations will be referred to as Lock 1, Tomahawk, and Chinquapin, individually, and collectively as index gages.

The largest ungaged areas are in the lower part of the Coastal Plain, the area adjacent to the estuary itself. Most of the runoff from the total area of 2,640 mi^2 below the index stations is ungaged. However, a relationship between the runoff from this ungaged area and the combined runoff at the Tomahawk and Chinquapin stations was established by obtaining periodic base flow measurements at sites in the ungaged areas and relating these on a per square mile basis to concurrent discharges at Tomahawk and Chinquapin (fig. 2.1). These two stations were used in the relation because they drain only areas in the Coastal Plain. The net outflow from the estuary is the sum of discharges for the three index stations plus that contribute by the ungaged area, which can be estimated from figur 2.1.

Because steady-flow conditions rarely occu throughout the Cape Fear River basin, lag-time correction must be applied to streamflow records at the various gage in order to arrive at an estimate of freshwater outflo from the estuary at a given time. Lag times, compute from theories of wave celerity and rounded to the neare whole day, are 2 days from Tomahawk to the mouth o the Black River and 3 days from Chinquapin to the mout of the Northeast Cape Fear River.

Combining all flow components, the following em pirical equation was developed for estimating freshwat outflow (Q_t) from the estuary,

$$Q_t = Q_1 + Q_2 + Q_3 + Q_4 \qquad (2.1$$

where

Q_t = total outflow from the estuary,
Q_1 = discharge at Lock 1 at day of Q_t,
Q_2 = discharge at Tomahawk two days prior t Q_t,
Q_3 = discharge at Chinquapin three days prior t Q_t, and
Q_4 = runoff obtained from figure 2.1 using $Q_2 + Q_3$.

Equation 2.1 was used to calculate average 7-day ou flows. The 7-day period was chosen because it was lon enough to dampen the effects of minor, localized vari tions in the pattern of basin runoff and short enough to l a sensitive parameter for relating inflow to the position the saltwater front.

Insofar as water supply, sewage dilution, and sal water encroachment in the Cape Fear River are concerne the most critical flow periods are usually those of sus tained low flow. Figure 2.2 shows the average recurrenc interval, in years, at which various average 7-day min mum flows may be expected to occur. These values we generated by combining estimated annual 7-day minimu flows for the various flow components of equation 2.1. is interesting to note that if releases from the B. Everc Jordan Reservoir (pl. 1) are controlled according to th current operating schedule, then the minimum flow of th Cape Fear River at Lillington is expected to be no le than 600 ft^3/s. Based on this, the minimum discharge the mouth, near Southport, might be about 800 ft^3/s, con pared with an estimated 300 ft^3/s without the reservoir f the 7-day, 100-year minimum net discharge near Soutl port.

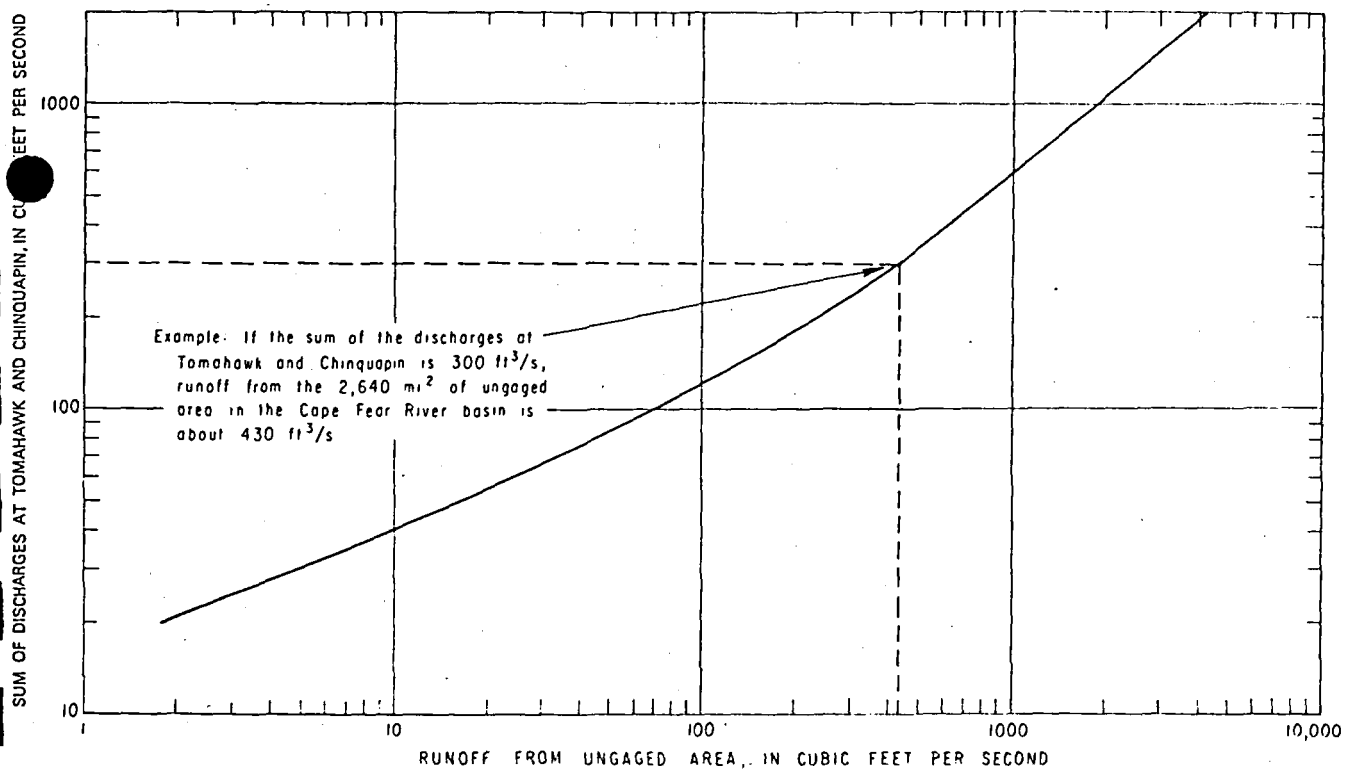

Figure 2.1. Concurrent discharge relation for estimating runoff from the ungaged drainage area between the index stations and the mouth of the Cape Fear River estuary. (Modified from Wilder and Hubbard, 1968.)

Tide-affected Flow

Flow of the Cape Fear River estuary is strongly influenced by ocean tides. The U.S. Geological Survey operated a tidal discharge gaging station near Phoenix (sta. 02107570) from April 1966 through March 1969. (See fig. 2.3.) The purpose of this station was to develop information on tide-affected flows for the estuary which could prove useful, for example, in better understanding the movement and dispersion characteristics of water substances discharged to the river or in better understanding the mechanics of sediment transport and deposition. Volumes of water flowing upstream and downstream on each tidal phase were published in the annual data reports of the U.S. Geological Survey. Calibration measurements were made over full or nearly full tidal cycles on three occasions—May 11–12, 1966, March 8, 1967, and July 27, 1967.

Partial results of the March 8, 1967, series of measurements are shown in figure 2.4. This series of measurements was made under fairly typical tide-affected flow conditions and provided, with other information, a means to calculate the minimum freshwater inflow required to prevent flow reversals in the vicinity of Phoenix.

Figure 2.4 shows that the maximum measured discharge on March 8, 1967, was 15,400 ft³/s downstream at 1500 hours on ebb tide. By contrast, the maximum discharge on flood tide was 6,690 ft³/s upstream at 1915 hours. The average flow over the tidal cycle was 6,240 ft³/s downstream at the Phoenix gage. This value appears reasonable compared with the estimated freshwater flow at Phoenix for March 8 of about 6,500 ft³/s. From this information, it appears that little or no upstream flow should occur near Phoenix whenever the freshwater inflow exceeds about 13,000 ft³/s. Downstream from Phoenix, the tidal component of flow would be larger and a correspondingly larger freshwater inflow would be reqired to prevent flow reversal. Upstream, the tidal component would be less and the freshwater inflow required to prevent reversal would be less also.

Two other facts from figure 2.4 are worth noting. First, times of high and low tides do not occur simultaneously with times of high and low slack water. Rather, slack water occurs from one-half to one-and-a-half hours later than high and low tides. Second, the duration of downstream flow is about 8 hours; the duration of upstream flow is less than 4 hours. These durations are more and less than the expected 6.21 hour duration of a tidal phase unaffected by freshwater inflow. As freshwater inflow increases, the duration of downstream flow also increases.

Figure 2.5 shows typical variations of velocity with depth in the Cape Fear River. This particular profile was taken at the Atlantic Coast Line Railroad Bridge at

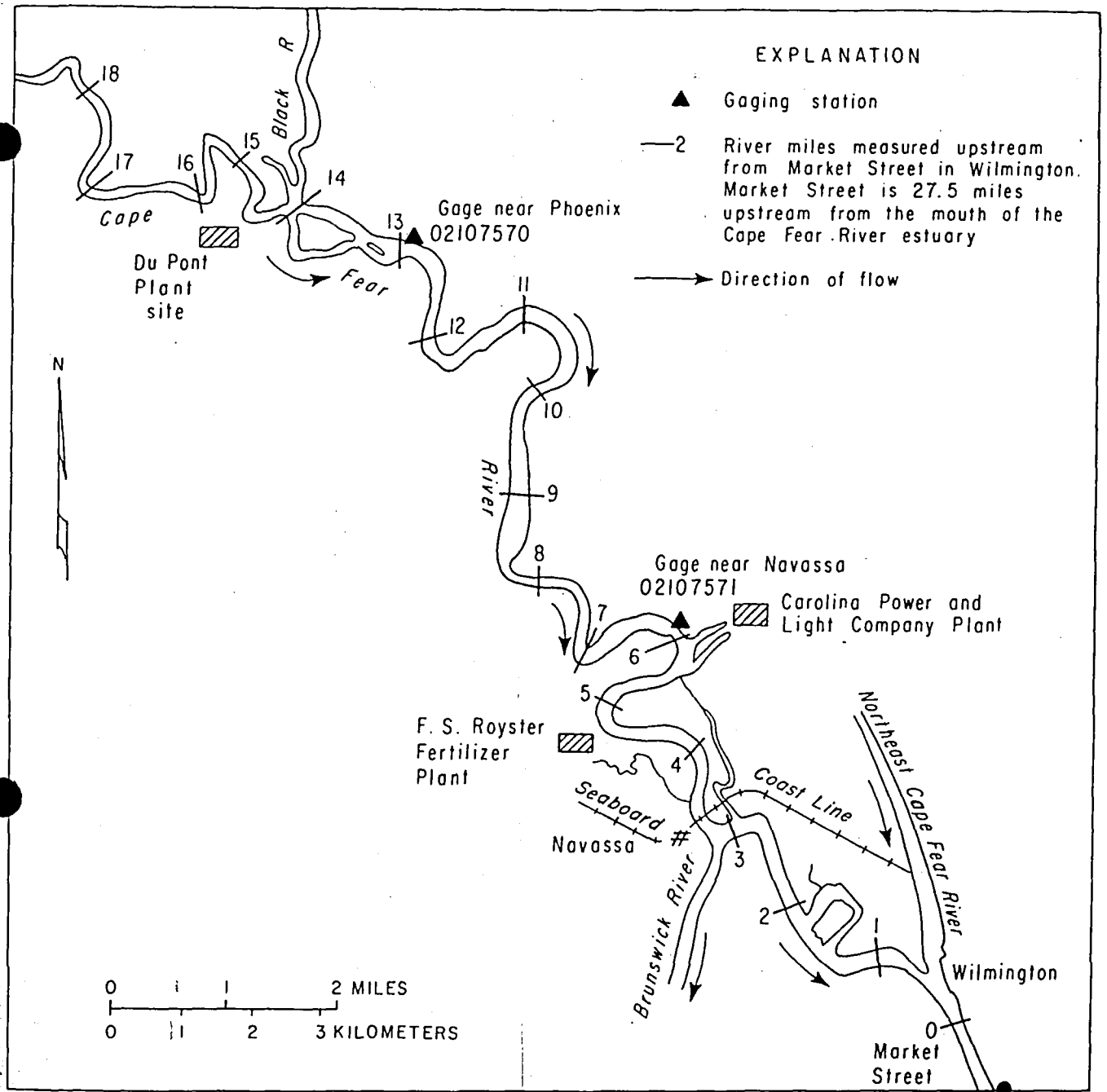

Figure 2.3. Cape Fear River estuary upstream from Wilmington.

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plants. Heating of the estuary water from power-plant operations and industrial-cooling operations may be a significant problem along some reaches. If not for contamination, the water, where fresh, would be suitable for most industrial, domestic, and agricultural uses.

Superimposed on difficulties in freshwater use due to contamination are difficulties due to saltwater intrusion, which may at times affect water quality as far as 20 miles upstream from Wilmington. Details of saltwater intrusion in the estuary are given later.

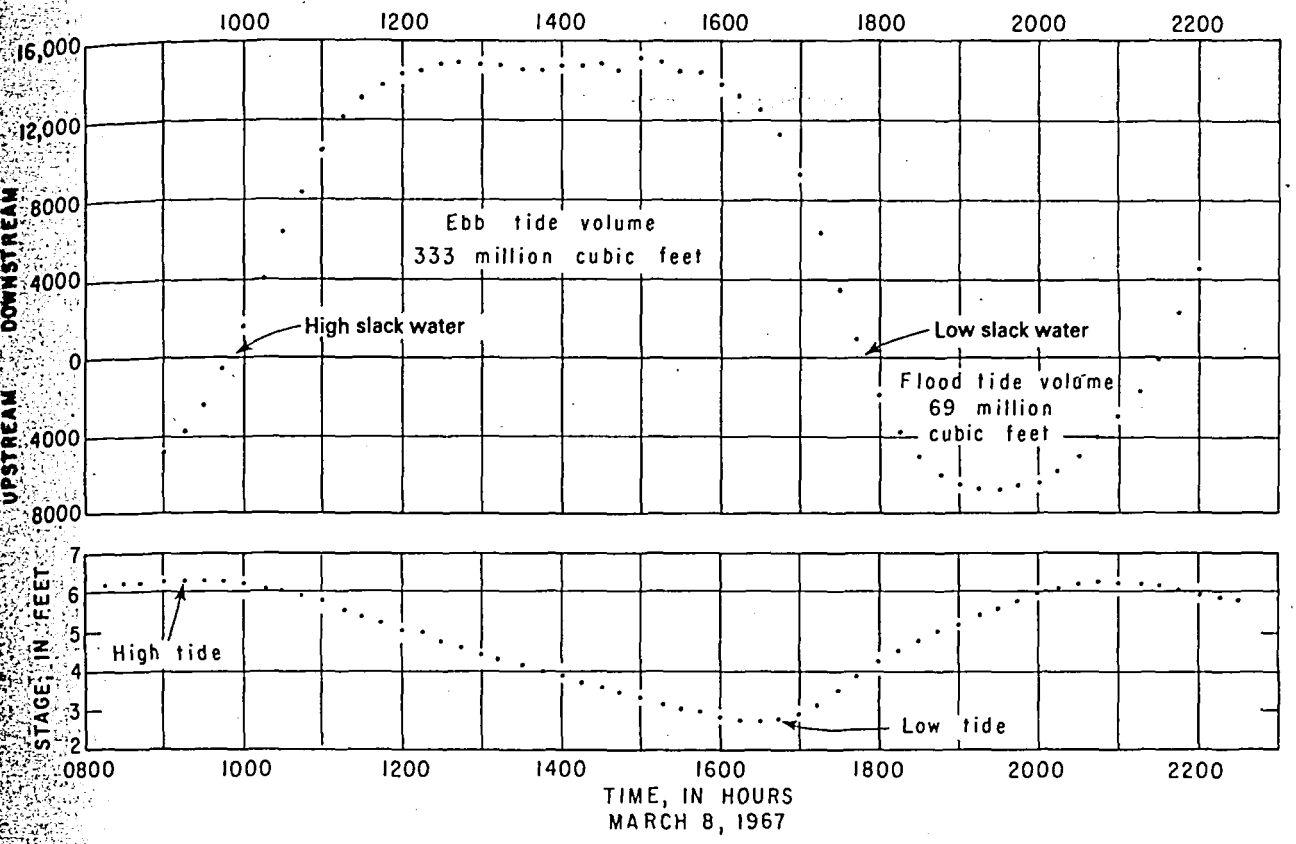

Figure 2.4. Stage and discharge of the Cape Fear River estuary near Phoenix on March 8, 1967.

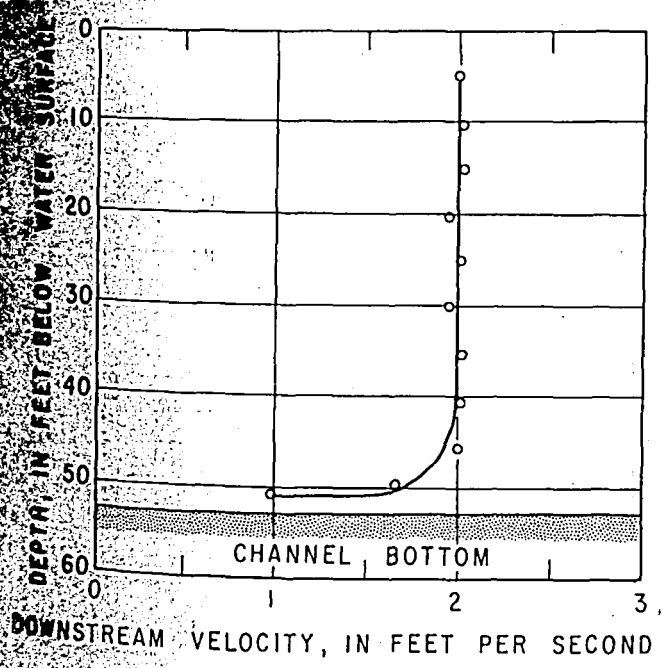

Figure 2.5. Variation of velocity with depth of the Cape Fear River estuary at Navassa on May 13, 1966 (at meter station 20, 0759-0803 hours).

Sediment

The Geological Survey has made suspended-sediment determinations from monthly samples collected at Lock 1 near Kelly (station number 02105769 on pl. 1) since January 1973. The average suspended-sediment load there is about 920 tons/day or 336,000 tons/year. Particle-size analyses (Simmons, 1976) show that over 90 percent of this material is of silt or clay size (.062 mm or less). The fate of this sediment has not been completely studied, but it is known that some is deposited in the estuary. The U.S. Army Corps of Engineers estimates that, in order to maintain navigation facilities at the Military Ocean Terminal at Sunny Point (MOTSU), about 18 miles downstream from Wilmington, 2,238,000 cubic yards, or about 3.5 million tons, of sediment must be removed annually at a cost of $2,169,000 (U.S. Army Corps of Engineers, 1976, p. 4). This gives some idea of the economic impact of sedimentation in the estuary.

Note, from the above discussion, that the amount of material removed from the estuary through dredging far exceeds the amount entering by way of Lock 1. Additional fluvial sediment entering the estuary from the Northeast Cape Fear River and other subbasins probably

does not exceed 35,000 tons/year. Therefore, the primary source of the new shoaling in the Sunny Point area could not be new fluvial sediment, but must be derived from within the estuarine reach or elsewhere—from slumping along the channel, from shore erosion, from old spoil areas, or possibly from sediment derived from the ocean.

Salinity

Variations in Time and Space

The Cape Fear River may be classified under some flow conditions as a partially mixed estuary. That is, turbulence is sufficient to prevent formation of a distinct saltwater wedge or tongue, yet there remains a definite salinity gradient with depth. This is illustrated in figure 2.6, which shows typical longitudinal variations in chloride concentrations of the Cape Fear River at a high slack water on November 1, 1967. The gradient is accounted for by the density differences between freshwater and saltwater. The less dense freshwater tends to flow on top of the heavier saltwater. These density differences are also responsible for upstream density currents which may occur along the channel bottom. These have been observed at and near the Military Ocean Terminal at Sunny Point where a predominant upstream or flood flow exists at times in the lower portions of the river water column (U.S. Army Corps of Engineers, 1976, p. 2).

A different view indicative of salinity stratification is shown in figure 2.7, which is a cross section showing chloride concentrations of the Cape Fear River estuary 1.5 miles upstream from Market Street, Wilmington, on June 5, 1962. The top-to-bottom differences are very marked. The surface concentration of 150 mg/L of chloride is equivalent to less than one percent seawater while the bottom concentration of 3,000 mg/L or greater is at least 16 percent that of seawater.

The salinity of the estuary is in a state of constant flux. Saline water moves in and out of the Cape Fear estuary regularly in response to tidal action, freshwater inflow, winds, and a number of other, less significant, factors. However, it has been found, at least for the part of the estuary above Wilmington, that the relative positions of the various lines of equal chloride concentration are fairly constant. In other words, if we know the river mile position of 300 mg/L of chloride, then the position of 200 or 1,000 or 3,000 mg/L of chloride may be predicted with a fair degree of accuracy, provided that the locations are somewhere above Wilmington. This relation is shown in figure 2.8. The values given are for the channel bottom at high slack water. Values at the surface would be somewhat less.

The maximum upstream movement of saltwater in the Cape Fear River estuary probably occurred during the passage of Hurricane Hazel on October 15, 1954. The eye of the hurricane moved inland near the South Carolina border and proceeded in a northerly direction along a path that crossed the upper end of the estuary. The counterclockwise circulation of winds around the hurricane eye produced strong winds from the southeast which raised tides to the highest level ever recorded at Wilmington. The high tide measured at the National Ocean Survey's

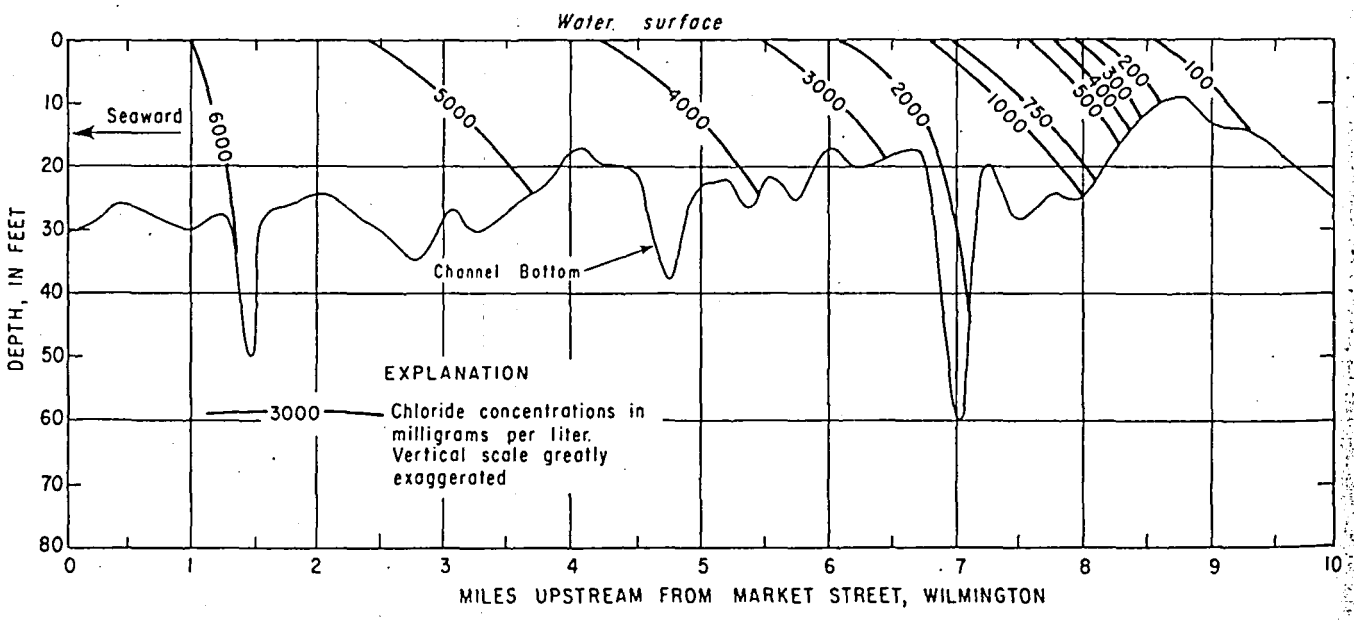

Figure 2.6. Longitudinal variations in chloride concentrations of the Cape Fear River estuary at high-slack water, November 1, 1967. (From Wilder and Hubbard, 1968.) (Refer to fig. 2.3 for locations.)

stant, probabilities may be determined with reasonable accuracy. For example, using figure 2.11 and assuming that the maximum tide will be 4.0 feet above mean low water during the period of annual minimum flow, it may be that encroachment to a point 10 miles above Wilmington will occur when the 7-day average outflow is about 820 ft^3/s, and we estimate from figure 2.2 that such a flow condition will recur on an average of 3.8 years.

It is apparent, from figure 2.11 that saltwater encroachment will not be a problem as far upstream as 15 miles above Wilmington, near the mouth of the Black River, without the simultaneous occurrence of both an exceptionally high tide and an exceptionally low inflow.

Another important factor that will affect the extreme annual position of the saltwater front is the B. Everett Jordan Reservoir. The operating scheme for this reservoir provides for a minimum flow of 600 ft^3/s in the Cape Fear River at Lillington. This reservoir release, plus the minimum inflow that may be expected to occur about once in 100 years, on average, between Lillington and the mouth, will produce about 800 ft^3/s of outflow from the estuary. This augmented flow shor maximum extent of saltwatei

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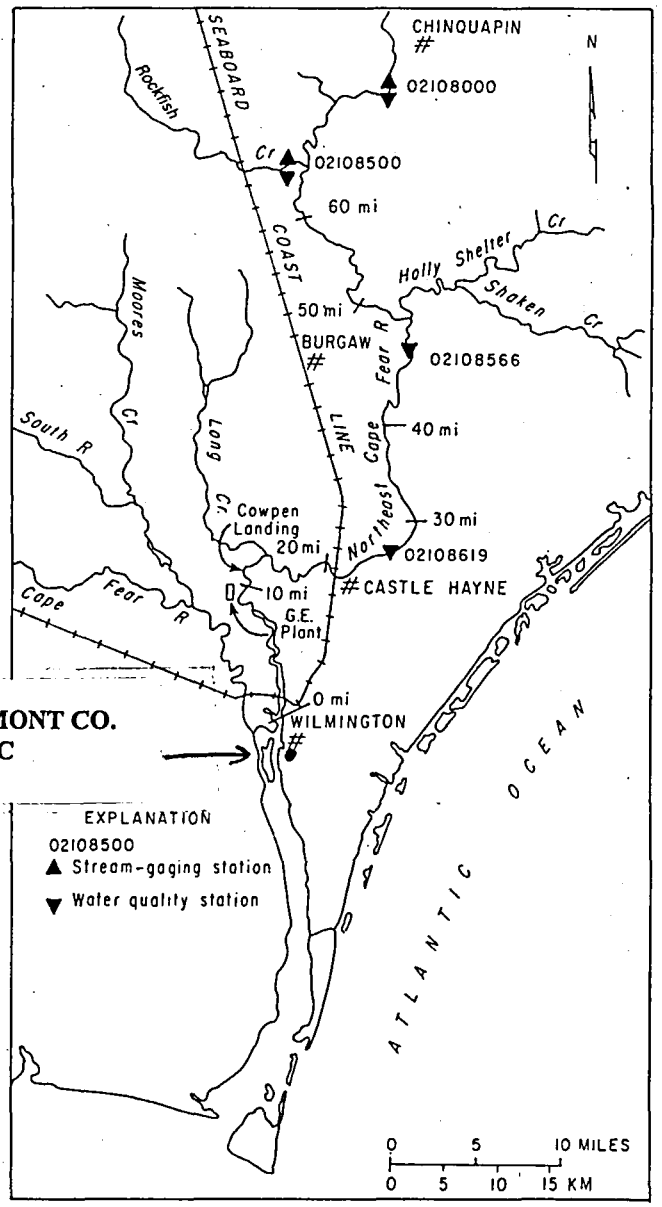


Figure 2.12. Northeast Cape Fear River estuary.

THE NORTHEAST CAPE FEAR RIVER ESTUARY

The Northeast Cape Fear River (see pl. 1 and fig. 2.12) originates in Wayne County, flows south through Duplin, Pender, and New Hanover Counties, and at Wilmington flows into the Cape Fear River, which empties into the ocean about 30 miles south of Wilmington. The total area drained is 1,740 mi^2. The entire basin lies within the Coastal Plain and stream gradients average less than one-half foot per mile. The two largest tributaries are Rockfish Creek and Holly Shelter Creek. Much of the main stem of the Northeast Cape Fear River and most of its tributaries are typical black-water, swamp-drainage streams, with imperceptible flows, sand-detritus bottoms, and low turbidity. Tide effects in the Northeast Cape Fear River extend upstream almost 50 miles from the mouth, to near Holly Shelter Creek. Thus, the river may be considered an estuary in that 50-mile reach. Many of the tributaries entering the Northeast Cape Fear River in its tidal reach are also affected by tides.

The lower 2.5 miles of the Northeast Cape Fear River estuary has been dredged and a navigation channel 32 feet deep and 300 feet wide is maintained. Upstream from this, to a point 48 miles above the mouth, the river was cleared to a depth of 6 feet in 1896; upstream from this, to 56 miles above the mouth, the river was cleared to a depth of 3 feet.

Several industries use the Northeast Cape Fear River and its tributaries both as a source of process water and as a conveyor of industrial wastes. The upper reaches of the Northeast Cape Fear River are used for recreation, primarily boating and fishing.

Freshwater Inflow

The average net outflow of the Northeast Cape Fear River estuary is about 2,120 ft^3/s. Of greater interest than average flow, however, are low flows, because pollution

and saltwater intrusion problems are greatest during low flows. In the Northeast Cape Fear River, an attempt to estimate low flows at the mouth by simple extrapolation of the measured low flow at Chinquapin, based on drainage-area ratios, will lead to erroneously high results. This is because, during low-flow periods, the upper part of the basin contributes a proportionately higher percentage of flow than does the lower part of the basin. For this reason, a relation was developed by Hubbard and Stamper (1972, p. E21) relating the low flow at Chinquapin to the flow at the mouth. The relationship, shown in figure 2.13, provides a reliable approximation of total freshwater flow out of the Northeast Cape Fear River only during stable low-flow recessions, when flow at Chinquapin is less than 360 ft^3/s. Therefore, the relationship should not be extended beyond the limits shown.

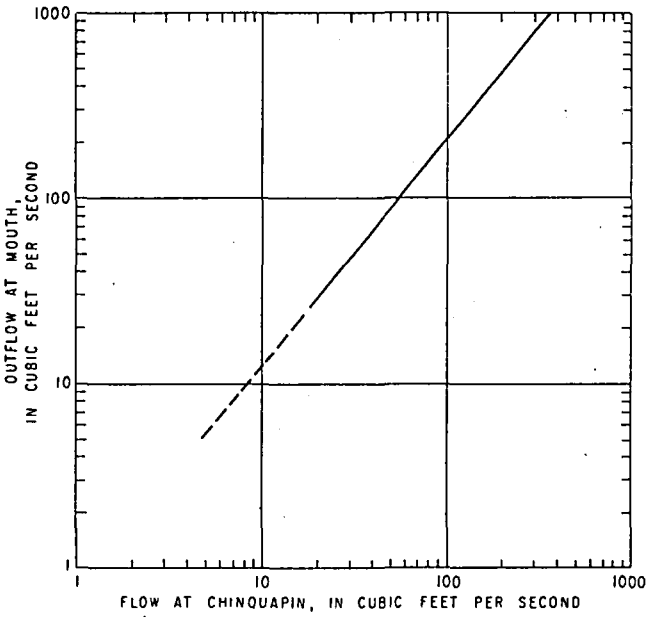


Figure 2.13. Relation between flow measured at Northeast Cape Fear River at Chinquapin and net outflow from the Northeast Cape Fear River estuary at the mouth. (Adapted from Hubbard and Stamper, 1972.)

Another important aspect of low flows is frequency of recurrence. Figure 2.14 shows low-flow frequency curves of net outflow from Hubbard and Stamper (1972). These curves may be used to estimate the frequency of recurrence of various annual minimum consecutive-day average outflows. For example, a minimum annual 7-consecutive-day average inflow of about 15 ft^3/s or less is expected to have an average recurrence interval of about 10 years. The flow relations presented in this section of th report can be used, as discussed later, to develop relation showing the frequency of recurrence of saltwater intrusio in the Northeast Cape Fear River estuary.

Tide-affected Flow

Tide ranges in the Northeast Cape Fear River es tuary vary considerably depending on distance upstrean from the mouth at Wilmington. At the General Electri plant, 6.4 miles upstream from the mouth, mean tid range is about 3.4 feet; near Castle Hayne, 23 miles up stream from the mouth, they average about 1.7 feet; nea the mouth of Holly Shelter Creek, 50 miles upstream fron the mouth, there are no lunar tides.

Flow due to tides is the dominant flow componen in the lower reaches of the Northeast Cape Fear estuary Strong flow reversals occur near the mouth with each tida cycle. Here, river velocities due to tides average about 1-1.5 ft/s, and seldom exceed 2 ft/s. Although no specifi information is available on velocities due to tides in th upper reaches of the Northeast Cape Fear River estuary they would become insignificant near river mile 50.

The average freshwater inflow to the estuary i about 2,100 ft^3/s. At this rate, average velocities near th mouth due to freshwater inflow alone are only about 0.0 ft/s, or 5 to 8 percent of the average velocities attributabl to tides.

The U.S. Geological Survey made a continuou measurement of tide-affected discharge during one com plete tidal cycle, 6.4 miles upstream from the mouth o the Northeast Cape Fear estuary, on October 23, 1969 The results of the measurement are shown in figure 2.15 The maximum discharge measured on October 23 wa 22,250 ft^3/s. This occurred during flood tide at 193 hours. The maximum discharge measured on ebb tide wa 18,080 ft^3/s at 1400 hours. These values are much large than the estimated 420 ft^3/s of freshwater inflow for tha day. During ebb tide, a total of 315 million cubic feet o water flowed past the measuring section. Of this amount only about 11 million cubic feet could be accounted for b freshwater inflow to the estuary. This represents about percent of the total flow volume.

Obviously, tides are the dominant short-term flo component near the mouth of the Northeast Cape Fea River estuary. A freshwater inflow of about 23,000 ft^3/s almost 11 times the average, would have been required t prevent flow reversals during the October 23 measure ments, and flows as large or larger than 23,000 ft^3/s occu only about 0.02 percent of the time. Further upstream, th influence of tides on flow is less and becomes negligibl about 50 miles upstream.

As in the case of the Cape Fear River estuary, time of high and low tides in the Northeast Cape Fear River es

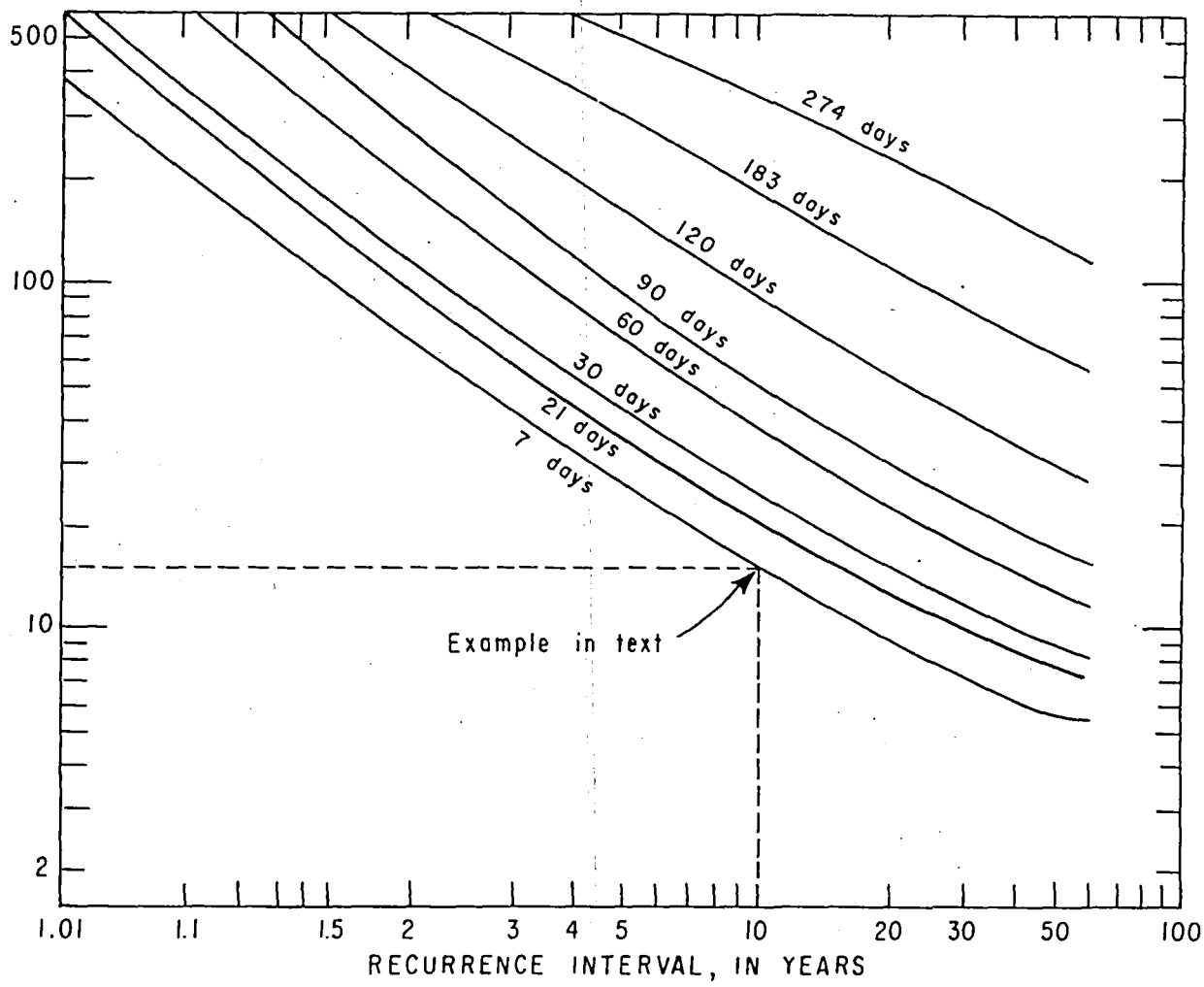


Figure 2.14. Low-flow frequency curves for the Northeast Cape Fear River estuary. (Adapted from Hubbard and Stamper, 1972.)

tary do not coincide with times of slack water, as shown in figure 2.15. During the October 23 measurement, slack water occurred more than an hour after high and low tides.

Detailed vertical velocity profiles are not available for the Northeast Cape Fear River estuary. However, based on some velocity observations made during the October 23 measurement, profiles would be similar to those observed during measurements of the Cape Fear River estuary, shown earlier in figure 2.5.

During October 1969, a study of the movement and dispersion of dye in the Northeast Cape Fear River estuary was made by the U.S. Geological Survey. The results of this study are contained in the 1972 report by Hubbard and Stamper. Figure 2.16, taken from that report, shows average flushing times for a solute injected into the estuary about 6.5 miles upstream from the mouth. When a solute (or pollutant) is injected as a slug, it travels upstream and downstream with flood and ebb flows. As it does so, it spreads out and becomes diluted, forming a cloud of the solute. In addition to the upstream-downstream movement of the cloud due to tidal flows, there is a net downstream movement of the cloud due to freshwater inflow. This cloud has a center of mass and it is the flushing time of the center of mass to which figure 2.16 refers. For example, referring to figure 2.16, if the outflow is 200 ft^3/s, it would take 30 days for the center of mass to reach the mouth from 6.5 miles upstream. At this

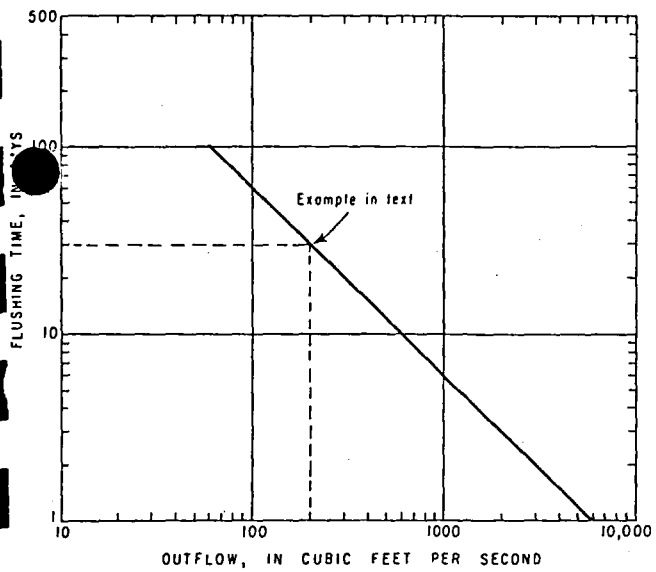


Figure 2.16. Average flushing time for a solute injected into the Northeast Cape Fear River estuary about 6.5 miles upstream from the mouth. (From Hubbard and Stamper, 1972.)

time, one-half of the solute would already have passed the mouth and one-half would not yet have reached the mouth. The results of this analysis can be extended upstream and downstream for different injection points by using cross-sectional areas and average freshwater inflows. Then, mean velocities for a given reach may be determined by the equation:

$$V = \frac{Q}{A} \tag{2.2}$$

where:

V = mean velocity, in feet per second through the subreach
Q = freshwater inflow, in cubic feet per second
A = area, in square feet

Dividing the length of each subreach by the mean velocities gives net traveltimes, which are based on freshwater inflow, disregarding tidal effects.

Hubbard and Stamper (1972) also give maximum concentration buildups at various river cross sections due to various constant injection rates of a solute 6.5 miles upstream from the mouth. They found that the dye cloud dispersed upstream and downstream several miles from the injection point but that maximum solute concentration buildup was only 0.3 miles below the injection point. It is difficult to extrapolate their results upstream or downstream for other injection points in the Northeast Cape Fear River estuary, but maximum concentration buildups would be expected near the injection points.

Water Quality

Summaries of the chemical quality of water at three key sites in the Northeast Cape Fear River basin are given in table 2.2, including observed ranges and average values of major chemical constituents. Iron concentrations sometimes exceed the 0.3 mg/L concentration limits recommended by the U.S. Environmental Protection Agency (1976) [1977] for public water supplies. The same is true for color, which often exceeds the upper limit of 75 color units recommended by the Environmental Protection Agency (1976) [1977]. The color of the Northeast Cape Fear River is derived primarily from decaying vegetation and the leaching of humic acids in swamp areas.

Sediment

The sediment-carrying capacity of the Northeast Cape Fear River and its tributaries is low due to low stream gradients. Most of the sediment that is carried is of clay or silt size (less than 0.062 mm). Based on flow and sediment measurements made at Northeast Cape Fear River at Chinquapin and Rockfish Creek near Wallace, the average annual sediment inflow to the estuary is probably no more than about 15,000 tons (20,000 cubic yards). This amount is less than one-third of the estimated 66,000 cubic yards of sediment that the U.S. Army Corps of Engineers removes on an average annual basis from the Northeast Cape Fear River estuary to maintain navigation.

Obviously, the amount of sediment from upstream sources is not enough to account for the amount of maintenance dredging that is done in the estuary. The question then arises, what is the source of the sediment that forms shoals in the navigation channel and harbor facilities in the Northeast Cape Fear River estuary? This question can be answered only speculatively because little work has been done to determine the exact sources. Probably only a part of the estimated 20,000 cubic yards of sediment that is carried into the estuary by freshwater inflow actually settles in the estuarine zone. Likely, a large proportion of it is carried out into the Cape Fear River estuary. However, sediment that is deposited from upstream sources would tend to settle in the deeper dredged areas.

A second possibility is that some shoaling materials may be transported upstream from the Cape Fear River. This could occur whenever the Northeast Cape Fear estuary is in a partially mixed or stratified state. Then, net upstream flow might prevail near the bottom. The mini-

um mixing ratio needed to produce partially mixed conitions is about 0.5. (Refer to discussion on estuarine types in the section on "General Hydrology.") Based on measurements of tide-affected flow in the estuary, the um freshwater inflow needed to produce partially mixed conditions (and, hence net upstream velocities near the channel bottom) would be about 6,500 ft^3/s. Although eshwater inflows of this magnitude or greater occur less an 5 percent of the time, it is possible that significant upstream migration of shoaling materials occurs due to is phenomenon.

The third and possibly the major source of shoaling materials is within the estuarine reach itself. These sources could include materials eroded from the shores, aterials resuspended from the channel bottom and moved tidal action to the shoaling areas, and slumping of materials adjacent to the navigation channel.

alinity

riations in Time and Space

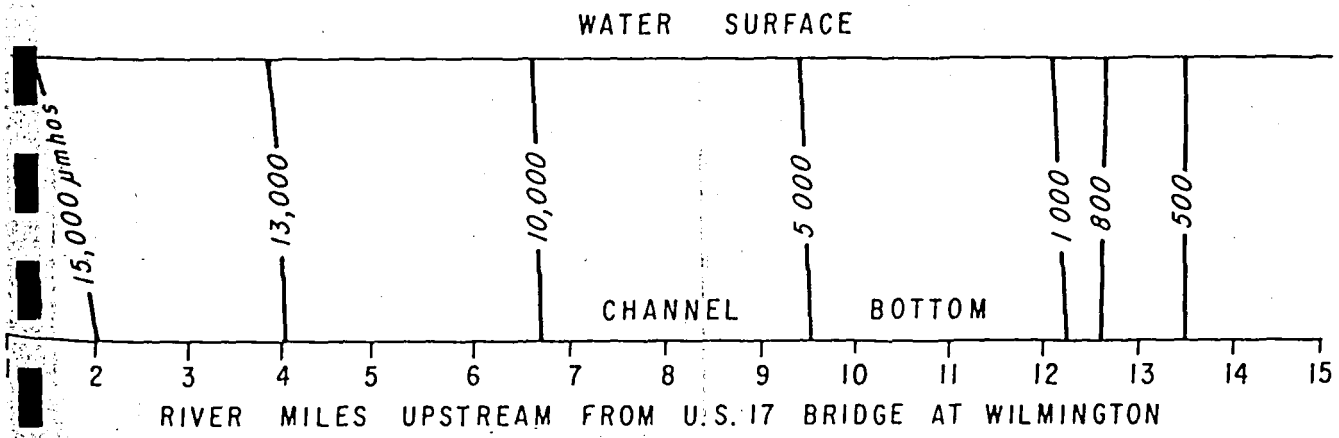
With respect to salinity, the Northeast Cape Fear River estuary may be classified as a well mixed estuary, most of the time, at least. This has been verified by eral specific conductance surveys, one of which is summarized in figure 2.17. This figure shows lines of al specific conductance along a channel profile of the theast Cape Fear River estuary, based on data collect n November 9, 1966. There was very little difference that day between surface and bottom specific condtances in most of the reach portrayed here. The mixing ex was estimated to be about 0.06 for that day, which is very close to the arbitrary upper limit of 0.05 for a well ed estuary. Although no extensive specific conductce data were collected within any cross section on that day, it is not likely that any significant specific conductce differences existed within cross sections.

Historically, the maximum observed upstream intrusion of saline water into the Northeast Cape Fear estuary occurred during Hurricane Hazel on October 15, 1954, when chloride concentrations reached 1,450 mg/L at Castle Hayne. Based on this and information in figure 2.18 (discussed later), the saltwater front could have been 2 or 3 miles upstream from Castle Hayne on that date.

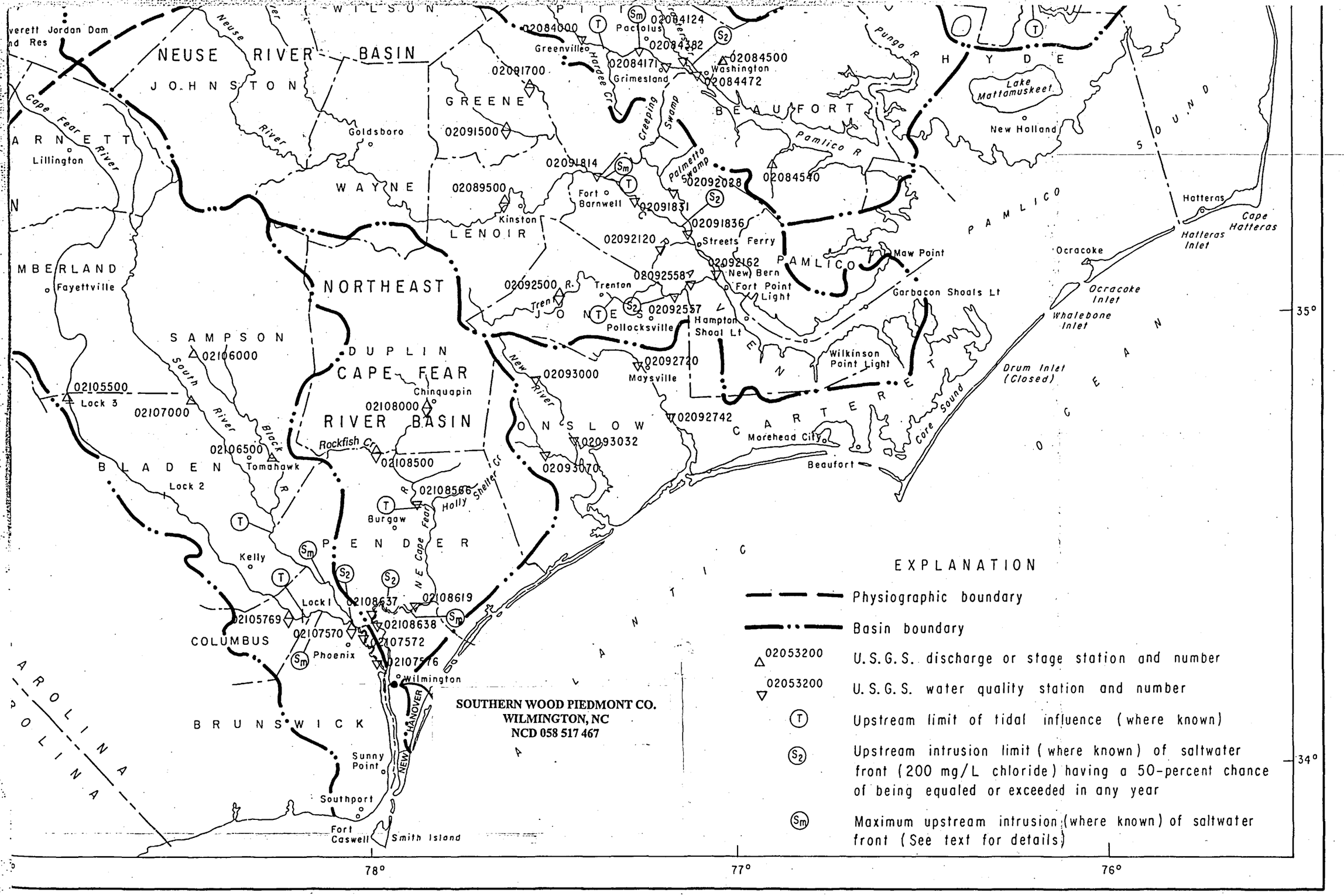
The very extreme saltwater encroachment which took place due to Hurricane Hazel was in addition to the extreme encroachment which had already taken place due to record low river flows immediately preceding the hurricane. At Chinquapin, for example, the discharge averaged only 5.3 ft^3/s on October 10–11, 1954, the all-time low for the 37–year period of record. On October 9 and 10, 1954, chloride concentrations were already about 500 mg/L at Castle Hayne, the greatest salinity intrusion of record, up to that time. The recurrence interval of two such rare events occurring in succession is not known, but it may be reckoned in centuries.

The maximum seaward movement of the saltwater front occurs during times of high freshwater inflow, usually in the spring. At such times, the front may be displaced out of the Northeast Cape Fear River estuary altogether, leaving the estuary completely fresh for a short period.

It is not economically feasible on a routine basis to survey the entire river to locate the saltwater front. However, based on previous salinity surveys, a type curve has been developed for the Northeast Cape Fear River estuary which may be used to estimate the specific conductance at any point in the estuary, if the specific conductance is known at only one point (fig. 2.18). As an example of the use of this type curve, suppose that the specific conductance near the channel bottom at a high slack water is 6,000 μmhos at Cowpen Landing, 11.2 miles upstream from the U.S. Highway 17 bridge in Wilmington, (U.S. Highway 17 bridge is about 0.85 miles upstream from the mouth of the estuary) and we want to know the location



Fi re 2.17. Longitudinal variations in specific conductance of the Northeast Cape Fear River estuary on November 9, 1966. D re variable and should not be inferred from the sketch.



MAJOR ESTUARIES AND SOUNDS OF NORTH CAROLINA

Ref. 38

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DRAINAGE AREAS OF SELECTED SITES ON STREAMS IN NORTH CAROLINA

By Robert L. Meikle

Open-File Report 83-211

Prepared in cooperation with the
NORTH CAROLINA DEPARTMENT OF NATURAL
RESOURCES AND COMMUNITY DEVELOPMENT

Raleigh, North Carolina
1983

BLACK RIVER - CONTINUED

STATION NUMBER	STATION NAME	DRAINAGE AREA (SQ MI)	SITE TYPE	LAT	LONG	QUAD NAME	COUNTY CODE
0210754595	DRY B AT MTH NR COSTIN	2.54	20	343644	780709	ATKINSON	141
0210754610	MOORES C AT SR 1209 NR COSTIN	22.4	20	343545	780724	ATKINSON	141
0210754625	WHITE OAK B HEADWATERS NR REB KEE	9.14	20	343610	781036	ATKINSON	141
0210755122	WHITE OAK B AT MTH NR COSTIN	19.5	20	343521	780728	ATKINSON	141
0210756000	MOORES C NR ATKINSON	52.7	02	343324	780725	ATKINSON	141
0210756110	BUXTON B AT MTH NR ATKINSON	6.41	20	343206	780633	ATKINSON	141
0210756135	MILL B AT MTH AT YAMACRAW	6.01	20	343017	780802	ATKINSON	141
0210756144	MOORES C AT SR 1125 AT YAMACRAW	74.2	20	343017	780800	ATKINSON	141
0210756146	MOORES C AT CURRIE	84.2	20	342736	780644	ACME	141
0210756148	MOORES C AT MTH AT THE BOROUGH	92.8	20	342538	780615	ACME	141
0210756150	BLACK R NR STILL BLUFF	1509.	20	342318	780520	ACME	141
0210756250	BLACK R NR HOOPER HILL	1515.	20	342204	780420	ACME	141
0210756270	LYON SWP CAN AT SR 1104 NR STILL BLUFF	20.5	20	342341	780942	ACME	141
0210756280	BUCKLE SWP C NR STILL BLUFF	11.8	20	342248	780724	ACME	141
0210756230	LYON C AT MTH NR STILL BLUFF	41.2	20	342221	780623	ACME	141

LOWER CAPE FEAR RIVER

0210756650	BAY B NR HOOPER HILL	2.02	20	341958	780253	ACME	019
0210757000	CAPE FEAR R NR PHOENIX	7036.	11	341950	780140	ACME	019
0210757020	CATFISH C NR CEDAR HILL	2.32	20	341730	780027	ACME	129
0210757055	INDIAN C AT PHOENIX	5.71	20	341804	780158	ACME	019
0210757075	INDIAN C AT MTH NR CEDAR CREEK	9.34	20	341702	780022	ACME	019
0210757200	CAPE FEAR R AT ROYSTER	7054.	11	341615	780000	ACME	019
0210757405	CARTWHEEL B AT MTH AT NAVASSA	1.69	20	341546	775924	CASTLE HAYNE (DM)	019

NORTHEAST CAPE FEAR RIVER

0210758100	NE CAPE FEAR R AT MT OLIVE	3.91	02	351110	780300	MT OLIVE	191
0210758475	NE CAPE FEAR R TRIB AT MTH NR MT OLIVE	3.38	20	351136	780140	MT OLIVE	191
0210758600	NE CAPE FEAR R NR MT OLIVE	10.5	20	351128	780105	MT OLIVE	191
0210758675	NE CAPE FEAR R TRIB AT DAM NR MT OLIVE	2.08	20	351139	780021	MT OLIVE	191
0210758692	HORSEPEN B AT MTH NR HOPEWELL	4.80	20	351152	775926	SEVEN SPRINGS	191
0210758695	LEWIS B AT NC 55 NR WILLIAMS	10.4	20	351112	775903	SEVEN SPRINGS	191
0210758725	NE CAPE FEAR R AT NC 403 AT WILLIAMS	25.1	20	351041	775852	SEVEN SPRINGS	191
0210758745	RATTLESNAKE B AT MTH NR BROCK CHAPEL	5.72	20	351013	775843	SEVEN SPRINGS	061
0210758855	POLLY RUN C AT SR 1526 AT JONES CHAPEL	4.28	20	350818	775626	SEVEN SPRINGS	061
0210758877	POLLY RUN C AT MTH NR GARNERS CHAPEL	9.25	20	350956	775721	SEVEN SPRINGS	061
0210758885	JUMPING RUN B AT SR 1754 NR WILLIAMS	2.62	20	351049	775622	SEVEN SPRINGS	191
0210760000	NE CAPE FEAR R NR SEVEN SPRINGS	48.7	01	351020	775556	SEVEN SPRINGS	191
0210760400	NE CAPE FEAR R NR GARNERS CHAPEL	55.0	20	350854	775350	SEVEN SPRINGS	191
0210760835	MIRE B AT SR 1501 NR HERRINGS X RDS	4.72	20	350752	775220	SEVEN SPRINGS	061
0210760845	CABIN B AT MTH NR PRICETOWN	6.58	20	351013	775228	SEVEN SPRINGS	191
0210760905	BUCK MARSH B AT SR 1754 AT GRADYS	14.5	20	351006	775221	SEVEN SPRINGS	191
0210760965	POLEY B AT MTH NR OUTLAWS BRIDGE	4.92	20	350842	775141	SEVEN SPRINGS	061
0210761000	BUCK MARSH B AT OUTLAWS BRIDGE	21.9	02	350836	775147	SEVEN SPRINGS	061
0210761200	NE CAPE FEAR R NR KORNEGAY	85.8	20	350740	775126	SEVEN SPRINGS	061
0210761205	BEAVERDAM B AT SR 1501 NR HERRINGS X RDS	3.01	20	350646	775152	SEVEN SPRINGS	061
0210761210	GREAT B AT NC 111 NR JONES CHAPEL	7.46	20	350717	774930	SEVEN SPRINGS	061
0210761230	GREAT B AT MTH NR ALBERTSON	10.5	20	350623	775008	SEVEN SPRINGS	061
0210761250	NE CAPE FEAR R AT SR 1519 NR KORNEGAY	104.	20	350602	774959	SEVEN SPRINGS	061
0210762000	MATHEWS C NR PINK HILL	8.13	03	350549	774910	SEVEN SPRINGS	061
0210762554	CAMP B AT SR 1501 NR KORNEGAY	1.92	20	350429	775044	SEVEN SPRINGS	061
0210767200	NE CAPE FEAR R AT KORNEGAY	120.	02	350310	775017	SEVEN SPRINGS	061
0210767245	BURN COAT C AT SR 1554 NR KORNEGAY	5.47	20	350412	774718	SEVEN SPRINGS	061
0210767325	BURN COAT C AT NC 11 AT KORNEGAY	10.2	20	350327	774921	SEVEN SPRINGS	061
0210768230	PANTHER C AT SR 1704 NR LEON	6.78	20	350133	774736	SEVEN SPRINGS	061
0210768300	PANTHER C AT MTH NR LEON	13.2	20	350200	775040	SEVEN SPRINGS	061
0210768325	NE CAPE FEAR R AB GOSHEN SWP AT LEON	146.	20	350114	775047	SEVEN SPRINGS	061
0210770344	GOSHEN SWP AT NC 50 NR SUTTONTOWN	8.10	20	351132	781330	DOBBERSVILLE	163
0210770354	RAILER B AT MTH NR SUTTONTOWN	4.64	20	351152	781304	DOBBERSVILLE	163
0210770362	LONG B AT MTH NR SUTTONTOWN	2.82	20	351112	781022	DOBBERSVILLE	163
0210770372	YOUNGS SWP HEADWATERS NR GIDDENSVILLE	3.98	20	350926	781140	DOBBERSVILLE	163
0210770376	YOUNGS SWP TRIB AT MTH NR GIDDENSVILLE	2.10	20	350926	781139	DOBBERSVILLE	163
0210770388	YOUNGS SWP AT MTH NR CALYPSO	8.88	20	351041	780952	DOBBERSVILLE	061
0210770392	GOSHEN SWP TRIB AB SR 1302 AT MTH NR CALYPSO	3.25	20	351019	780846	DOBBERSVILLE	061
0210770400	GOSHEN SWP NR CALYPSO	36.8	20	351010	780833	DOBBERSVILLE	061
0210770412	GOSHEN SWP TRIB AT MTH NR CALYPSO	2.34	20	351005	780820	DOBBERSVILLE	061
0210770418	MILL B AT MTH NR CALYPSO	2.73	20	350905	780741	DOBBERSVILLE	061
0210772380	PANTHER B AT NC 50 AT FAISON	3.72	20	350723	780909	FAISON	061
0210772397	PANTHER B AT MTH NR CALYPSO	6.06	20	350817	780726	MT OLIVE	061
0210772400	GOSHEN SWP AT FAISON	50.9	02	350805	780722	MT OLIVE	061
0210777550	REEDY B AT DAM AT FAISON	1.55	20	350618	780805	FAISON	061
0210777598	REEDY B AT NC 403 AT FAISON	2.65	20	350659	780737	FAISON	061
0210777905	REEDY B AT MTH NR FAISON	3.30	20	350754	780707	MT OLIVE	061
0210778600	GOSHEN SWP NR FAISON	58.6	20	350722	780537	WARSAW NORTH	061
0210778650	DICKS B 0.1 MI AB NC 403 NR CALYPSO	1.08	20	350754	780518	MT OLIVE	061
0210778665	WHITEOAK B AT SR 1318 NR CALYPSO	3.14	20	350853	780501	MT OLIVE	061
0210778675	WHITEOAK B AT MTH NR BEAUTANCUS	5.06	20	350710	780449	WARSAW NORTH	061
0210778725	COW HOLE B AT MTH NR BEAUTANCUS	2.87	20	350642	780357	WARSAW NORTH	061
0210778745	BEAR MARSH B AT DAM NR CALYPSO	3.22	20	350809	780236	MT OLIVE	061
0210778774	BEAR MARSH B AT SR 1357 AT BEAUTANCUS	6.10	20	350637	780313	WARSAW NORTH	061
0210778810	GOSHEN SWP BL BEAR MARSH B AT BEAUTANCUS	72.6	20	350615	780320	WARSAW NORTH	061

STATION NUMBER	STATION NAME	DRAINAGE AREA (SQ MI)	SITE TYPE	LAT	LONG	QUAD NAME	COUNTY CODE
0210850355	MILL C AT SR 1111 NR NEWTONS X RDS	11.8	20	344305	780709	ATKINSON	163
0210850365	DOCTORS C TRIB AT MTH NR WALLACE	4.91	20	344325	780630	ATKINSON	061
0210851000	DOCTORS C NR WALLACE	53.6	02	344330	780318	ATKINSON	061
0210851800	ROCKFISH C BL DOCTORS C NR WALLACE	131.	20	344350	780120	ATKINSON	061
0210852900	ROCKFISH C AT WALLACE	135.	20	344334	780018	ATKINSON	061
0210852910	CROOKED RUN AT MTH AT PENDERLEA	5.38	20	344013	780237	ATKINSON	141
0210852920	SILLS C AT SR 1001 NR PENDERLEA	18.3	20	344114	780051	ATKINSON	141
0210852935	SILLS C AT MTH NR WILLARD	20.5	20	344307	775946	BURGAW	141
0210852950	SAWYER C AT MTH AT WILLARD	3.49	20	344300	775937	BURGAW	141
0210853600	ROCKFISH C AB L ROCKFISH C NR TIN CITY	162.	02	344310	775830	BURGAW	061
0210854300	L ROCKFISH C AT TIN CITY	7.04	20	344425	775855	BURGAW	061
0210854800	L ROCKFISH C AT WALLACE	7.83	01	344402	775803	BURGAW	061
0210855220	L ROCKFISH C AT MTH NR WALLACE	10.2	20	344311	775829	BURGAW	061
0210856300	ROCKFISH C AT MTH NR WALLACE	177.	20	344310	775520	BURGAW	061
0210856365	WASHINGTON C AT MTH NR WILLARD	4.38	20	344056	775614	BURGAW	141
0210856375	LEWIS C AT MTH NR WATHA	9.13	20	343932	775427	BURGAW	161
0210856400	NE CAPE FEAR R NR WATHA	886.	02	343850	775220	BURGAW	141
0210856450	NE CAPE FEAR R TRIB AT MTH NR SHELTER NECK	2.56	20	343820	775303	BURGAW	141
0210856600	NE CAPE FEAR R NR BURGAW	918.	20	343555	775235	BURGAW	141
0210857050	MOORES C AT NC 53 NR MAPLE HILL	11.7	20	344053	774108	MAPLE HILL	141
0210857065	HOLLY SHELTER C AT NC 50 NR MAPLE HILL	27.1	20	343925	774122	MAPLE HILL	141
0210858000	HOLLY SHELTER C NR MAPLE HILL	33.6	02	343820	774402	MAPLE HILL	141
0210858125	BACK SWP AT SR 1001 NR CATHERINE LAKE	14.9	20	345005	773811	RICHLANDS	133
0210858135	BACK SWP TRIB AT MTH NR CATHERINE LAKE	6.11	20	344911	774008	RICHLANDS	133
0210858142	BACK SWP TRIB AT MTH NR FOUNTAIN	3.95	20	344821	774028	RICHLANDS	061
0210858154	NINE MILE C TRIB AT SR 1207 NR JACKSONVILLE	7.71	20	344543	774009	RICHLANDS	061
0210858163	NINE MILE C AT SR 1826 NR CYPRESS CREEK	18.9	20	344546	774153	RICHLANDS	061
0210858177	BACK SWP AT SR 1828 NR CYPRESS CREEK	60.9	20	344528	774232	RICHLANDS	061
0210858183	CYPRESS C AT MTH AT CYPRESS CREEK	12.0	20	344506	774312	RICHLANDS	061
0210858192	ANGOLA C TRIB NR MAPLE HILL	23.4	20	344134	774418	MAPLE HILL	141
0210858500	ANGOLA C NR MAPLE HILL	55.8	02	343915	774402	MAPLE HILL	141
0210858515	JUNIPER SWP TRIB AT MTH NR HOLLY RIDGE	8.70	20	343343	773556	MAPLE HILL	133
0210858520	JUNIPER SWP TRIB AT MTH NR FOLKSTONE	6.87	20	343341	773618	MAPLE HILL	133
0210858535	JUNIPER SWP AT MTH NR HOLLY RIDGE	30.9	20	343356	773652	MAPLE HILL	133
0210858555	SANDY RUN SWP AT SR 1105 AT PADGETT	6.65	20	344024	773522	MAPLE HILL	133
0210858600	SANDY RUN SWP NR PADGETT	18.4	20	343805	773647	MAPLE HILL	133
0210858625	SANDY RUN SWP NR MAPLE HILL	22.5	20	343731	774003	MAPLE HILL	141
0210858646	SHELTER SWP C AT MTH NR MAPLE HILL	61.4	20	343446	773924	MAPLE HILL	141
0210858659	SHAKEN C NR MAPLE HILL	121.	20	343455	774131	MAPLE HILL	141
0210858720	SHAKEN C AT MTH AT SHAKEN	133.	20	343702	774601	BURGAW	141
0210858900	HOLLY SHELTER C NR WHITE STOCKING	231.	20	343700	774610	BURGAW	141
0210858963	MILL POND AT NC 53 NR WHITE STOCKING	13.2	20	343729	774724	BURGAW	141
0210858375	CAME B AT MTH NR WHITE STOCKING	3.74	20	343628	774938	BURGAW	141
0210859200	HOLLY SHELTER C NR BURGAW	257.	20	343520	774900	BURGAW	141
0210859265	NE CAPE FEAR R TRIB AT MTH AT WHITE STOCKING	8.17	20	343506	774846	BURGAW	141
0210859305	NE CAPE FEAR R TRIB AT MTH NR WALKERS	57.2	20	343308	774847	BURGAW	141
0210859800	BURGAW C AT BURGAW	3.07	02	343310	775520	BURGAW	141
0210860100	BURGAW C AT US 117 NR BURGAW	8.56	11	343350	775530	BURGAW	141
0210860400	BURGAW C NR BURGAW	17.7	11	343400	775340	BURGAW	141
0210860550	BURGAW C AT SR 1411 AT WALKERS	24.8	11	343227	775113	BURGAW	141
0210860565	BURGAW C AT MTH NR WALKERS	28.3	20	343224	774951	BURGAW	141
0210860610	CYPRESS C AT MTH NR WALKERS STORE	7.39	20	343047	775031	BURGAW	141
0210860800	LILLINGTON C AT SR 1520 NR ST HELENA	6.91	11	343027	774857	BURGAW	141
0210860855	LILLINGTON C AT MTH NR ROCKY POINT	8.87	20	342950	775029	MOORETOWN (OM)	141
0210861045	PIKE C AT SR 1411 NR TWIN OAK	4.47	20	342747	775233	ROCKY POINT (OM)	141
0210861065	PIKE C AT MTH NR ROCKY POINT	10.4	20	342802	775030	MOORETOWN (OM)	141
0210861200	NE CAPE FEAR R NR ROCKY POINT	1326.	02	342535	775003	MOORETOWN (OM)	141
0210861225	TRUMPETER SWP AT MTH NR MOORETOWN	16.3	20	342622	774636	MOORETOWN (OM)	141
0210861235	CATSKIN C AT MTH NR MOORETOWN	25.2	20	342654	774802	MOORETOWN (OM)	141
0210861250	MERRICKS C HEADWATERS NR MOORETOWN	5.80	20	342655	774803	MOORETOWN (OM)	141
0210861300	MERRICKS C NR ROCKY POINT	31.2	20	342646	774813	MOORETOWN (OM)	141
0210861325	MERRICKS C AT MTH NR ROCKY POINT	35.2	20	342418	774754	MOORETOWN (OM)	141
0210861700	HARRISONS C NR HAMPSTEAD	14.0	20	342343	774619	MOORETOWN (OM)	141
0210861754	HARRISONS C AT MTH NR MOORETOWN	54.7	20	342409	774841	MOORETOWN (OM)	141
0210861765	ISLAND C TRIB AT MTH NR PORTER	3.48	20	342106	774827	SCOTTS HILL (OM)	129
0210861776	ISLAND C TRIB AT MTH NR SCOTTS HILL	4.57	20	342128	774841	SCOTTS HILL (OM)	141
0210861779	ISLAND C AT SR 1002 NR SCOTTS HILL	18.1	20	342201	774855	SCOTTS HILL (OM)	141
0210861785	ISLAND C AT MTH NR MOORETOWN	20.1	20	342317	774921	MOORETOWN (OM)	141
0210861800	STURGEON C NR CASTLE HAYNE	1.97	20	342123	775154	SCOTTS HILL (OM)	129
0210861845	STURGEON C AT MTH NR CASTLE HAYNE	2.78	20	342214	775227	SCOTTS HILL (OM)	129
0210861900	NE CAPE FEAR R NR CASTLE HAYNE	1426.	20	342151	775353	CASTLE HAYNE (OM)	129
0210861950	PRINCE GEORGE C 0.3 MI AB SR 1318 NR CASTLE HAYNE	2.86	20	342015	775206	SCOTTS HILL (OM)	129
0210862000	PRINCE GEORGE C NR CASTLE HAYNE	4.20	02	342019	775222	SCOTTS HILL (OM)	129
0210862025	PRINCE GEORGE C TRIB AT MTH NR CASTLE HAYNE	2.85	20	342019	775247	CASTLE HAYNE (OM)	129
0210862050	PRINCE GEORGE C AT NC 132 NR CASTLE HAYNE	8.19	20	342019	773338	CASTLE HAYNE (OM)	129
0210862200	PRINCE GEORGE C NR WRIGHTSBORO	10.3	20	342040	775410	CASTLE HAYNE (OM)	129
0210862235	PRINCE GEORGE C TRIB AT MTH AT CASTLE HAYNE	2.76	20	342110	775601	CASTLE HAYNE (OM)	129
0210862248	PRINCE GEORGE C AT MTH NR CASTLE HAYNE	17.1	20	342150	775701	CASTLE HAYNE (OM)	129
0210863000	TURKEY C NR CASTLE HAYNE	10.5	03	342347	775448	ROCKY POINT (OM)	141
0210863025	TURKEY C AT MTH NR CASTLE HAYNE	15.4	20	342249	775729	ROCKY POINT (OM)	141
0210863115	HORSE BRANCH C AT SR 1336 NR BURGAW	5.88	20	343711	775917	BURGAW	141
0210863125	HORSE BRANCH C AT SR 1332 NR BURGAW	20.1	20	343411	775852	BURGAW	141
0210863150	HORSE BRANCH C AT NC 53 NR BURGAW	33.6	20	343230	780005	ATKINSON	141
0210863195	BEE B AT SR 1335 NR PENDERLEA	5.06	20	343621	780234	ATKINSON	141
0210863300	CYPRESS C NR WARDS CORNER	19.3	20	343240	780209	ATKINSON	141

NORTHEAST CAPE FEAR RIVER - CONTINUED

STATION NUMBER	STATION NAME	DRAINAGE AREA (SQ MI)	SITE TYPE	LAT	LONG	QUAD NAME	COUNTY CODE
0210863315	CYPRESS C AT MTH NR WARDS CORNER	21.8	20	343158	780142	ATKINSON	141
0210863320	LONG C AT SR 1120 NR MALPASS CORNER	60.5	20	343112	780140	ATKINSON	141
0210863350	BIG B AT MTH NR LONG CREEK	3.58	20	342802	780228	ACME	141
0210863400	LONG C AT LONG CREEK	85.3	20	342620	780134	ACME	141
0210863525	RIZZO C AT MTH NR HIGHSMITH	9.04	20	342825	775826	ROCKY POINT (DM)	141
0210863535	MILL C AT MTH AT HIGHSMITH	3.58	20	342824	775827	ROCKY POINT (DM)	141
0210863545	KELLYS C AT MTH NR LITTLE KELLY	7.50	20	342804	775810	ROCKY POINT (DM)	141
0210863554	RILEYS C TRIB AT MTH NR LITTLE KELLY	4.11	20	342728	775816	ROCKY POINT (DM)	141
0210863600	RILEYS C NR LONG CREEK	27.6	20	342634	775941	ROCKY POINT (DM)	141
0210863625	GUFFORDS B AT MTH NR LONG CREEK	1.87	20	342629	780005	ACME	141
0210863650	RILEYS C AT MTH AT LONG CREEK	34.0	20	342521	780133	ACME	1410
0210863675	MORGANS C AT MTH NR ROCKY POINT	6.48	20	342256	775800	ROCKY POINT (DM)	141
0210863685	LONG C AT MTH NR ROCKY POINT	144.	20	342243	775816	ROCKY POINT (DM)	141
0210863700	NE CAPE FEAR R NR CASTLE HAYNE	1620.	20	342018	775939	CASTLE HAYNE (DM)	129
0210863735	FISHING C AT MTH NR WRIGHTSBORO	0.28	20	342011	775927	CASTLE HAYNE (DM)	129
0210863800	NE CAPE FEAR R NR WRIGHTSBORO	1620.	20	341910	775720	CASTLE HAYNE (DM)	129
0210863845	NESS C HEADWATERS AT WRIGHTSBORO	1.96	20	341757	775535	CASTLE HAYNE (DM)	129
0210863855	NESS C AT MTH NR WRIGHTSBORO	3.49	20	341710	775714	CASTLE HAYNE (DM)	129
0210863875	NE CAPE FEAR R TRIB HEADWATERS AT WRIGHTSBORO	1.38	20	341656	775600	CASTLE HAYNE (DM)	129
0210863885	NE CAPE FEAR R TRIB AT MTH NR WRIGHTSBORO	2.00	20	341656	775700	CASTLE HAYNE (DM)	129
0210863950	SMITH C HEADWATERS AT BONNIE	4.61	20	341723	775138	SCOTTS HILL (DM)	129
0210863955	SMITH C TRIB AT SR 1322 AT BONNIE	2.96	20	341739	775147	SCOTTS HILL (DM)	129
0210863958	SMITH C TRIB AT MTH AT BONNIE	3.23	20	341723	775139	SCOTTS HILL (DM)	129
0210864000	SMITH C NR MURRAYSVILLE	8.94	02	341638	775207	SCOTTS HILL (DM)	129
0210864050	SMITH C NR WILMINGTON	9.34	20	341619	775223	SCOTTS HILL (DM)	129
0210864100	SMITH C TRIB NO 2 NR BAYMEADE	3.66	02	341610	775210	SCOTTS HILL (DM)	129
0210864155	SMITH C TRIB AT MTH NR WRIGHTSBORO	3.43	20	341554	775316	CASTLE HAYNE (DM)	129
0210864200	SMITH C AB AIRPORT AT WILMINGTON	17.2	20	341545	775317	CASTLE HAYNE (DM)	129
0210864500	SPRING B NR MURRAYSVILLE	1.52	02	341520	775220	SCOTTS HILL (DM)	129
0210864600	SPRING B NR WILMINGTON	2.87	11	341533	775347	CASTLE HAYNE (DM)	129
0210864750	SMITH C TRIB AT MTH NR BAYMEADE	0.56	20	341531	775425	CASTLE HAYNE (DM)	129
0210864775	SMITH C TRIB AT MTH AT WILMINGTON	0.84	20	341526	775456	CASTLE HAYNE (DM)	129
0210864800	SMITH C AT 23 ST AT WILMINGTON	24.2	20	341530	775511	CASTLE HAYNE (DM)	129
0210865605	BURNT MILL C HEADWATERS AT WILMINGTON	3.28	20	341343	775422	WILMINGTON (DM)	129
0210866050	BURNT MILL C AT MARKET ST AT WILMINGTON	5.62	20	341414	775518	WILMINGTON (DM)	129
0210866300	BURNT MILL C AT MTH NR WRIGHTSBORO	6.98	20	341518	775538	CASTLE HAYNE (DM)	129
0210868300	SMITH C AB MTH AT WILMINGTON	33.1	20	341600	775640	CASTLE HAYNE (DM)	129
0210869230	NE CAPE FEAR R AT US 117 AT WILMINGTON	1670.	20	341506	775705	CASTLE HAYNE (DM)	129

LOWER CAPE FEAR RIVER

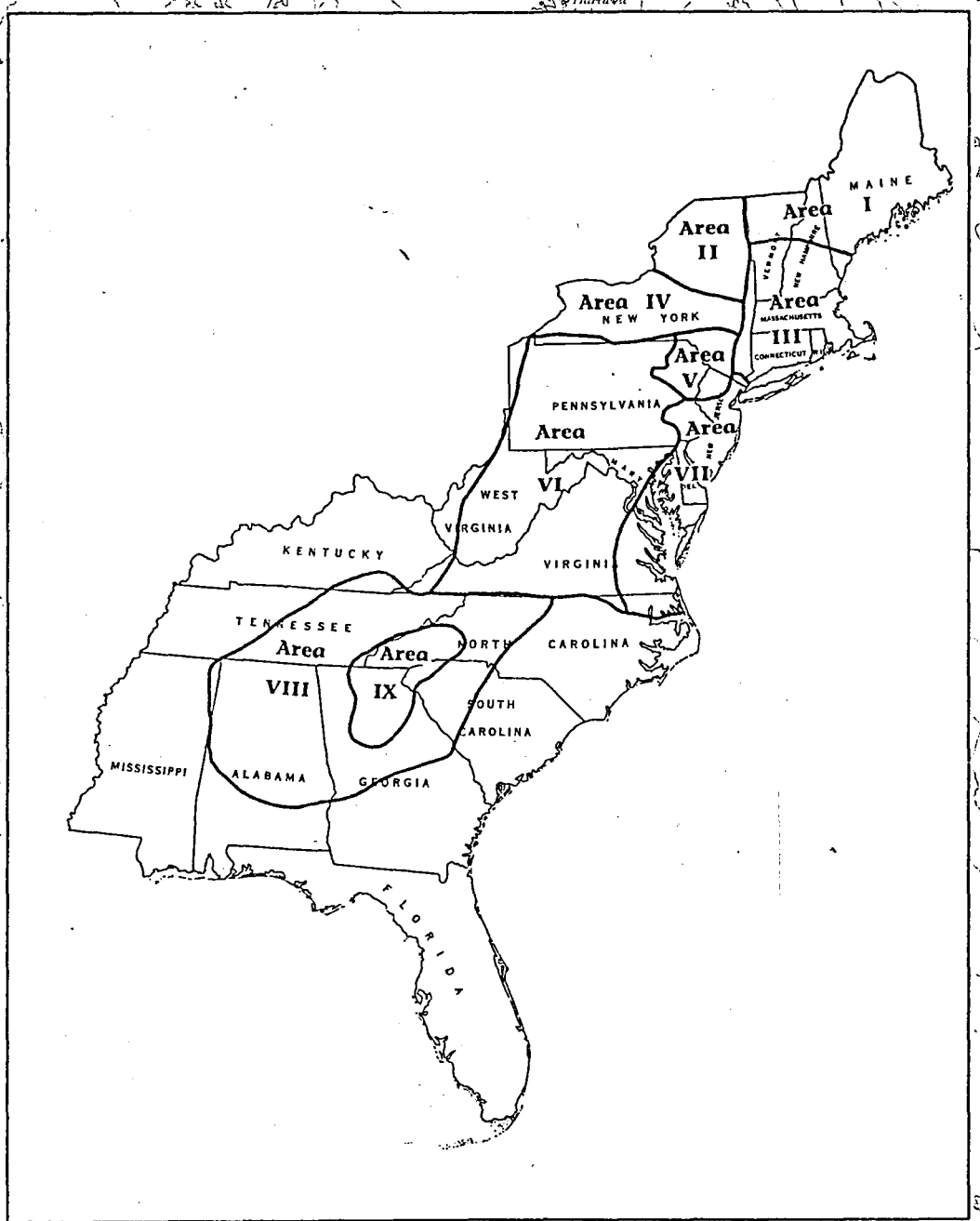
STATION NUMBER	STATION NAME	DRAINAGE AREA (SQ MI)	SITE TYPE	LAT	LONG	QUAD NAME	COUNTY CODE
0210873000	GREENFIELD LAKE OUTLET AT WILMINGTON	3.73	02	341240	775644	WILMINGTON (DM)	129
0210873635	STURGEON C HEADWATERS NR ELIAH	2.68	20	341400	780306	WINNABOW	019
0210873640	STURGEON C AT SR 1437 NR ELIAH	5.44	20	341425	780214	WINNABOW	019
0210873645	STURGEON C AB MILL C NR EASY HILL	9.11	20	341441	780048	WINNABOW	019
0210873650	MILL C AT LELAND	4.32	20	341524	780217	ACME	019
0210873655	MILL C AB STURGEON C NR EASY HILL	6.33	20	341443	780041	WINNABOW	019
0210873660	STURGEON C AT MTH NR CLAIRMONT	17.3	20	341439	775927	WILMINGTON (DM)	019
0210873662	JACKEYE C AB PINEY B NR LANVALE	3.22	20	341206	780111	WINNABOW	019
0210873663	PINEY B AT MTH NR LANVALE	1.53	20	341205	780110	WINNABOW	019
0210873666	JACKEYE C AT NC 133 NR CLARENDON	8.63	20	341157	775851	WILMINGTON (DM)	019
0210874500	CAPE FEAR R AT BRUNSWICK RIVER	8760.	20	341037	775730	WILMINGTON (DM)	129
0210874550	MALLORY C AT NC 133 NR CLAIRMONT	4.75	20	341021	775927	WILMINGTON (DM)	019
0210874575	L MALLORY C AT NC 133 NR CLAIRMONT	1.88	20	340944	775907	WILMINGTON (DM)	019
0210874580	MALLORY C AT MTH NR CLAIRMONT	8.88	20	340958	775814	WILMINGTON (DM)	019
0210874800	BARNARDS C NR MYRTLE GROVE	2.01	20	340931	775445	WILMINGTON (DM)	129
0210874825	BARNARDS C TRIB NR MYRTLE GROVE	1.68	20	341003	775552	WILMINGTON (DM)	129
0210874850	BARNARDS C AT SR 1100 NR WILMINGTON	6.77	20	340930	775619	WILMINGTON (DM)	129
0210875750	TOWN C HEADWATERS NR ACME	3.23	20	341147	781227	LEWIS SWAMP	019
0210875755	TOWN C TRIB NR ACME	2.97	20	341131	781111	LEWIS SWAMP	019
0210875765	TOWN C NR BATARORA	8.98	20	341123	781045	LEWIS SWAMP	019
0210875770	TURKEY B HEADWATERS NR BARTARORA	3.42	20	341233	780838	LEWIS SWAMP	019
0210875780	TURKEY R AT MTH NR PINEY GROVE	7.58	20	341049	780949	LEWIS SWAMP	019
0210876000	TOWN C NR BOLIVIA	19.4	02	341031	780840	LEWIS SWAMP	019
0210876135	LEWIS SWP TRIB NR PINEY GROVE	3.70	20	340948	781140	LEWIS SWAMP	019
0210876150	LEWIS SWP AT PINEY GROVE	8.47	20	340947	781138	LEWIS SWAMP	019
0210876700	TOMPKIN B NR WINNABOW	1.91	20	340948	781138	LEWIS SWAMP	019
0210876725	LEWIS SWP TRIB AT RABONTOWN	1.73	20	341006	781037	LEWIS SWAMP	019
0210876735	LEWIS B HEADWATERS NR RABONTOWN	5.22	20	340827	781028	LEWIS SWAMP	019
0210876750	LEWIS B AT MTH NR RABONTOWN	7.36	20	340958	781049	LEWIS SWAMP	019
0210876765	LEWIS SWP AT MTH NR BOLIVIA	22.3	20	341028	780837	LEWIS SWAMP	019
0210877050	TOWN C NR HENRYTOWN	45.7	20	340951	780743	LEWIS SWAMP	019
0210877100	RUSSELLS C NR BOLIVIA	2.69	02	340848	780654	WINNABOW	019
0210877150	RUSSELLS C AT MTH NR BOLIVIA	3.09	20	340922	780655	WINNABOW	019
0210877210	TOWN C NR BOLIVIA	51.3	20	340926	780606	WINNABOW	019
0210877400	BELL SWP HEADWATERS AT NEW HOPE	1.77	20	340620	780952	BOLIVIA	019
0210877450	CHERRY TREE SWP AT MTH NR NEW HOPE	2.64	20	340718	780800	BOLIVIA	019
0210877455	BELL SWP NR NEW HOPE	8.08	20	340718	780759	BOLIVIA	019
0210877900	BELL SWP NR BOLIVIA	11.5	20	340802	780543	WINNABOW	019
0210877905	BELL SWP AB MILL C NR MILL CREEK	14.0	20	340710	780445	FUNSTON	019
0210877908	MILL C TRIB NR MILL CREEK	1.16	20	340435	780517	FUNSTON	019
0210877910	MILL C HEADWATERS NR MILL CREEK	5.12	20	340435	780518	FUNSTON	019
0210877915	SWAIN B TRIB NR BOLIVIA	1.29	20	340444	780351	FUNSTON	019
0210877920	SWAIN B TRIB NR MILL CREEK	1.17	20	340446	780358	FUNSTON	019
0210877925	SWAIN B AT MTH NR MILL CREEK	4.64	20	340508	780437	FUNSTON	019
0210877950	HICKMAN B AT MTH AT MILL CREEK	0.82	20	340543	780438	FUNSTON	019

U.S. Geological Survey

Water-Resources Investigations Report 88–4094

Ref. 39

MAP OF MEAN ANNUAL RUNOFF FOR THE NORTHEASTERN, SOUTHEASTERN, AND MID-ATLANTIC UNITED STATES, WATER YEARS 1951-80



Prepared in cooperation with the
U.S. Environmental Protection Agency

MAP OF MEAN ANNUAL RUNOFF FOR THE NORTHEASTERN, SOUTHEASTERN, AND MID-ATLANTIC UNITED STATES, WATER YEARS 1951–80

By
William R. Krug, Warren A. Gebert, David J. Graczyk, U.S. Geological Survey;
Donald L. Stevens, Jr., Eastern Oregon State College;
Barry P. Rochelle, Northrop Services, Inc.;
and M. Robbins Church, U.S. Environmental Protection Agency

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 88–4094

Prepared in cooperation with the
U.S. ENVIRONMENTAL PROTECTION AGENCY

Madison, Wisconsin
1990

sions that the methods that used the area-weighted average of the drainage area or the centroid of the drainage area produced somewhat better correlations—that is, the interecept was closer to zero, the standard errors were small, and the correlation coefficients were larger. These methods have slightly greater power to predict actual runoff

Additional statistical investigation found no significant differences in reliability of the runoff estimates among the areas. No significant differences existed in the errors for stations with drainage areas of differing size.

USE OF MEAN ANNUAL RUNOFF MAP

Mean annual runoff for a site can be estimated from the runoff map by several methods. The simplest method of estimating the runoff is to locate the site on the runoff map and to identify the runoff contour nearest the site. This method, however, is less accurate than other methods. The most accurate method is to draw the drainage basin on the runoff map, and use the runoff contours to divide the basin into bands of differing runoff. The area of each of the bands within the drainage basin is then determined. The areas of the separate bands are then used to compute a weighted average runoff for the basin. For example, if 50 percent of the basin is in an area of 18 in/yr (inches per year) of runoff, 30 percent in an area of 20 in/yr of runoff and 20 percent in an area of 22 in/yr of runoff the mean annual runoff would be calculated as follows:

$$0.5 \times 18 + 0.3 \times 20 + 0.2 \times 22 = 19.4$$

Runoff estimated from the map is in inches per year, averaged over the entire drainage basin. Multiply this value by the drainage area, in square miles, and divide by 13.58 to convert to mean annual discharge, in cubic feet per second. In the above example, assume the drainage area of the site is 100 mi^2. The mean annual discharge, in cubic feet per second, would be:

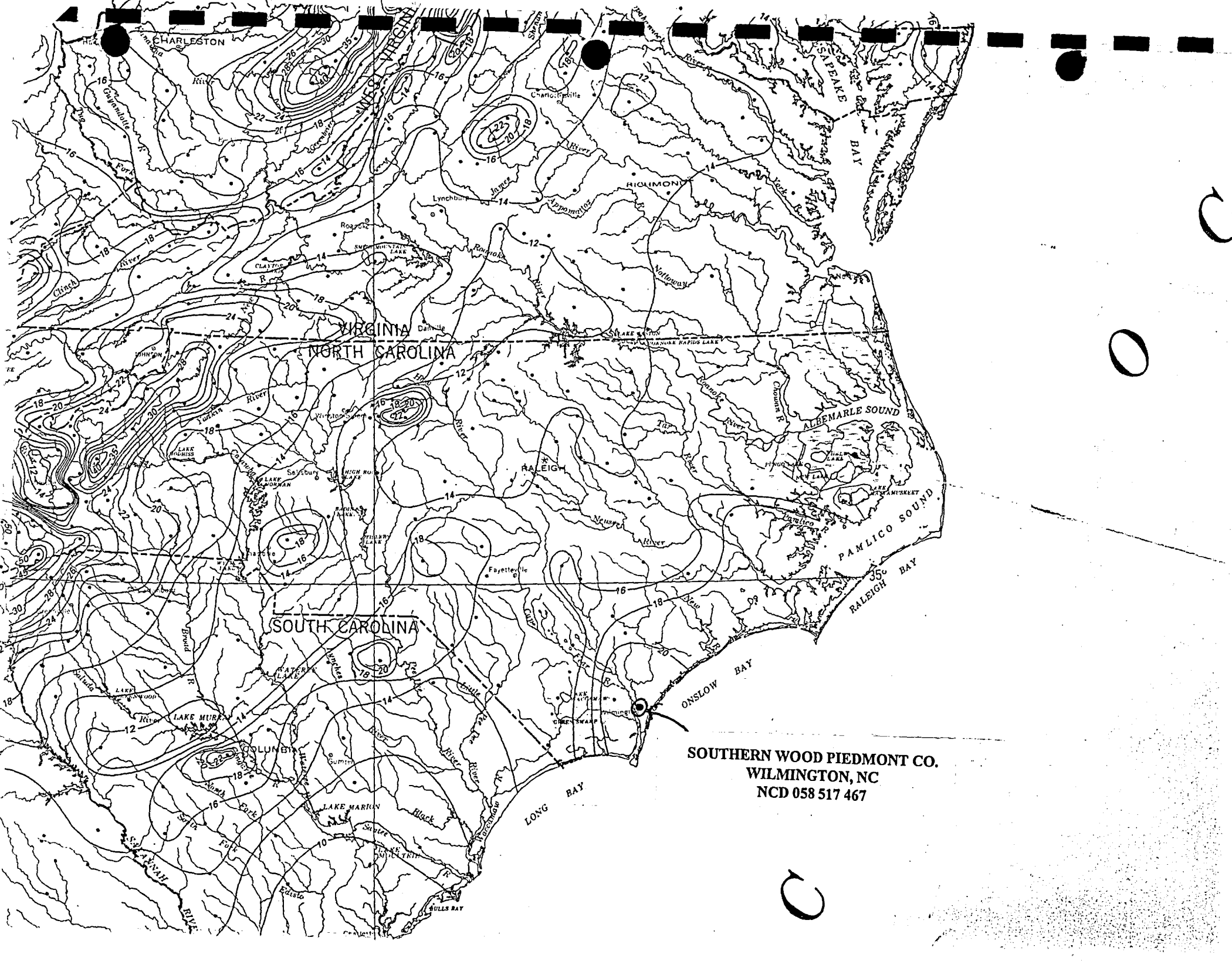
$$19.4 \times 100/13.58 = 143$$

The runoff map was prepared to allow estimation of mean annual runoff at sites where no streamflow data are available. The map represents mean annual runoff for areas with natural land cover. Caution should be used in applying the map to estimate runoff for areas that are not natural land areas. The runoff map should not be used for areas, such as large urban areas, where the land cover has been altered in ways that would change the amount of runoff. The runoff map is not applicable for lakes or bays, for coastal wetlands affected by tides, for streams controlled by reservoirs large enough to influence the total annual streamflow, or for streams with substantial diversions.

Local features could cause the runoff at a particular site to differ substantially from the runoff indicated by the runoff map. The geology of the drainage basin might cause substantial amounts of water to enter or leave the basin as ground water. This could substantially increase or decrease the runoff. For example, a stream with a small drainage area that includes a large spring probably would have higher average streamflow than indicated by the runoff map.

Table 5.—Descriptive statistics of errors in estimated runoff at 93 test stations

Method	Mean absolute value	Mean	Standard error of mean	Standard deviation
		Error, in inches		
Area-weighted	2.0	–0.35	0.30	2.9
Centroid	2.2	–.71	.33	3.1
GIS	2.7	–1.74	.37	3.6
Nearest-inch	2.8	–1.77	.38	3.7
Nearest contour	2.8	–1.79	.39	3.8
		Percent error		
Area-weighted	9.0	–0.54	1.3	12.9
Centroid	9.8	–.71	1.4	13.5
GIS	12.0	–6.42	1.6	15.9
Nearest-inch	12.1	–6.20	1.6	15.6
Nearest-contour	12.2	–6.26	1.6	15.8



SOUTHERN WOOD PIEDMONT CO.
WILMINGTON, NC
NCD 058 517 467

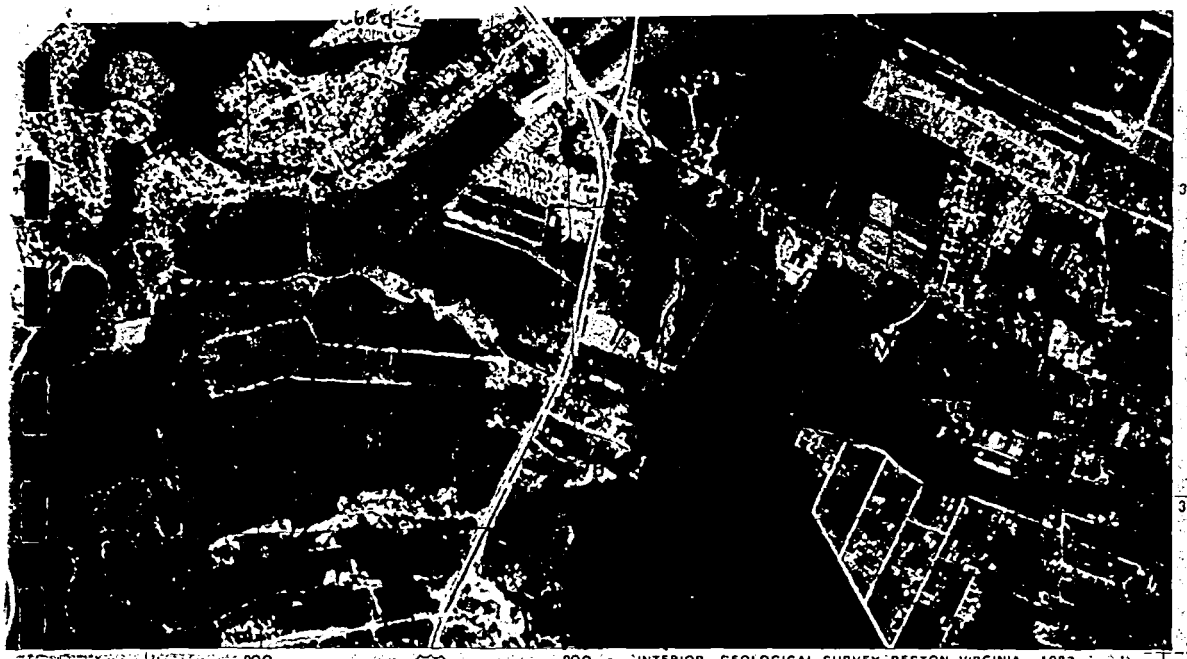
MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist
Date: October 6, 1994
Re: Southern Wood Piedmont Co.,Wilmington
NCD 058 517 467
Wetland Delineation

SFP examined National Wetland Inventory 7-1/2 minute quadrangle maps (included in Figure 3) to determine the approximate total wetland frontage along those sections of the Cape Fear River, the Brunswick River and the Northeast Cape Fear River which lie within 15 water miles of the site. Total mapped frontages of CERCLA-recognized wetlands (e.g., Palustrine Emergent, Palustrine Forested, Palustrine Scrub-shrub, etc.) were measured along those various river segments and their tributaries which undergo tidal flow-reversal (see Ref. 8). The breakdown of frontage is estimated as follows:

On-site drainage ditch and Greenfield Creek:	0.45 mile
Cape Fear River (CFR) from Creek to NE CFR:	1.0 mile
NE Cape Fear River:	42.8 miles
Upper Cape Fear River:	34.4 miles
Brunswick River:	33.7 miles
Downstream CFR:	58.2 miles
Total:	170.6 miles

Due to the limited potential for release of site contaminants to the atmosphere, wetland acreage was not evaluated within the 4-mile target distance limit around the site.



WILMINGTON, N. C.

O THE USER

ds which have been field examined are indicated
nap by an asterisk (*).
ns or corrections to the wetlands information
on this map are solicited. Please forward such
tion to the address indicated.
tems, Classes, Subclasses, and Water Regimes
s are developed specifically for NATIONAL
N INVENTORY mapping.
ir designated as R4SB, R4SBW, OR R4SBJ
MITTENT STREAMS) may not meet the defini-
wetland.
ap ses the class Unconsolidated Shore (US).
li NWI maps that class was designated Beach/
), or Flat (FL). Subclasses remain the same in both
s.

U.S. DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

Prepared by National Wetlands Inventory

RIAL PHOTOGRAPHY

/82 DATE: ___/___/___
000 SCALE: _____
CIR TYPE: _____

SYSTEM

2 — INTERTIDAL **SUBSYSTEM**

F — REEF	SB — STREAMBED	RS — ROCKY SHORE	US — UNCONSOLIDATED SHORE	EM — EMERGENT	SS — SCRUB-SHRUB	FO — FORESTED	CLASS
2 Mollusc 3 Worm	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Persistent 2 Nonpersistent	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen	Subclass

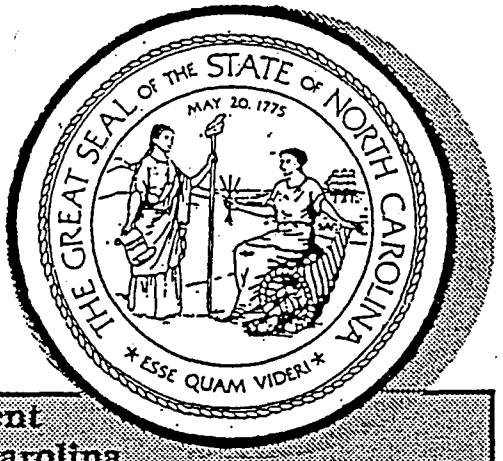
SYSTEM

2 — LITTORAL **SUBSYSTEM**

Ref. 41

STATE OF
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT, HEALTH,
AND NATURAL RESOURCES

Classifications and Water Quality Standards Assigned to The Waters of the Cape Fear River Basin



Division of Environmental Management
Raleigh, North Carolina

Reprint from North Carolina Administrative Code: 15A NCAC 2B .0311
Current through: February 1, 1993

SECTION .0300 - ASSIGNMENT OF STREAM CLASSIFICATIONS

.0301 CLASSIFICATIONS: GENERAL

(a) Schedule of Classifications. The classifications assigned to the waters of the State of North Carolina are set forth in the schedules of classifications and water quality standards assigned to the waters of the river basins of North Carolina, 15A NCAC 2B .0302 to .0317. These classifications are based upon the existing or contemplated best usage of the various streams and segments of streams in the basin, as determined through studies and evaluations and the holding of public hearings for consideration of the classifications proposed.

(b) Stream Names. The names of the streams listed in the schedules of assigned classifications were taken as far as possible from United States Geological Survey topographic maps. Where topographic maps were unavailable, U.S. Corps of Engineers maps, U.S. Department of Agriculture soil maps, and North Carolina highway maps were used for the selection of stream names.

(c) Classifications. The classifications assigned to the waters of North Carolina are denoted by the letters WS-I, WS-II, WS-III, WS-IV, WS-V, B, C, SA, SB, and SC in the column headed "class." A brief explanation of the "best usage" for which the waters in each class must be protected is given as follows:

Fresh Waters

Class WS-I:	waters protected as water supplies which are in natural and undeveloped watersheds; point source discharges of treated wastewater are permitted pursuant to Rules .0104 and .0211 of this Subchapter; local programs to control nonpoint source and stormwater discharge of pollution are required; suitable for all Class C uses;
Class WS-II:	waters protected as water supplies which are generally in predominantly undeveloped watersheds; point source discharges of treated wastewater are permitted pursuant to Rules .0104 and .0211 of this Subchapter; local programs to control nonpoint source and stormwater discharge of pollution are required; suitable for all Class C uses;
Class WS-III:	waters protected as water supplies which are generally in low to moderately developed watersheds; point source discharges of treated wastewater are permitted pursuant to Rules .0104 and .0211 of this Subchapter; local programs to control nonpoint source and stormwater discharge of pollution are required; suitable for all Class C uses;
Class WS-IV:	waters protected as water supplies which are generally in moderately to highly developed watersheds; point source discharges of treated wastewater are permitted pursuant to Rules .0104 and .0211 of this Subchapter; local programs to control nonpoint source and stormwater discharge of pollution are required; suitable for all Class C uses;
Class WS-V:	waters protected as water supplies which are generally upstream and draining to Class WS-IV waters; no categorical restrictions on watershed development or treated wastewater discharges are required, however, the Commission or its designee may apply appropriate management requirements as deemed necessary for the protection of downstream receiving waters (15A NCAC 2B .0203); suitable for all Class C uses;
Class B:	primary recreation and any other usage specified by the "C" classification;
Class C:	aquatic life propagation and survival, fishing, wildlife, secondary recreation, and agriculture.

Tidal Salt Waters

Class SA:	shellfishing for market purposes and any other usage specified by the "SB" and "SC" classification;
Class SB:	primary recreation and any other usage specified by the "SC" classification;
Class SC:	aquatic life propagation and survival, fishing, wildlife, and secondary recreation.

Supplemental Classifications

Trout Waters:	Suitable for natural trout propagation and maintenance of stocked trout;
Swamp Waters:	Waters which have low velocities and other natural characteristics which are different from adjacent streams;
NSW:	Nutrient Sensitive Waters which require limitations on nutrient inputs;
HQW:	High Quality Waters which are waters that are rated as excellent based on biological and physical/chemical characteristics through division monitoring or special studies, native and special native trout waters (and their tributaries) designated by the Wildlife Resources Commission, primary nursery areas (PNA) designated by the Marine Fisheries Commission and other functional nursery areas designated by the Wildlife Resources Commission, critical habitat areas designated by the Wildlife Resources Commission or the Department of Agriculture, all water supply watersheds which are either classified as WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II has been received from the appropriate local government and accepted by the Division of Environmental Management and all Class SA waters.
ORW:	Outstanding Resource Waters which are unique and special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses.

(d) Water Quality Standards. The water quality standards applicable to each classification assigned are those established in 15A NCAC 2B .0200, Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina, as adopted by the North Carolina Environmental Management Commission.

(e) Index Number.

(1) Reading the Index Number. The index number appearing in the column so designated is an identification number assigned to each stream or segment of a stream, indicating the specific tributary progression between the main stem stream and the tributary stream.

(2) Cross-Referencing the Index Number. The inclusion of the index number in the schedule is to provide an adequate cross reference between the classification schedules and an alphabetic list of streams.

(f) Classification Date. The classification date indicates the date on which enforcement of the provisions of Section 143-215.1 of the General Statutes of North Carolina became effective with reference to the classification assigned to the various streams in North Carolina.

(g) Reference. Copies of the schedules of classifications adopted and assigned to the waters of the various river basins may be obtained at no charge by writing to:

Director
Division of Environmental Management
Department of Environment, Health, and Natural Resources
Post Office Box 29535
Raleigh, North Carolina 27626-0535

(h) Places where the schedules may be inspected:

Division of State Library
Archives -- State Library Building
109 E. Jones Street
Raleigh, North Carolina.

(i) Unnamed Streams.

(1) Any stream which is not named in the schedule of stream classifications carries the same classification as that assigned to the stream segment to which it is tributary except:

(A) unnamed streams specifically described in the schedule of classifications; or

(B) unnamed freshwaters tributary to tidal saltwaters will be classified "C"; or

(C) after November 1, 1986, any newly created areas of tidal saltwater which are connected to Class SA waters by approved dredging projects will be classified "SC" unless case-by-case reclassification proceedings are conducted.

(2) The following river basins have different policies for unnamed streams entering other states or for specific areas of the basin:

.0311 CAPE FEAR RIVER BASIN

Name of Stream	Description	Class	Classification Date	Classification Index No.
	near Acme to Lock # 1 (City of Wilmington water supply intake)			
CAPE FEAR RIVER	From U. S. Corps of Engineers Lock #1 near Acme to a point 0.5 mile upstream of raw water supply intake at Federal Paper Board Corporation (Riegelwood)	WS-IV Sw	8/3/92	18-(59)
Natmore Creek	From source to Cape Fear River	WS-IV Sw	8/3/92	18-60
Salt Marsh Ditch	From source to Natmore Creek	WS-IV Sw	8/3/92	18-60-1
White Oak Canal	From source to Natmore Creek	WS-IV Sw	8/3/92	18-60-2
Weyman Creek	From source to Cape Fear River	WS-IV Sw	8/3/92	18-61
Copper Smith Branch	From source to Weyman Creek	WS-IV Sw	8/3/92	18-61-1
Turkeypen Branch	From source to Weyman Creek	WS-IV Sw	8/3/92	18-61-2
Turner Branch	From source to Weyman Creek	WS-IV Sw	8/3/92	18-61-3
Beaverdam Creek	From source to Weyman Creek	WS-IV Sw	8/3/92	18-61-4
Horsepen Branch	From source to Beaverdam Creek	WS-IV Sw	8/3/92	18-61-4-1
Double Branch	From source to Cape Fear River	WS-IV Sw	8/3/92	18-62
CAPE FEAR RIVER	From a point 0.5 mile upstream of raw water supply intake at Federal Paper Board Corporation (Riegelwood) to raw water supply intake at Federal Paper Board Corporation (Riegelwood), located 0.6 mile upstream of Livingston Creek	WS-IV Sw CA	8/3/92	18-(62.5)
CAPE FEAR RIVER	From raw water supply intake at Federal Paper Board Corporation (Riegelwood) to upstream mouth of Toomers Creek	C Sw	4/1/59	18-(63)
Livingston Creek (Broadwater Lake)	From source to Cape Fear River	C Sw	3/1/77	18-64
Gapway Creek	From source to Livingston Creek	C Sw	4/1/59	18-64-2
Gapway Swamp	From source to Gapway Creek	C Sw	4/1/59	18-64-2-1
Poplar Branch	From source to Livingston Creek	C Sw	4/1/59	18-64-3
Scott Branch	From source to Livingston Creek	C Sw	4/1/59	18-64-4
McClennen Branch	From source to Scott Branch	C Sw	4/1/59	18-64-4-1
Terrapin Branch	From source to Scott Branch	C Sw	4/1/59	18-64-4-2
Boggy Branch (Chapel Creek)	From source to Livingston Creek	C Sw	4/1/59	18-64-5
Johns Branch	From source to Livingston Creek	C Sw	9/1/74	18-64-6
Taylor Branch	From source to Johns Branch	C Sw	9/1/74	18-64-6-1
Dans Creek	From source to Livingston Creek	C Sw	4/1/59	18-64-7
All connecting drainage canals	From source to Dans Creek	C Sw	9/1/74	18-64-7-1
Mill Creek	From source to Dans Creek	C Sw	4/1/59	18-64-7-2
Strauss Canal (Strauss Swamp)	From source to Mill Creek	C Sw	4/1/59	18-64-7-2-1
Simon Branch	From source to Livingston Creek	C Sw	4/1/59	18-64-8
Hall Branch	From source to Livingston Creek	C Sw	4/1/59	18-64-9
Big Branch	From source to Livingston Creek	C Sw	9/1/74	18-64-10
Bay Branch	From source to Big Branch	C Sw	9/1/74	18-64-10-1
Mill Branch	From source to Big Branch	C Sw	9/1/74	18-64-10-2

.0311 CAPE FEAR RIVER BASIN

Name of Stream	Description	Class	Classification Date	Classification Index No.
Cherry Tree Prong	From source to Indian Creek	C Sw	4/1/59	18-70-2
Mulberry Branch	From source to Indian Creek	C Sw	4/1/59	18-70-3
Otter Branch	From source to Mulberry Branch	C Sw	4/1/59	18-70-3-1
Mill Branch	From soruce to Indian Creek	C Sw	4/1/59	18-70-4
CAPE FEAR RIVER	From upstream mouth of Toomers creek to a line across the river from Snows Point (through Snows Marsh) to Federal Point	SC	8/9/81	18-(71)
Cartwheel Branch	From source to Cape Fear River	SC Sw	4/1/59	18-72
Toomers Creek	From upstream mouth to a point 0.8 mile upstream of mouth	WS-IV	8/3/92	18-73-(1)
Toomers Creek	From a point 0.8 mile upstream of mouth to mouth (City of Wilmington water supply intake)	WS-IV CA	8/3/92	18-73-(2)
Northeast Cape Fear River	From source to Muddy Creek	C Sw	9/1/74	18-74-(1)
Barlow Branch	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-2
Lewis Branch (Williams Millpond)	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-3
Horse Pen Branch	From source to Lewis Branch	C Sw	9/1/74	18-74-3-1
Rattlesnake Branch	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-4
Polly Run Creek (Deavers Pond)	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-5
Ladds Branch (Whitfield Pond)	From source to Polly Run Creek	C Sw	9/1/74	18-74-5-1
Wolfscrape Branch	From source to Polly Ann Creek	C Sw	9/1/74	18-74-5-2
Jumping Run Branch	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-6
Juniper Branch	From source to Jumping Run Branch	C Sw	9/1/74	18-74-6-1
Mire Branch	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-7
Reedy Branch	From source to Mire Branch	C Sw	4/1/59	18-74-7-1
Buck Marsh Branch	From source to Northeast Cape Fear River	C Sw	7/1/73	18-74-8
Tom Branch	From source to Buck Marsh Branch	C Sw	9/1/74	18-74-8-1
Jones Branch	From source to Buck Marsh Branch	C Sw	9/1/74	18-74-8-2
Cabin Branch	From source to Buck Marsh Branch	C Sw	9/1/74	18-74-8-3
Poley Branch	From source to Buck Marsh Branch	C Sw	9/1/74	18-74-8-4
Oak Branch	From source to Poley Branch	C Sw	9/1/74	18-74-8-4-1
Mill Branch	From source to Oak Branch	C Sw	9/1/74	18-74-8-4-1-1
Beaverdam Barnch	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-9
Jumping Run	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-10
Great Branch (Hussey Pond)	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-11
Beaverdam Branch (Rouse Pond)	From source to Great Branch	C Sw	4/1/59	18-74-11-1
Horsepen Branch	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-12
Matthews Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-13
Sawyer Branch	From source to Matthews Creek	C Sw	4/1/59	18-74-13-1
Juniper Branch	From source to Matthews Creek	C Sw	4/1/59	18-74-13-2
Sandy Run	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-14
Camp Branch	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-15
Housland Branch	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-16

.0311 CAPE FEAR RIVER BASIN

Name of Stream	Description	Class	Classification Date	Classification Index No.
Cypress Creek	From source to Angola Creek	C Sw	4/1/59	18-74-33-3-1
Back Swamp	From source to Angola Creek	C Sw	9/1/74	18-74-33-3-2
Little Limestone Creek	From source to Back Swamp	C Sw	9/1/74	18-74-33-3-2-1
Nine Mile Creek	From source to Back Swamp	C Sw	7/1/73	18-74-33-3-2-2
Ten Mile Creek	From source to Nine Mile Creek	C Sw	7/1/73	18-74-33-3-2-2-1
Bob Creek	From source to Angola Creek	C Sw	4/1/59	18-74-33-3-3
Moccasin Creek	From source to Angola Creek	C Sw	4/1/59	18-74-33-3-4
Shaken Creek	From source to Holly Shelter Creek	C Sw	4/1/59	18-74-33-4
Juniper Swamp	From source to Shaken Creek	C Sw	4/1/59	18-74-33-4-1
Shelter Swamp Creek	From source to Shaken Creek	C Sw	4/1/59	18-74-33-4-2
Mill Pond	From source to Holly Shelter Creek	C Sw	4/1/59	18-74-33-5
Cams Branch	From source to Holly Shelter Creek	C Sw	4/1/59	18-74-33-6
Ashes Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-34
Fishing Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-35
Peggy Island Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-36
Watermellon Run	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-37
Jumping Run	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-38
Burgaw Creek	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-39
Osgood Branch	From source to Burgaw Creek	C Sw	9/1/74	18-74-39-1
Cypress Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-40
Gregory Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-41
Lillington Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-42
Sand Hill Creek	From source to Lillington Creek	C Sw	4/1/59	18-74-42-1
Graveyard Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-43
Green Oak Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-44
McIntire Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-45
Pike Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-46
Hawkins Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-47
Northeast Cape Fear River	From N.C. Hwy. 210 to Prince George Creek	B Sw	8/1/87	18-74-(47.5)
Honey Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-48
Harrisons Creek	From source to Northeast Cape Fear River	C Sw	7/1/73	18-74-49
Godfrey Creek	From source to Harrisons Creek	C Sw	9/1/74	18-74-49-1
Merricks Creek	From source to Harrisons Creek	C Sw	7/1/73	18-74-49-2
Catskin Creek	From source to Merricks Creek	C Sw	9/1/74	18-74-49-2-1
Trumpeters Swamp	From soruce to Catskin Creek	C Sw	9/1/74	18-74-49-2-1-1
Blossom Swamp	From source to Trumpeters Swamp	C Sw	9/1/74	18-74-49-2-1-1-1
Players Creek	From source to Merricks Creek	C Sw	9/1/74	18-74-49-2-2
Island Creek	From source to Northeast Cape Fear River	C Sw	7/1/73	18-74-50
Old Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-51
Sturgeon Creek	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-52
Northeast Cape Fear River	From Prince George Creek to mouth of Ness Creek	C Sw	9/1/74	18-74-(52.5)
Prince George Creek	From source to Northeast Cape Fear River	C Sw	7/1/73	18-74-53
Turkey Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-54
Long Creek	From source to Northeast Cape Fear River	C Sw	7/1/73	18-74-55
Horse Branch Creek	From source to Long Creek	C Sw	9/1/74	18-74-55-1
Pole Branch (Penderler Lake)	From source to Horse Branch Creek	C Sw	9/1/74	18-74-55-1-1

.0311 CAPE FEAR RIVER BASIN

Name of Stream	Description	Class	Classification Date	Classification Index No.
Long Creek	From source to Horse Branch Creek	C Sw	9/1/74	18-74-55-1-2
Keith Branch	From source to Horse Branch Creek	C Sw	9/1/74	18-74-55-1-3
Cypress Creek	From source to Long Creek	C Sw	4/1/59	18-74-55-2
Bee Branch	From source to Cypress Creek	C Sw	4/1/59	18-74-55-2-1
Mill Branch	From source to Long Creek	C Sw	4/1/59	18-74-55-3
Big Branch	From source to Long Creek	C Sw	4/1/59	18-74-55-4
Jumping Run Branch	From source to Long Creek	C Sw	4/1/59	18-74-55-5
Mill Branch	From source to Long Creek	C Sw	4/1/59	18-74-55-6
Mulberry Branch	From source to Long Creek	C Sw	4/1/59	18-74-55-7
Mill Run	From source to Long Creek	C Sw	4/1/59	18-74-55-8
Rileys Creek	From source to Long Creek	C Sw	7/1/73	18-74-55-9
Rizzo Creek (Resoe Creek)	From source to Rileys Creek	C Sw	9/1/74	18-74-55-9-1
Birch Creek	From source to Rizzo Creek	C Sw	9/1/74	18-74-55-9-1-1
Mill Creek	From source to Rileys Creek	C Sw	9/1/74	18-74-55-9-2
Kellys Creek	From source to Rileys Creek	C Sw	9/1/74	18-74-55-9-3
Guffords Branch	From source to Rileys Creek	C Sw	7/1/73	18-74-55-9-4
Juniper Branch	From source to Long Creek	C Sw	4/1/59	18-74-55-10
Mill Creek	From source to Long Creek	C Sw	4/1/59	18-74-55-11
Collins Branch	From source to Mill Creek	C Sw	4/1/59	18-74-55-11-1
Morgans Creek	From source to Long Creek	C Sw	9/1/74	18-74-55-12
Cowpen Branch	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-56
Tonys Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-57
Lagoon Creek	From source to Northeast Cape Fear River	C Sw	4/1/59	18-74-58
Fishing Creek	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-59
Dock Creek	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-60
Northeast Cape Fear River	From mouth of Ness Creek to Cape Fear River	SC Sw	4/1/59	18-74-(61)
Ness Creek	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-62
Smith Creek	From source to Northeast Cape Fear River	C Sw	9/1/74	18-74-63
Spring Branch	From source to Smith Creek	C Sw	9/1/74	18-74-63-1
Burnt Mill Creek	From source to Smith Creek	C Sw	3/1/77	18-74-63-2
Mineral Springs Branch	From source to Burnt Mill Creek	C SW	8/1/85	18-74-63-2-1
Alligator Creek	From source to Cape Fear River	SC Sw	4/1/59	18-75
Greenfield Creek	From Greenfield Lake to Cape Fear River	SC Sw	4/1/59	18-76
Greenfield Lake	Entire Lake	C Sw	4/1/59	18-76-1
Silver Stream Branch	From source to Greenfield Lake, Greenfield Creek	C Sw	4/1/59	18-76-1-1
Clay Bottom Branch	From source to Greenfield Lake, Greenfield Creek	C Sw	4/1/59	18-76-1-2
Jumping Run Branch	From source to Greenfield Lake, Greenfield Creek	C Sw	4/1/59	18-76-1-3
Squash Branch	From source to Greenfield Lake, Greenfield Creek	C Sw	4/1/59	18-76-1-4
Brunswick River	From source to Cape Fear River	SC	8/9/81	18-77
Sturgeon Creek	From source to Burnswick River	C Sw	4/1/59	18-77-1
Mill Creek	From source to Sturgeon Creek	C Sw	4/1/59	18-77-1-1
Rowell Branch	From source to Mill Creek	C Sw	4/1/59	18-77-1-1-1
Banton Branch	From source to Mill Creek	C Sw	4/1/59	18-77-1-1-2
Redmond Creek	From source to Brunswick River	SC Sw	4/1/59	18-77-2

.0311 CAPE FEAR RIVER BASIN

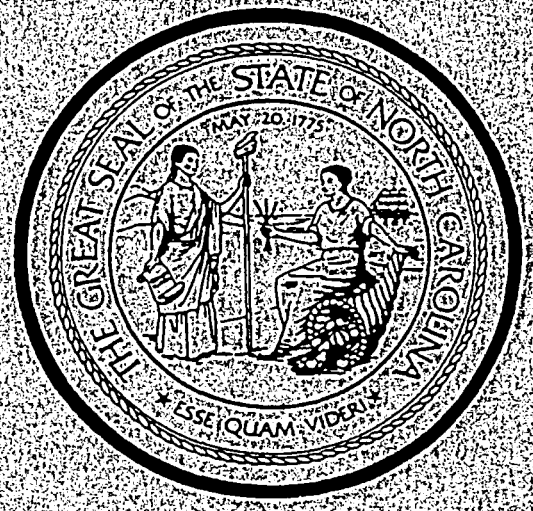
Name of Stream	Description	Class	Classification Date	Classification Index No.
Carolina Beach Yacht Basin	All waters beginning at a point on the northern side of Snows Cut and running directly east across the Intracoastal Waterway to a point on the eastern side, thence following the shoreline, of the Carolina Beach Yacht Basin to a point on the south side of Snows Cut, thence in a straight line across the cut to the point of beginning.	SB	7/1/87	18-87-31.2
Snows Cut	From Carolina Beach Yacht Basin to Cape Fear River	SC	8/9/81	18-87-31.5
Telfairs Creek	From source to Snows Cut	SC Sw	4/1/59	18-87-31.5-1
CAPE FEAR RIVER (excluding area described below)	From a line across the river from Snows Point (through Snows Marsh) to Federal Point to Atlantic Ocean	SA	1/1/85	18-(87.5)
Walden Creek	From source to Cape Fear River	SC Sw HQW	8/1/90	18-88-1
White Spring Creek	From source to Walden Creek	SC Sw HQW	8/1/90	18-88-1-1
Nigis Creek	From source to Walden Creek	SC Sw HQW	8/1/90	18-88-1-2
Nancys Creek	From source to Walden Creek	SC Sw HQW	8/1/90	18-88-1-3
Gum Log Branch	From source to Nancys Creek	SC Sw HQW	3/1/90	18-88-1-3-1
Governors Creek	From source to Walden Creek	SC Sw HQW	8/1/90	18-88-1-4
Fishing Creek	From source to Governors Creek	SC Sw HQW	8/1/90	18-88-1-4-1
Snows Marsh	Entire Marsh	SC	8/9/81	18-88-2
Price Creek	From source to Cape Fear River	SC Sw	4/1/59	18-88-3
Southport Restricted Area	Beginning at a point on the west bank of the Cape Fear River 1000 yards upstream of Price Creek, thence in an easterly direction to the eastern border of the Lower Cape Fear River Channel, thence in a southwesterly direction along the eastern border of the Lower Cape Fear River ship channel to channel marker # 14 (Qk Fl 14), thence to the northern edge of the mouth of Dutchman Creek, thence along the western bank of the Cape Fear River to the Intracoastal Waterway, thence north across the Intracoastal Waterway to a point on the north shore, thence in a northeasterly direction along the west bank of the Cape Fear River to the point of beginning	SC	1/1/85	18-88-3.5
Shelbed Creek	From Muddy Slough to Cape Fear River	SA	1/1/85	18-88-4
Middle Creek	From Muddy Slough to Cape Fear River	SA	1/1/85	18-88-5

STATE OF NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL MANAGEMENT

ADMINISTRATIVE CODE SECTION

15A NCAC 2B .0100 - Procedures for Assignment of Water Quality Standards

15A NCAC 2B .0200 - Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina



Amended Effective February 1, 1993

Environmental Management Commission
Raleigh, North Carolina

SUBCHAPTER 2B - SURFACE WATER STANDARDS: MONITORING

SECTION .0100 - PROCEDURES FOR ASSIGNMENT OF WATER QUALITY STANDARDS

.0101 GENERAL PROCEDURES

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

(b) The Environmental Management Commission, prior to classifying and assigning standards of water quality to any waters of the state, will proceed as follows:

(1) The Commission, or its designee, will determine waters to be studied for the purpose of classification and assignment of water quality standards on the basis of user requests, petitions, or the identification of existing or attainable water uses, as defined by 15A NCAC 2B .0202, not presently included in the water classification.

(2) After appropriate studies of the identified waters to obtain the data and information required for determining the proper classification of the waters or segments of water are completed, the Commission, or its designee, will make a decision on whether to initiate proceedings to modify the classifications and water quality standards of identified waters. In the case of the Commission's designee deciding to initiate said proceedings, the designee will inform the Commission of the decision prior to scheduling a public hearing.

(3) In the case of a petition for classification and assignment of water quality standards according to the requirements of General Statute 150B-20, the Director will make a preliminary recommendation on the appropriate classifications and water quality standards of the identified waters on the basis of the study findings or information included in the petition supporting the classification and standards changes.

(4) The Commission will make a decision on whether to grant or deny a petition in accordance with the provisions of General Statute 150B-20 based on the information included in the petition and the recommendation of the Director. The Commission may deny the petition and request that the Division study the appropriate classifications and water quality standards for the petitioned waters in accordance with Subparagraph (b)(2) of this Rule.

(5) The Director will give due notice of such hearing or hearings in accordance with the requirements of General Statute 143-214.1 and G.S. 150B, and will appoint a hearing officer(s) in consultation with the chairman of the Commission.

(6) The hearing officer(s) will, as soon as practicable after the completion of the hearing, submit a complete report of the proceedings of the hearing to the Commission. The hearing officer(s) shall include in the report a transcript or summary of testimony presented at such public hearing, relevant exhibits, a summary of relevant information from the stream studies conducted by the technical staff of the Commission, and final recommendations as to classification of the designated waters and the standards of water quality and best management practices which should be applied to the classifications recommended.

(7) The Commission, after due consideration of the hearing records and the final recommendations of the hearing officer(s), will adopt its final action with respect to the assignment of classifications, and any applicable standards or best management practices applicable to the waters under consideration. The Commission will publish such action, together with the effective date for the application of the provisions of General Statute 143-215.1 and 143-215.2, as amended, as a part of the Commission's official rules.

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

(c) Freshwater Classifications.

(1) Class C; freshwaters protected for secondary recreation, fishing, aquatic life including propagation

and survival, and wildlife; all freshwaters are classified to protect these uses at a minimum;

(2) Class B; freshwaters protected for primary recreation which includes swimming on a frequent or organized basis and all Class C uses;

(3) Class WS-I; waters protected as water supplies which are essentially in natural and undeveloped watersheds; point source discharges of treated wastewater are permitted pursuant to Rules .0104 and .0211 of this Subchapter; local programs to control nonpoint sources and stormwater discharges of pollution are required; suitable for all Class C uses;

(4) Class WS-II; waters protected as water supplies which are generally in predominantly undeveloped watersheds; point source discharges of treated wastewater are permitted pursuant to Rules .0104 and .0211 of this Subchapter; local programs to control nonpoint sources and stormwater discharges of pollution are required; suitable for all Class C uses;

(5) Class WS-III; waters protected as water supplies which are generally in low to moderately developed watersheds; point source discharges of treated wastewater are permitted pursuant to Rules .0104 and .0211 of this Subchapter; local programs to control nonpoint sources and stormwater discharges of pollution are required; suitable for all Class C uses;

(6) Class WS-IV; waters protected as water supplies which are generally in moderately to highly developed watersheds; point source discharges of treated wastewater are permitted pursuant to Rules .0104 and .0211 of this Subchapter; local programs to control nonpoint sources and stormwater discharges of pollution are required; suitable for all Class C uses;

(7) Class WS-V; waters protected as water supplies which are generally upstream of and draining to Class-IV waters; no categorical restrictions on watershed development or treated wastewater discharges are required; however, the Commission or its designee may apply appropriate management requirements as deemed necessary for the protection of downstream receiving waters (15A NCAC 2B .0203); suitable for all Class C uses.

(d) Tidal Salt Water Classifications.

(1) Class SC; saltwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife; all saltwaters are classified to protect these uses at a minimum;

(2) Class SB; saltwaters protected for primary recreation which includes swimming on a frequent or organized basis and all Class SC uses;

(3) Class SA; suitable for commercial shellfishing and all other tidal saltwater uses.

(e) Supplemental Classifications.

(1) Trout waters (Tr); freshwaters protected for natural trout propagation and survival of stocked trout;

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

(3) Nutrient Sensitive Waters (NSW); waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs;

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

(5) High Quality Waters (HQW); waters which are rated as excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, native and special native trout waters (and their tributaries) designated by the Wildlife Resources Commission, primary nursery areas (PNA) designated by the Marine Fisheries Commission and other functional nursery areas designated by the Wildlife Resources Commission, critical habitat areas designated by the Wildlife Resources Commission or the Department of Agriculture, all water supply watersheds which are either classified as WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II has been received from the appropriate local government and accepted by the Division of Environmental Management and all Class SA waters.

(f) In determining the best usage of waters and assigning classifications of such waters, the Commission will consider the criteria specified in General Statute 143-214.1(d) and all existing uses as defined by 15A NCAC 2B .0202. In determining whether to revise a designated best usage for waters through a revision to the classifications, the Commission will follow the requirements of 40 CFR 131.10(b),(c),(d) and (g) which are hereby incorporated by reference including any subsequent amendments and editions. This material is available for inspection at the Department of Environment, Health, and Natural Resources, Division of Environmental Management, Water Quality Planning Branch, 512 North Salisbury Street, Raleigh, North Carolina. Copies may be obtained from the U.S. Government Printing Office, Superintendent of Documents,

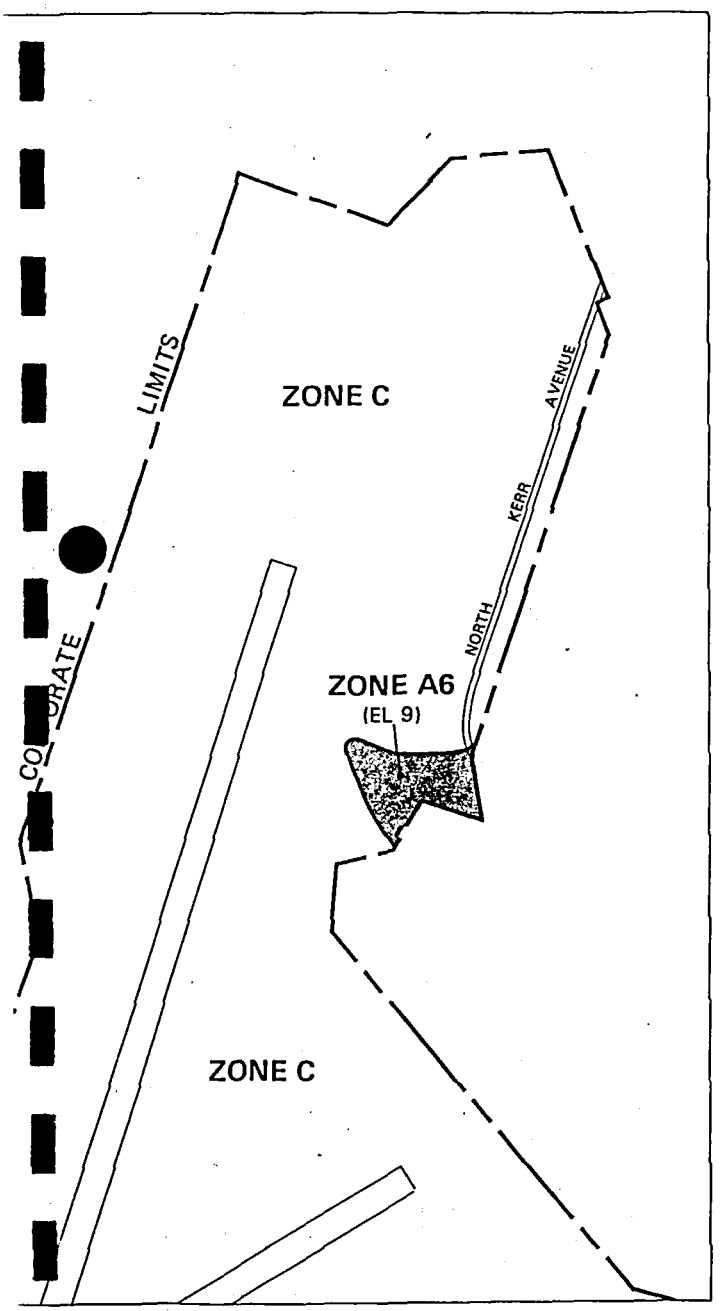
RENCE MARKS

DESCRIPTION OF LOCATION

of headwall of Burnett Boulevard culvert between Front Street and

ll of Barnards Creek culvert under U.S. Route 421.

erguard on River Road bridge over Barnards Creek.



To determine if flood insurance is available in this community, contact your insurance agent, or call the National Flood Insurance Program, at (800) 638-6620.

Ref. 42

APPROXIMATE SCALE

1000 0 1000 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

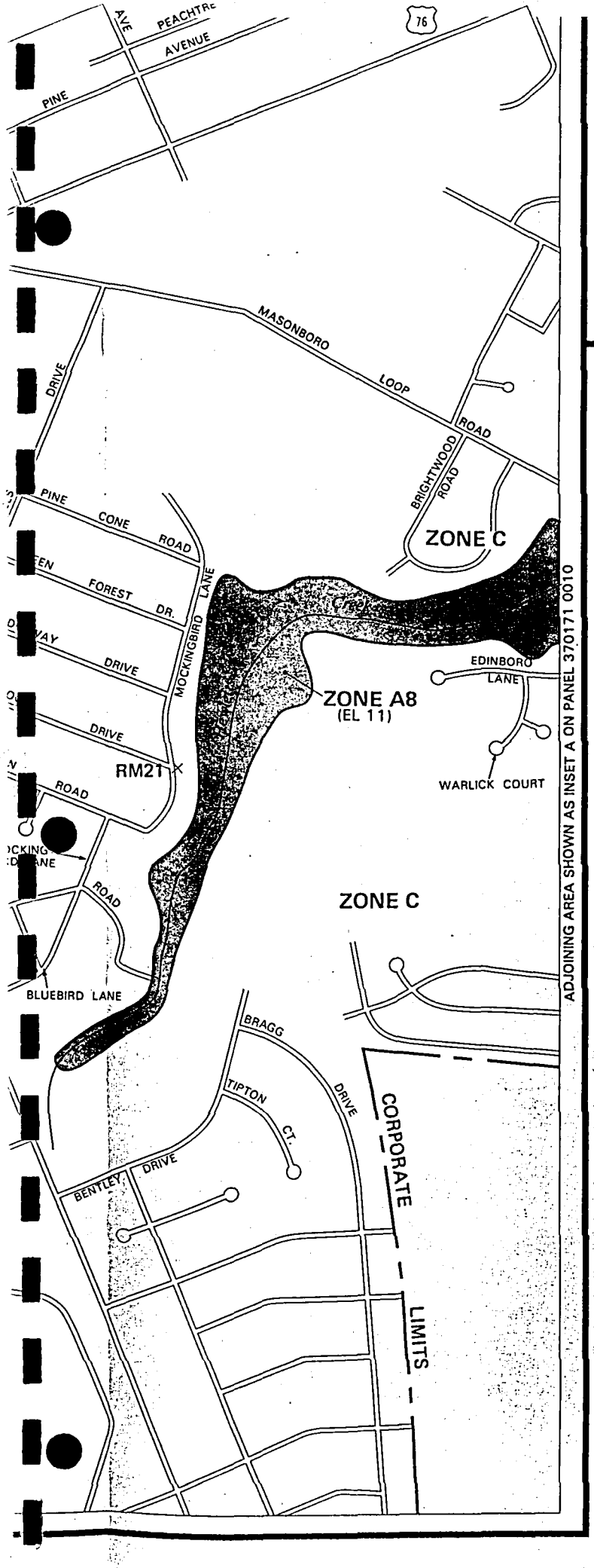
CITY OF
WILMINGTON,
NORTH CAROLINA
NEW HANOVER COUNTY

PANEL 10 OF 10

COMMUNITY-PANEL NUMBER
370171 0010 B

MAP REVISED:
APRIL 2, 1986

Federal Emergency Management Agency



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APPROXIMATE SCALE

1000 0 1000 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
WILMINGTON,
NORTH CAROLINA
NEW HANOVER COUNTY

PANEL 5 OF 10

COMMUNITY-PANEL NUMBER
370171 0005 C

MAP REVISED:
NOVEMBER 4, 1987

Federal Emergency Management Agency

TION REFERENCE MARKS

DESCRIPTION OF LOCATION

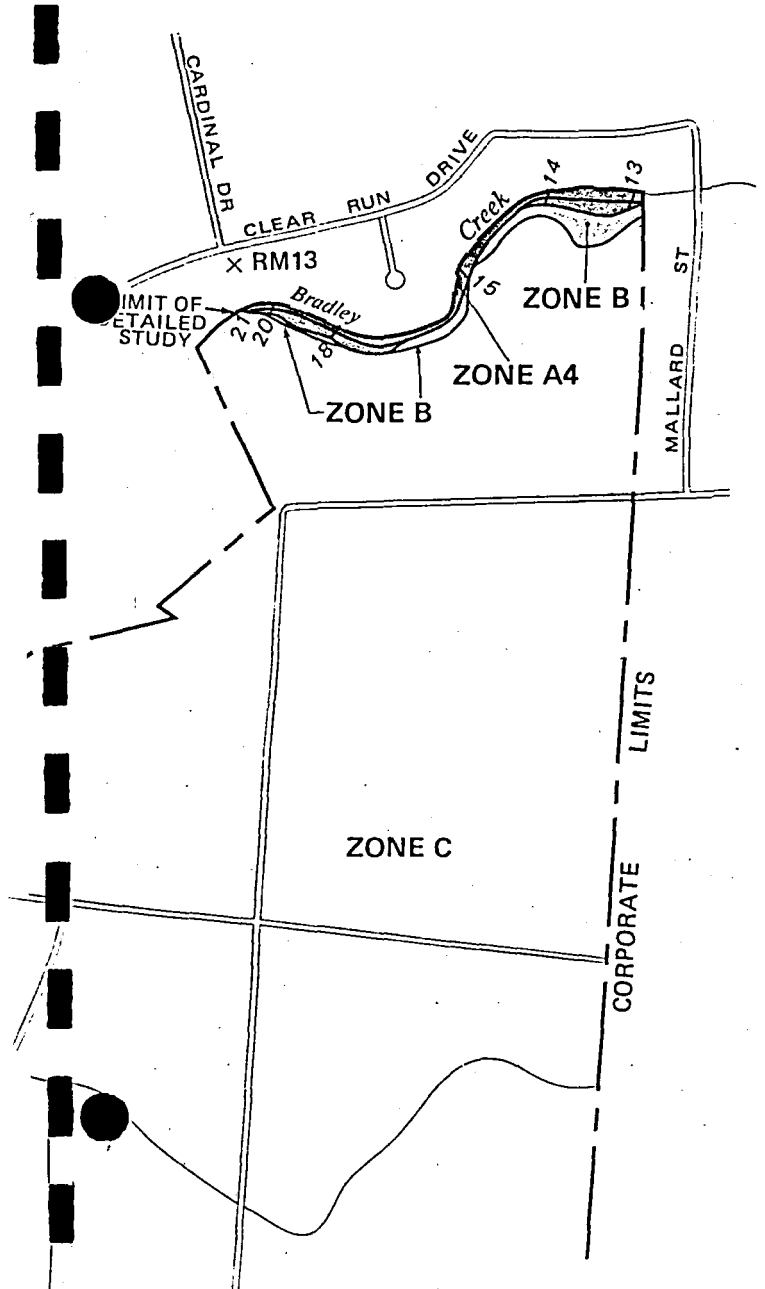
Corps of Engineers ID cap in southwest end of headwall of Greenfield Lake der k anch Drive.

hydrant in northeast quadrant of Robin Hood Road and East Lake Shore section.

hy nt in northeast quadrant of East Lake Shore Drive intersection with ce to Cypress Grove Apartments.

Co s of Engineers ID cap on powerole at the north end of south traffic tat Road 132 at the intersection with Shipyard Boulevard.

Corps of Engineers ID cap on a powerpole with transformer on the south rse ion of Mockingbird Lane and Parkwood Drive.



KEY TO MAP

500-Year Flood Boundary	
100-Year Flood Boundary	
Zone Designations*	ZONE B / ZONE B
100-Year Flood Boundary	
500-Year Flood Boundary	
Base Flood Elevation Line With Elevation In Feet**	513
Base Flood Elevation in Feet Where Uniform Within Zone**	(EL 987)
Elevation Reference Mark	RM7×
Zone D Boundary	
River Mile	•M1.5

**Referenced to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
A0	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

NOTES TO USER

This map is for use in administering the National Flood Insurance Program; it does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size, or all planimetric features outside Special Flood Hazard Areas.

Certain areas not in the Special Flood Hazard Areas may be protected by flood control structures.

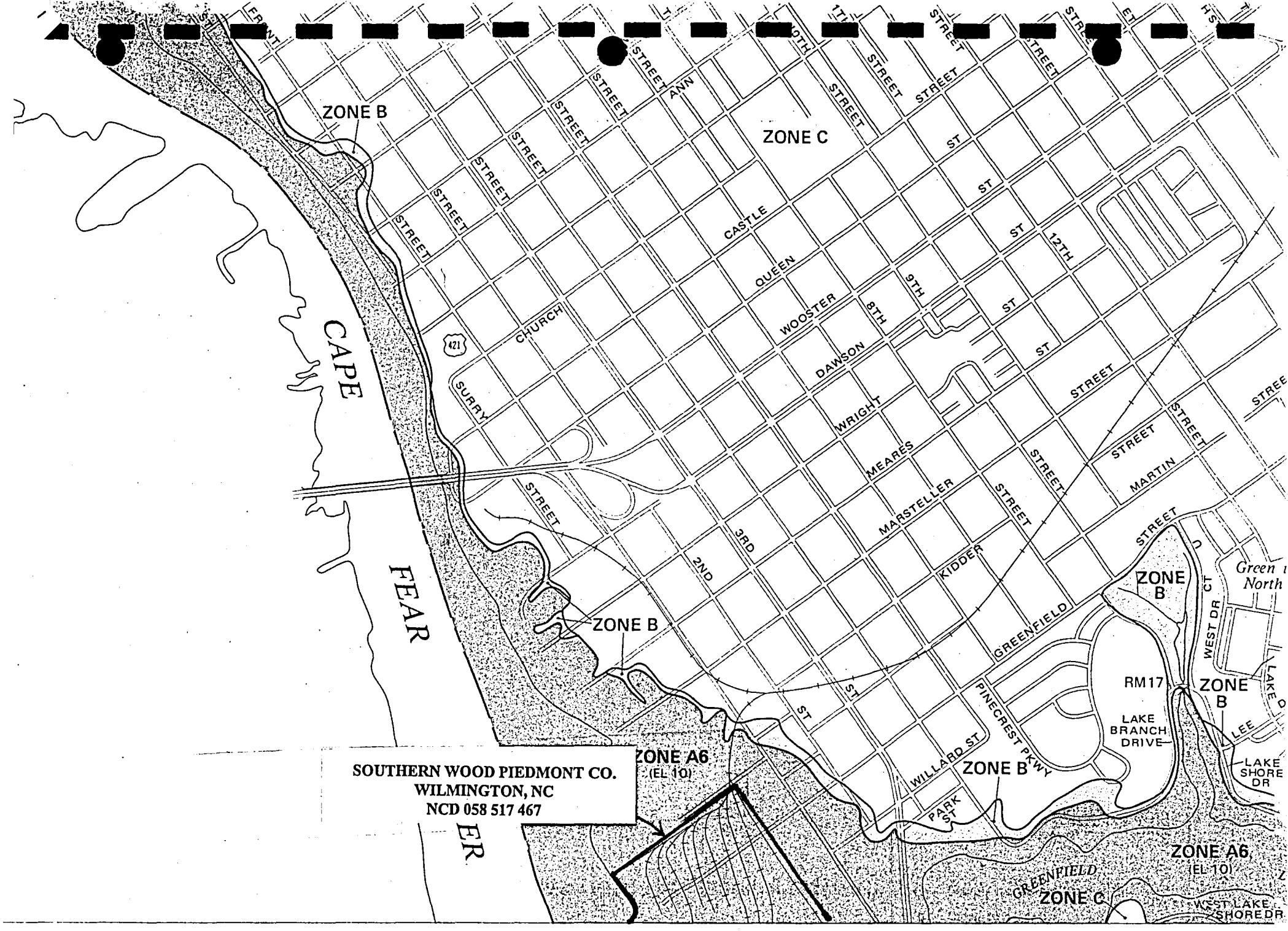
Corporate limits shown are current as of the date of this map. The user should contact appropriate community officials to determine if corporate limits have changed subsequent to the issuance of this map.

For adjoining panels, see separately printed Map Index.

INITIAL IDENTIFICATION:

MARCH 1, 1974

FLOOD HAZARD BOUNDARY MAP REVISIONS:


ZONE B
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RM17
CAPE
FEAR
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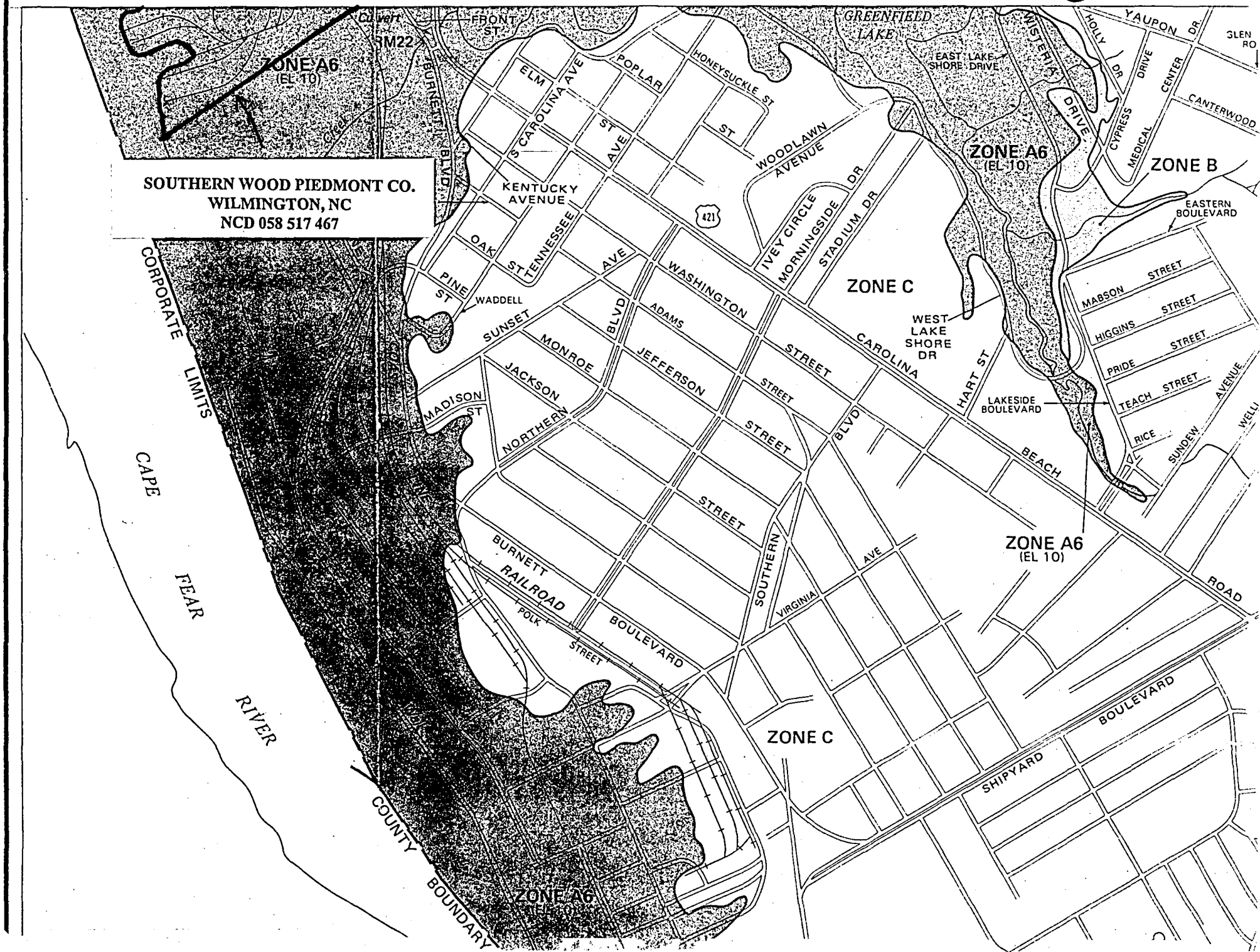
ANN
CASTLE
QUEEN
WOOSTER
DAWSON
WRIGHT
MEARES
MARSTELLER
KIDDER
GREENFIELD
PINECREST PKWY
WILLARD ST
PARK ST
MARTIN
CHURCH
SURRY
421
2ND
3RD
8TH
9TH
12TH
WEST DR
LAKE BRANCH DRIVE
LEE
LAKE SHORE DR
WEST LAKE SHORE DR
Green
North
SOUTHERN WOOD PIEDMONT CO.
WILMINGTON, NC
NCD 058 517 467


SOUTHERN WOOD PIEDMONT CO.
WILMINGTON, NC
NCD 058 517 467
ZONE A6
(EL 10)
Culvert
FRONT ST
BM22
BURNETT BLVD
Creek
GREENFIELD LAKE
EAST LAKE SHORE DRIVE
WISTERIA DRIVE
HOLLY DR
YAUPON DR
GLEN RO
CANTERWOOD
CENTER DRIVE
MEDICAL
CYPRESS
ZONE B
EASTERN BOULEVARD
ELM
POPLAR
HONEYSUCKLE ST
S CAROLINA AVE
ST
AVE
WOODLAWN AVENUE
KENTUCKY AVENUE
TENNESSEE
OAK ST
PINE ST
WADDELL
421
IVEY CIRCLE
MORNINGSIDE DR
STADIUM DR
ZONE C
WEST LAKE SHORE DR
WASHINGTON
ADAMS
JEFFERSON
STREET
CAROLINA
HART ST
SUNSET
MONROE
JACKSON
MADISON ST
NORTHERN
BLVD
MABSON STREET
HIGGINS STREET
PRIDE STREET
TEACH STREET
RICE
SUNDEW
AVENUE
LAKESIDE BOULEVARD
BEACH
ROAD
CORPORATE LIMITS
CAPE FEAR RIVER
BURNETT
RAILROAD
POLK STREET
BOULEVARD
SOUTHERN
VIRGINIA AVE
SHIPYARD
COUNTY BOUNDARY

MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist SFP
Date: January 25, 1995
Re: Southern Wood Piedmont - Wilmington
NCD 058 517 467
Fisheries in the Study Area.

On 9/29/94, SFP telephoned Brad Hammers, Wilmington District Fisheries Biologist (919-939-1167), and Fritz Rhode, of Marine Fisheries (910-395-3900) for fisheries information on the Cape Fear and Northeast Cape Fear Rivers in New Hanover County. According to them, both the Cape Fear and Northeast Cape Fear Rivers are recreationally and commercially fished for human consumption. Species in the fisheries include american and hickory shad, herring, atlantic and short-nosed sturgeon, resident and seasonal striped bass, largemouth bass, redbreast, and flathead and blue catfish. Additionally, the Cape Fear River in Wilmington is a nursery for blue crab, eel, and shrimp. Neither Hammers or Rhode had any specific data on fishery yields, and Hammers did not know anything about Greenfield Lake or Greenfield Creek below the lake.

SFP telephoned Lee Willis, enforcement officer for the area (Home: 910-313-1212) on 1/25/95 to get additional information on Greenfield Creek and Greenfield Lake. Willis maintained that people fish both at Greenfield Lake and downstream on Greenfield Creek, wherever there is access to the water.

MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist
Date: September 28, 1994
Re: Southern Wood Piedmont - Wilmington
NCD 058 517 467
Analysis of Greenfield Creek Contaminants.

On 12/9 and 12/14 1992, during Phase II of ETE/Virogroup's Groundwater Quality Assessment at the Southern Wood Piedmont site, ETE collected soil and sediment samples from the buried creosote ditch at the site, from the existing on-site drainage ditch, and from Greenfield Creek, which links the drainage ditch to the Cape Fear River. Analytical results indicated contamination by volatile and semi-volatile organic compounds in several of the samples. Contaminants were detected in on-site soil and sediment samples SS-4, SS-5, SS-6, and SS-7. Contaminants were also detected in samples SS-9, SS-10, and SS-10A, in the downstream interval of Greenfield Creek. Detected semi-volatile organic species common to both sampling areas included the following:

Acenaphthene	Chrysene
Anthracene	Dibenzo(a,h)anthracene
Benzo(a)anthracene	Fluoranthene
Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene
Benzo(k)fluoranthene	Phenanthrene

In addition, benzo(b)fluoranthene was detected in downstream sediment samples SS-9 and SS-10. The volatiles toluene and xylene were detected in both areas.

No semi-volatiles were detected in sediment samples SS-8 and SS-11, which are located downstream of the site but upstream of lower Greenfield Creek. Sediment sample SS-1, located on Greenfield Creek just upstream of the confluence with the drainage ditch, contained low concentrations of 7 of the above compounds. In SS-9, SS-10,and SS-10A concentrations of all contaminants (except for benzo-k-fluoranthene) were more than 3 times their respective SS-1 concentrations. Therefore, even if SS-1 is regarded as a contaminated background sample, the downstream contaminants still count as an Observed Release.

(next page)

Tidal fluctuations apparently affect the section of the creek that includes SS-1. Therefore, this sample might not represent a background sample, but rather, may have been contaminated from downstream.

Contaminated samples SS-9, SS-10, and SS-10A were collected in the interval of lower Greenfield Creek that passes directly north of the Paktank petroleum storage terminal, located south of the site. The Amerada Hess Corporation facility, located adjacent to the north site boundary and the Cape Fear River, has investigated an apparent diesel spill which was detected in monitoring well MW-27 in the northeastern corner of the site. Citing the potential sources above, ETE concluded that "The distribution of various constituents detected in soil samples collected along Greenfield Creek suggested the likelihood that multiple sources exist."

Apparently, the above interpretation assumes that each of the semi-volatile organic compounds detected in the lower Greenfield Creek sediments could be attributed to petroleum products as well as to creosote. To address this assumption, SFP reviewed available reference material to compare the characteristic semi-volatile organic constituents of the two product types. Sources included The Soil Chemistry of Hazardous Materials by J. Dragun, Hazardous Materials Control Research Institute (Tables 9.16, 9.21), the 1983 Merck Index, and a telecommunication with John Neal, Supervising Chemist, NC Environmental Sciences Section/ State Laboratory of Public Health, dated September 27, 1994.

All of the 10 semi-volatile organic compounds detected in the Greenfield Creek sediments are identified components of creosote. Only 3 of the compounds, acenaphthene, anthracene, and phenanthrene, are listed as identified components of petroleum products (Ref. 34). The structures of these 3 compounds are all either dicyclic or simple tricyclic. By contrast, the other 7 compounds are all either tetracyclic or pentacyclic (Ref. 36). According to John Neal, semi-volatiles detected in refined petroleum products tend to be restricted to the simpler compounds like naphthalene and phenanthrene. The heavier polycyclic compounds are generally encountered in coal tar/creosote or petroleum refining wastes, but are essentially eliminated from unburned refined fuels. The above information and discussion supports at least partial attribution of Greenfield Creek contaminants to the site.

MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist
Date: December 3, 1994
Re: Southern Wood Piedmont Co., Wilmington
NCD 058 517 467
Review of Natural Heritage Program Maps
and File Information

SFP reviewed NC Natural Heritage Program field location maps and rare species lists to identify rare plant and animal species within a 4-mile radius of the site and within the 3, 15-mile surface water pathways.

The NHP has identified 16 rare animal species and 14 rare plant species within the study area. Of these, 5 animal species are listed as Endangered in NC and/or the US. Additionally, 1 animal and 4 plant species are listed as Threatened in NC and/or the US. The species are listed as follows:

Species Name:	Distance from Site (miles)		Status		Rank	
	(Radial)	(Water)	NC	US	NC	Global
Animals:						
Trichecus manatus (West Indian Manatee)	--	12	E	E	S1N	G2?
Picoides borealis (Red-cockaded Woodpecker)	3.5	--	E	E	S2	G2
Planorbella magnifica (Magnificent Ram's Horn (snail))	0.2	7.4	E	C2	S1	G1
Anodonta couperiana (Barrel Floater (freshwater bivalve))	0.5	--	E	--	S1	G3/G4
Acipensor brevirostrum (Shortnose Sturgeon)	0.5	0.5	E	--	S1	G3
Alligator mississippiensis (American alligator)	0.3	1.4	T	T	S3	G5
Neotoma floridana floridana (Eastern Woodrat)	2.1	--	T	--	S1	G5T?
Rana capito capito (Carolina Gopher Frog)	3.1	--	SC	C2	S2	G4T?
Heterandria formosa (Least Killifish)	0.9	--	SC	--	S1	G5
Problema bulenta (Rare Skipper (butterfly)	1.8	6.0	SR	C2	S1?	G2/G3

Species Name:	Distance from Site (Radial)	(Dnstrm)	Status NC	US	Rank NC	Global
Animals (cont):						
Euphyes dukesi (Duke's skipper (butterfly))	0.25	0.25	SR	--	S1	G3/G5
Hymantopus mexicanus (Black-necked Stilt (bird))	1.3	--	SR	--	S2B	G5
Anhinga anhinga (Anhinga (bird))	--	7.4	SR	--	S2B/SZN	G5
Eleotris pisonis (Spiny Cheek Sleeper (fish)	--	4.8	SR	--	S2	G5
Evorthodus lyricus (Lyre Goby)	--	4.8	SR	--	S2	GU
Hypsoblennius ionthus (Freckled Blenny(fish)	--	12	SR	--	S2	GU
Plants:						
Platanthera nivea (Snowy Orchid)	3.0	3.0	T	--	S1	G5
Utricularia olivacea (Dwarf Bladderwort)	3.8	--	T	--	S2	G4
Lilaeopsis caroliniansis (Carolina Grasswort)	0.1	2.4	T	3C	S3	G3
Dionaea muscipula (Venus flytrap)	3.2	--	C-SC	3C/PC2	S3	G3
Peltandra sagittifolia (Spoonflower)	2.9	--	SR	--	S2	G3/G4
Rhyncospora tracyi (Tracy's Beaksedge)	3.8	--	SR	--	S2	G4
Carex decomposita (Cypress Knee Sedge)	1.1	--	SR	3C	SH	G3/G4
Crinum americanum (Swamp-lily)	1.9	1.9	C	--	S1	G5
Ptilumnium sp. (Carolina Bishopweed)	1.0	2.0	C	--	S1	G2
Ptilimnium costatum (Ribbed Bishopweed)	3.1	4.1	C	--	S1	G3/G4
Lechea torreyi (Torrey's Pinweed)	--	10.9	C	--	S1	G4/G5
Polygala hookeri (Hooker's Milkwort)	--	11.1	C	--	S2	G3
Rhyncospora oligantha (Feather-bristle Beaksedge)	3.0	3.0	C	--	S2	G4
Litsea aestivalis (Pondspice)	3.3	--	C	C2	S2	G4/G5

Status Codes:

US	NC
E = Endangered	E = Endangered
T = Threatened	T = Threatened
SC = Special Concern	C2= Candidate 2
SR = Significantly Rare	3C = Candidate 3

Rank Codes:

NC

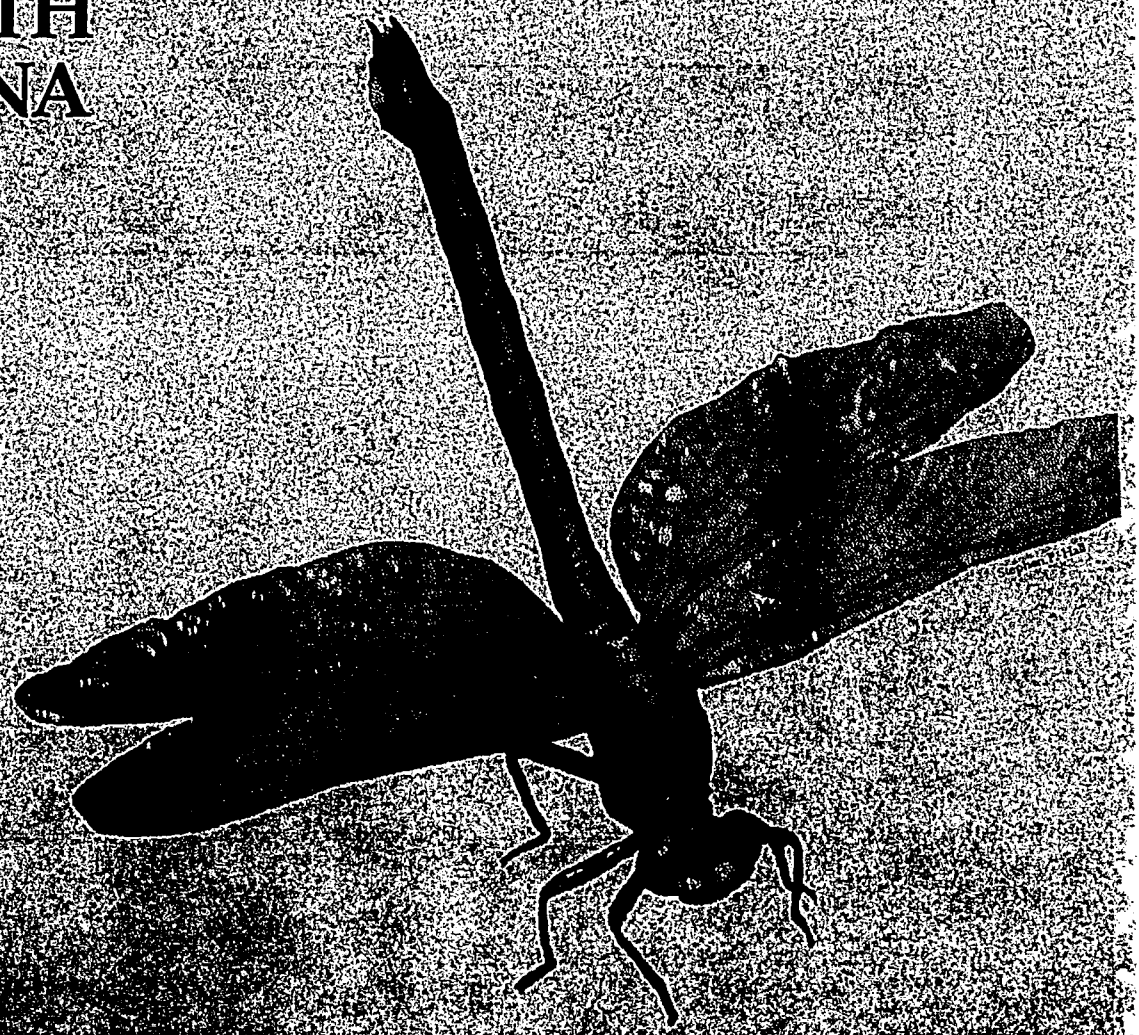
S1 = Critically Imperiled in NC due to extreme rarity.
S2 = Imperiled in NC.
S3 = Rare/Uncommon in NC.
SH = Historical Occurrence in NC.
S? = Unranked or Rank Uncertain.
B = Breeding, migratory.
N = Nonbreeding, migratory.
Z = Not of significant concern.

Global

G1 = Critically Imperilled globally due to extreme rarity/ vulnerable to extinction.
G2 = Imperilled globally due to rarity/ vulnerable to extinction.
G3 = Very rare and local/restricted range.
G4 = Apparently secure globally, rare in parts of range.
G5 = Demonstrably secure globally, rare in parts of range.
T = Subspecies or Variety

Ref. 46

NATURAL HERITAGE PROGRAM LIST OF THE RARE ANIMAL SPECIES OF NORTH CAROLINA



Compiled By
Harry E. LeGrand, Jr., Zoologist
With Contributions by Stephen P. Hall

North Carolina Natural Heritage Program
Division of Parks and Recreation
N. C. Department of Environment, Health, and Natural Resources 1993

NATURAL HERITAGE PROGRAM LIST OF THE RARE ANIMALS OF NORTH CAROLINA*

1993 Edition

compiled by Harry E. LeGrand Jr., Zoologist
with contributions by Stephen P. Hall, Invertebrate Zoologist
North Carolina Natural Heritage Program
Division of Parks and Recreation
Department of Environment, Health, and Natural Resources

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*This list is dynamic and is revised frequently as further data become available. New species are added to the list, and others are dropped from the list for various reasons. The list will be revised periodically, generally once every year or two. If you are using a copy of this list which is more than a year old (check the edition date at the top of the first page), it might be invalid and you should request a new version. Further information on these species may be obtained by contacting the North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources, P.O. Box 27687, Raleigh, NC 27611-7687 or the Nongame and Endangered Wildlife Program, North Carolina Wildlife Resources Commission, 512 North Salisbury Street, Raleigh, NC 27611.

LIST FORMAT

Species are grouped by major taxa. The vertebrates are arranged by class, beginning with the most advanced phylogenetically (mammals). Within a given taxa, species are listed alphabetically by scientific name. The following information is presented for each species on the list. "Status" is a word or phrase that indicates the degree of protection (if any), based on rarity, of a species; "rank" is a numerical scale of the rarity of a species, regardless of legal protection.

Scientific Name.

Common Name. For most groups, these names are not standardized.

North Carolina Status. Endangered, Threatened, and Special Concern species of Mammals, Birds, Reptiles, Amphibians, Freshwater Fishes, and Freshwater and Terrestrial Mollusks have legal protection status in North Carolina (Wildlife Resources Commission). In addition to the above categories, the Natural Heritage Program maintains computer and map files on Significantly Rare, Vulnerable, and Undetermined status species, as well as species considered Extirpated. Paper files only are maintained for some of the above species; these species are indicated by the phrase "not tracking."

STATUS CODE	STATUS	DEFINITION
E	Endangered	"Any native or once-native species of wild animal whose continued existence as a viable component of the State's fauna is determined by the Wildlife Resources Commission to be in jeopardy or any species of wild animal determined to be an 'endangered species' pursuant to the Endangered Species Act." (Article 25 of Chapter 113 of the General Statutes; 1987).
T	Threatened	"Any native or once-native species of wild animal which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, or one that is designated as a threatened species pursuant to the Endangered Species Act." (Article 25 of Chapter 113 of the General Statutes; 1987).
SC	Special Concern	"Any species of wild animal native or once-native to North Carolina which is determined by the Wildlife Resources Commission to require monitoring but which may be taken under regulations adopted under the provisions of this Article." (Article 25 of Chapter 113 of the General Statutes; 1987).

SR	Significantly Rare	Any species which has not been listed by the N.C. Wildlife Resources Commission as an Endangered, Threatened, or Special Concern species, but which exists in the state in small numbers and has been determined by the N.C. Natural Heritage Program to need monitoring. (This is a N.C. Natural Heritage Program designation.) Significantly Rare species include "peripheral" species, whereby North Carolina lies at the periphery of the species' range (such as Purple Gallinule). The designation also includes marine and estuarine fishes identified as "Vulnerable" by the N.C. State Museum of Biological Sciences (Ross et al., 1988, Endangered, Threatened, and Rare Fauna of North Carolina. Part II. A Re-evaluation of the Marine and Estuarine Fishes). Also included in the Significantly Rare designation are species formerly listed by the Natural Heritage Program (1991) as "Undetermined". "Undetermined" species are those that are secretive or are otherwise poorly known in North Carolina, which the Natural Heritage Program believes are rare and should be monitored.
EX	Extirpated	A species which is no longer believed to occur in the state.
W	Watch List	Any other species believed to be of conservation concern in the state because of scarcity, declining populations, threats to populations, or inadequacy of information to assess its rarity (see Page 33 for a more complete discussion).
*	---	Species is a game animal, and therefore (by law) cannot be listed for State protection as E, T, or SC.
#	---	Species proposed for Endangered status, but not adopted by the Wildlife Resources Commission; species is protected from taking.
@	---	Species proposed for Special Concern status, but not adopted by the Wildlife Resources Commission; species is protected from taking.

United States Status is designated by the U.S. Fish and Wildlife Service. Federally listed Endangered and Threatened species are protected under the provisions of the Endangered Species Act of 1973, as amended through the 100th Congress. Unless otherwise noted, definitions are taken from the the Federal Register, Vol. 56, No. 225, November 21, 1991 (50 CFR Part 17).

STATUS CODE	STATUS	DEFINITION
E	Endangered	A taxon "which is in danger of extinction throughout all or a significant portion of its range" (Endangered Species Act, Section 3).
T	Threatened	A taxon "which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (Endangered Species Act, Section 3).
C1	Candidate 1	"Taxa for which the [Fish and Wildlife] Service has on file enough substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened species. Proposed rules have not yet been issued because this action is precluded at present by other listing activity. [Such proposed rules] are anticipated, however, and the Service encourages other Federal agencies to give consideration to such taxa in environmental planning."
C2	Candidate 2	"Taxa for which information now in the possession of the [Fish and Wildlife] Service indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat are not currently available to support proposed rules.... Further biological research and field study usually will be necessary to ascertain the status of taxa in this category....The Service hopes that this notice will encourage necessary research on vulnerability, taxonomy, and/or threats for these taxa."
C1*, C2*	---	Candidate taxa, but lacking known occurrences
3A	Candidate 3A	"Taxa for which the [Fish and Wildlife] Service has persuasive evidence of extinction. If rediscovered, such taxa might acquire high priority for listing."
3B	Candidate 3B	"Names that, on the basis of current taxonomic understanding..., do not represent distinct entities meeting the Act's definition of 'species'; it also includes vertebrate populations that do not meet this definition."
3C	Candidate 3C	"Taxa that have proven to be more abundant or widespread than previously believed and/or those that are not subject to any identifiable threat. If further research or changes in habitat indicate a significant decline in any of these taxa, they may be reevaluated for possible inclusion in categories 1 or 2."
P_	Proposed	Species currently proposed, as either endangered or threatened. Species formally proposed receive some protection by law.

North Carolina Rank. North Carolina ranks are based on the Natural Heritage Program Network of measuring rarity and threat status. This system is widely used by other agencies and organizations, as the best available scientific and objective assessment of a species' rarity at the state level.

RANK	NUMBER OF EXTANT POPULATIONS	DESCRIPTION
S1	1-5	Critically imperiled in North Carolina because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from North Carolina.
S2	6-20	Imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from North Carolina.
S3	21-100	Rare or uncommon in North Carolina.
S4	100-1000	Apparently secure in North Carolina, with many occurrences.
S5	1000+	Demonstrably secure in North Carolina and essentially ineradicable under present conditions.
SA	1-?	Accidental or casual; one to several records for North Carolina, but the state is outside the normal range of the species.
SH	0?	Of historical occurrence in North Carolina, perhaps not having been verified in the past 20 years, and suspected to be still extant.
SR	--	Reported from North Carolina, but without persuasive documentation which would provide a basis for either accepting or rejecting the report.
SX	0	Apparently extirpated from North Carolina.
SU	--	Possibly in peril in North Carolina but status uncertain; need more information.
S?	--	Unranked, or rank uncertain.
_B	1-?	Rank of the breeding population in the state. Used for migratory species only.
_N	1-?	Rank of the non-breeding population in the state. Used for migratory species only.
_Z_	1-?	Population is not of significant conservation concern. For example, the status "SZN" indicates that the population in the non-breeding seasons (generally in migration or in winter) is transitory, without any regular locales of occurrence whereby the species can be protected. Where a number is listed with the "B" or "N" modifier, there are definable locales of occurrence that can be identified for protection.

Global Rank: Similar to North Carolina ranks, global ranks are assigned by a consensus of scientific experts, the individual natural heritage programs, and the Natural Heritage Network. Global ranks apply to the status of a species throughout its range, and are based on data on the species' status rangewide. This system is widely used by other agencies and organizations, as the best available scientific and objective assessment of a species' rarity throughout its range.

RANK	NUMBER OF EXTANT POPULATIONS	DESCRIPTION
G1	1-5	Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction.
G2	6-20	Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3	21-100	Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single physiographic region) or because of other factors making it vulnerable to extinction throughout its range.
G4	100-1000	Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5	1000+	Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GH	0?	Of historical occurrence throughout its range, i.e., formerly part of the established biota, with the expectation that it may be rediscovered.
GX	0	Believed to be extinct throughout its range (e.g., Passenger Pigeon) with virtually no likelihood that it will be rediscovered.
GU	--	Possibly in peril range-wide, but status uncertain; more information is needed.
G?	--	Unranked, or rank uncertain.
G_Q	--	Questionable taxonomic assignment.
T_	--	The rank of a subspecies or variety. As an example, G4T1 would apply to a subspecies of a species with an overall rank of G4, but the subspecies warranting a rank of G1.

Physiographic Province. The provinces in which the animal is known to occur are indicated. This should not be regarded as the only province(s) of the state in which the species could occur; our knowledge of the fauna of North Carolina, especially the invertebrates, is still very imperfect. The provinces are abbreviated as follows:

M	Mountains	All parts of North Carolina west of the foot of the Blue Ridge Escarpment.
P	Piedmont	All parts of North Carolina east of the foot of the Blue Ridge Escarpment and west of the Fall Line, including outlying "foothill" ranges, such as the Brushy, Uwharrie, and Sauratown mountains.
C	Coastal Plain	All parts of North Carolina east of the Fall Line (including the Sandhills), but excluding the portions associated with tidal water (ocean, sounds, barrier islands, and mainland brackish or salt marshes).
T	Tidewater	That part of the state associated with tidal water, such as the ocean and barrier islands, sounds, estuaries, and mainland brackish or salt marshes.

Habitat. The known, or the most typical, habitats are described briefly; as with provinces, these should not be regarded as the only possible habitats of the species in the state.

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
MAMMALS					
Canis rufus CM: swamps, pocosins, extensive forests	Red Wolf	E	E	S1	G1*
Condylura cristata parva MC: moist meadows, bogs, swamps, bottomlands [Coastal Plain population is SC; mountain population not of concern]	Star-nosed Mole	SC	3C	S4	G5
Felis concolor couguar MPC: extensive forests, remote areas	Eastern Cougar (Panther, Mountain Lion)	E	E	SH	G4TH
Glaucomys sabrinus coloratus M: high elevation forests, mainly spruce-fir	Carolina Northern Flying Squirrel	E	E	S1	G5T1
Microsorex (see Sorex)					
Microtus chrotorrhinus carolinensis M: rocky areas at high elevations, forests or fields	Southern Rock Vole	SC	C2	S2	G5T3
Mustela nivalis M: fields and forests, mostly at high elevations	Least Weasel	SR		S2	G5
Myotis austroriparius CP: roosts in buildings, hollow trees; forages near water	Southeastern Bat	SC	C2	S2	G4
Myotis grisescens M: roosts in caves; forages mainly over open water	Gray Bat	E	E	SA	G2
Myotis leibii leibii M: roosts in hollow trees (warmer months), in caves and mines (winter)	Eastern Small-footed Bat	SC	C2	SUB,S1N	G3T?
Myotis septentrionalis (= M. keenii) MP: roosts in hollow trees and buildings (warmer months), in caves and mines (winter)	Northern Long-eared Bat	SC		SUB,S2N	G4
Myotis sodalis M: roosts in hollow trees or under loose bark (warmer months), in caves (winter)	Indiana Bat	E	E	SUB,SZN	G2
Neotoma floridana haemitoreia; Neotoma floridana magister M: rocky places in deciduous or mixed forests (haemitoreia = G5T5; magister = G5T4Q)	Eastern Woodrat (haemitoreia = Southern Appalachian Woodrat; magister = Allegheny Woodrat)	SC	C2	S2	G5
Neotoma floridana floridana [Coastal Plain race] C: forests, mainly in moist areas	Eastern Woodrat	T		S1	G5T?
Peromyscus polionotus P: sandy, fallow fields near South Carolina line	Oldfield Mouse	SR		S1	G5
Plecotus rafinesquii MC: roosts in old buildings, caves, and mines, usually near water	Rafinesque's Big-eared Bat	SC	C2	S3	G4
Plecotus townsendii virginianus M: roosts in caves (and rarely in mines), especially in limestone areas	Virginia Big-eared Bat	E	E	S1	G5T2
Sciurus niger CPM: open forests, mainly longleaf pine/scrub oak	Fox Squirrel	SR*		S3	G5
Sorex dispar M: high elevation forests with talus or rocky slopes	Long-tailed Shrew	SC	3C	S2	G5
Sorex hoyi winnemana (= Microsorex) MC: montane deciduous forests; old fields and clearcuts in northeastern Coastal Plain	Southern Pygmy Shrew	SC	3C	S2?	G5T5
Sorex longirostris fisheri C: woodlands and brushy fields, especially where damp, in Dismal Swamp vicinity	Dismal Swamp Southeastern Shrew	T	T	S2	G5T1T3
Sorex palustris punctulatus M: stream banks in montane forests	Southern Water Shrew	SC	C2	S1	G5T3
Sylvilagus aquaticus M: wet woods and floodplains in southern mountains	Swamp Rabbit	SR*		SH	G5
Sylvilagus transitionalis M: dense cover of montane woods and thickets	New England Cottontail	SR*	C2	S3	G4

* Re-introduction, at Alligator River NWR and Great Smoky Mountains NP, NC

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
Tadarida brasiliensis C: roosts in buildings and other man-made structures	Brazilian Free-tailed Bat	SC		SUB,S2N	G5
Trichechus manatus T: warm waters of estuaries and river mouths	West Indian Manatee	E	E	S1N	G2?
Ursus americanus MC: extensive montane forests; pocosins, swamps	Black Bear	SR*		S3	G5
BIRDS					
Accipiter cooperii MPC: forests and woodlands (for nesting) [breeding evidence only]	Cooper's Hawk	SC		S2B,S3N	G4
Accipiter gentilis M: extensive, remote forests, mainly at high elevations (for nesting) [breeding evidence only]	Northern Goshawk	SR	C2	SUB,SZN	G4
Accipiter striatus MP: forests and woodlands (for nesting) [breeding evidence only]	Sharp-shinned Hawk	SR		S2B,S4N	G5
Aegolius acadicus M: spruce-fir forests or mixed hardwood/spruce forests (for nesting) [breeding season only]	Northern Saw-whet Owl	SC		S2B,SZN	G5
Aimophila aestivalis CP: open longleaf pine forests, old fields [breeding season only]	Bachman's Sparrow	SC	C2	S3B,S2N	G3
Ammodramus henslowii C: clearcut pocosins and other damp weedy fields [breeding season only]	Henslow's Sparrow	SR	C2	S2B,S1N	G4
Anhinga anhinga C: wooded lakes or ponds, or open swamps (for nesting) [breeding evidence only]	Anhinga	SR		S2B,SZN	G5
Aquila chrysaetos MC: extensive open country; formerly nested on cliffs [regular wintering or summering sites]	Golden Eagle	SR		SXB?,S1N	G4
Botaurus lentiginosus CT: fresh or brackish marshes [breeding season only]	American Bittern	SR		S1B,S3N	G4
Campephilus principalis C: swamps with mature timber [not tracking; presumed extirpated in USA]	Ivory-billed Woodpecker	E	E	SX	G1
Catharus guttatus M: spruce-fir forests (for nesting) [breeding season only]	Hermit Thrush	SR		S1B,S5N	G5
Charadrius melodus T: ocean beaches and island-end flats [breeding evidence only]	Piping Plover	T	T	S2B,S2N	G3
Chondestes grammacus C: barren, sandy fields with scattered saplings in the sandhills region [breeding season only]	Lark Sparrow	SR		S1B,SZN	G5
Circus cyaneus T: extensive brackish marshes (for nesting) [breeding evidence only]	Northern Harrier	SR		S1B,S4N	G5
Coccyzus erythropthalmus M: deciduous forests, mainly at higher elevations [breeding season and habitat only]	Black-billed Cuckoo	SR		S2B,SZN	G5
Columbina passerina T: dunes, sandy fields, margins of maritime woods and thickets [breeding season only]	Common Ground-Dove	SR		S1B,S1N	G5
Contopus borealis M: montane conifer forests (mainly spruce-fir) with openings or dead trees [breeding season only]	Olive-sided Flycatcher	SC		S1B,SZN	G5

Scientific Name / Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
Coragyps atratus MPC: forested areas for nesting; forests or open country for foraging [not tracking]	Black Vulture	SC		S3	G5
Corvus corax MP: cliffs for nesting; forests or fields (mainly at high elevations) for foraging [breeding evidence only]	Common Raven	SR		S3	G5
Coturnicops noveboracensis TC: brackish or fresh marshes, wet fields [winter season only]	Yellow Rail	SR		S2N	G4
Dendroica cerulea MC: mature hardwood forests; steep slopes and coves in mountains, natural levees in Coastal Plain [breeding season only]	Cerulean Warbler	SR	C2	S3B,S2N	G5
Dendroica kirtlandii PC: [not tracking; a casual or accidental migrant]	Kirtland's Warbler	E	E	SA	G1
Dendroica magnolia M: spruce-fir forests, especially in immature stands [breeding season only]	Magnolia Warbler	SR		S1B,S2N	G5
Egretta caerulea T: forests or thickets on maritime islands [breeding sites only]	Little Blue Heron	SC		S3B,S3N	G5
Egretta thula T: forests or thickets on maritime islands [breeding sites only]	Snowy Egret	SC		S3B,S3N	G5
Egretta tricolor T: forests or thickets on maritime islands [breeding sites only]	Tricolored Heron	SC		S3B,S3N	G5
Empidonax alnorum M: high elevation shrub/sapling thickets [breeding season only]	Alder Flycatcher	SR		S2B,S2N	G5
Falco peregrinus MT: cliffs (for nesting); coastal ponds and mudflats (for foraging in winter) [nesting evidence; regular wintering sites]	Peregrine Falcon	E	E	S1B,S2N	G3
Haliaeetus leucocephalus PCT: mature forests near large bodies of water (for nesting); lakes and sounds [nesting sites; regular non-breeding sites]	Bald Eagle	E	E	S1B,S2N	G3
Himantopus mexicanus T: fresh or brackish ponds and impoundments [breeding sites only]	Black-necked Stilt	SR		S2B	G5
Ictinia mississippiensis C: mature, extensive bottomland forests, mainly in Roanoke River floodplain [regular summer locations only]	Mississippi Kite	SR		S1B	G5
Lanius ludovicianus CPM: fields and pastures [not tracking]	Loggerhead Shrike	SC	C2	S2B,S3N	G4
Laterallus jamaicensis TCP: brackish marshes, rarely fresh marshes [breeding season only]	Black Rail	SR	C2	S3B,S2N	G4?
Mycteria americana T: fresh or brackish ponds (for foraging) [regular non-breeding sites]	Wood Stork	E	E	S1N	G5
Parus atricapillus M: high elevation forests, mainly spruce-fir [breeding season only]	Black-capped Chickadee	SC		S3	G5
Passerculus sandwichensis M: grassy fields and pastures [breeding season only]	Savannah Sparrow	SR		S1B,S5N	G5
Pelecanus occidentalis T: maritime islands [breeding sites only]	Brown Pelican	SC		S3B,S4N	G5

Scientific Name / Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
Phalacrocorax auritus CP: lakes with scattered trees for nesting [breeding sites only]	Double-crested Cormorant	SR		S1B,S5N	G5
Picoides borealis CP: mature open pine forests, mainly in longleaf pine [breeding evidence only]	Red-cockaded Woodpecker	E	E	S2	G2
Plegadis falcinellus T: forests or thickets on maritime islands [breeding sites only]	Glossy Ibis	SC		S2B,S1N	G5
Porphyrula martinica C: freshwater ponds with floating vegetation [breeding sites only]	Purple Gallinule	SR		S1B	G5
Regulus satrapa M: spruce-fir forests; hardwood forests mixed with spruce or hemlock [not tracking]	Golden-crowned Kinglet	SC		S3B,S5N	G5
Riparia riparia P: high, vertical banks for nesting [breeding sites only]	Bank Swallow	SR		S1B,S2N	G5
Rynchops niger T: sand flats on maritime islands [breeding sites only]	Black Skimmer	SC		S3B,S3N	G5
Sphyrapicus varius M: mature, open hardwoods with scattered dead trees [breeding season only]	Yellow-bellied Sapsucker	SR		S2B,S5N	G5
Sterna caspia T: sand flats on maritime islands [breeding sites only]	Caspian Tern	SR		S1B,S2N	G5
Sterna dougallii T: sand flats on maritime islands [breeding evidence only]	Roseate Tern	E	E	SAB,S1N	G3
Sterna nilotica T: sand flats on maritime islands [breeding sites only]	Gull-billed Tern	T		S3B,S2N	G5
Thryomanes bewickii altus M: woodland borders or openings, farmlands or brushy fields, at high elevations [breeding season only]	Appalachian Bewick's Wren	E	C2	SHB,S2N	G5T?
Vermivora bachmanii P: [not tracking; accidental visitor]	Bachman's Warbler	E	E	SA	G1
Vermivora pinus M: low elevation brushy fields and thickets [breeding season only]	Blue-winged Warbler	SR		S2B,S2N	G5
Vireo gilvus M: groves of hardwoods along rivers and streams [breeding season only]	Warbling Vireo	SR		S2B,S2N	G5
REPTILES					
Alligator mississippiensis CT: fresh to slightly brackish lakes, ponds, rivers, and marshes	American Alligator	T	T(S/A)[10]	S3	G5
Apalone spinifera spinifera M: large streams in the French Broad system	Eastern Spiny Softshell	SC		S1	G5T5
Caretta caretta T: nests on beaches; forages in ocean and sounds	Loggerhead	T	T	S2B,S2N	G3
Chelonia mydas T: nests on beaches; forages in ocean and sounds	Green Turtle	T	T	S1B,S2N	G3
Clemmys muhlenbergii MP: bogs, wet pastures, wet thickets	Bog Turtle	T	C2	S2	G3

[10] T(S/A) = Threatened due to Similarity of Appearance

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
Crotalus adamanteus C: pine flatwoods, savannas, pine-oak sandhills	Eastern Diamondback Rattlesnake	SR#		S1	G5
Dermochelys coriacea T: oceans, rarely in sounds	Leatherback	E	E	SZN	G3
Eretmochelys imbricata T: oceans, very rarely in sounds	Hawksbill	E	E	SZN	G3
Heterodon simus C: sandy woods, particularly pine-oak sandhills	Southern Hognose Snake	SR	C2	S3	G4G5
Lampropeltis getula sticticeps T: maritime forests, thickets, and grasslands on the Outer Banks	Outer Banks Kingsnake	SC		S2	G5T2Q
Lepidochelys kempii T: ocean and sounds	Atlantic Ridley	E	E	SZN	G1
Malaclemys terrapin T: salt or brackish marshes; estuaries [not tracking]	Diamondback Terrapin	SC	C2	S3	G5
Micrurus fulvius C: pine-oak sandhills, sandy flatwoods, maritime forests	Eastern Coral Snake	SR#		S1	G5
Nerodia sipedon williamengelsi T: salt or brackish marshes	Carolina Salt Marsh Snake	SC		S2	G5T2
Opheodrys vernalis M: fields and grassy meadows	Smooth Green Snake	SC		SH	G5
Ophisaurus mimicus C: pine flatwoods, savannas, pine/oak sandhills	Mimic Glass Lizard	SC		S2	G3
Pituophis melanoleucus melanoleucus CM: dry and sandy woods, mainly in pine/oak sandhills	Northern Pine Snake	SC	C2	S3	G5T?
Sistrurus miliarius CP: pine flatwoods, pine/oak sandhills, other pine/oak forests	Pigmy Rattlesnake	SR@		S3	G5
Sternotherus minor [S. m. peltifer] M: streams and rivers in Mississippi drainage	Loggerhead Musk Turtle [Stripeneck Musk Turtle]	SC		S1	G5
AMPHIBIANS					
Ambystoma talpoideum MP: breeds in fish-free semipermanent woodland ponds; forages in adjacent woodlands	Mole Salamander	SC		S2	G5
Ambystoma tigrinum C: breeds in fish-free semipermanent ponds; forages in adjacent woods, usually sandy pinewoods	Tiger Salamander	T		S2	G5
Aneides aeneus M: damp, shaded crevices of cliffs or rock outcrops in deciduous forests (southern mountains)	Green Salamander	E	C2	S1	G3G4
Cryptobranchus alleganiensis M: large and clear fast-flowing streams	Hellbender	SC	C2	S3	G4
Desmognathus santeetlah M: stream headwaters and seepage areas; southwestern mountains	Santeetlah Dusky Salamander	SR		S2S3	G3Q
Eurycea junaluska M: forests near seeps and streams in the Cheoah River system	Junaluska Salamander	SC	C2	S2	G2Q
Eurycea longicauda longicauda M: moist woods and floodplains	Longtail Salamander	SC		S2	G5T5
Eurycea quadridigitata (part) C: pocosins, bay forests, flatwoods, savannas	Dwarf Salamander (silver-bellied morph)	SC		S2	G5T?Q
Hemidactylium scutatum MPC: pools, bogs, and other wetlands in hardwood forests	Four-toed Salamander	SC		S3	G5
Hyla andersonii C: pocosins, bay forests, boggy areas	Pine Barrens Treefrog	SR	3C	S3	G4
Necturus lewisi PC: rivers and large streams in Neuse and Tar drainages (endemic to North Carolina)	Neuse River Waterdog	SC	3C	S3	G3
Necturus maculosus	Mudpuppy	SC		S1	G5

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
M: rivers and large streams (French Broad drainage)					
Plethodon aureolus M: forests in the Unicoi Mountains	Tellico Salamander	SR		S2	G2G3Q
Plethodon dorsalis M: moist areas of talus slopes or rock outcrops in hardwood forests	Zigzag Salamander	SC		S1	G5
Plethodon longicrus M: cool rock crevices or talus slopes in Hickorynut Gorge area (endemic to North Carolina)	Crevice Salamander	SC		S1	G1Q
Plethodon wehrlei P: upland forests (on a monadnock in North Carolina)	Wehrle's Salamander	T		S1	G5
Plethodon welleri M: high elevation forests in northern mountains, mainly in spruce-fir	Weller's Salamander	SC		S2	G4
Pseodacris brachyphona M: forests near temporary pools or ponds, in extreme southwestern mountains	Mountain Chorus Frog	SC		SH	G5
Rana capito capito C: breeds in temporary fish-free pools; forages in sandy woods, especially pine-oak sandhills	Carolina Gopher Frog	SC	C2	S2	G4T?
Rana heckscheri C: river floodplains, such as pools or borrow pit ponds	River Frog	SC		S1	G5
FRESHWATER FISHES					
Acipenser brevirostrum (see listing under Marine and Estuarine Fishes)					
Acipenser fulvescens M: large rivers of Tennessee drainages	Lake Sturgeon	SC	C2	SRSX	G3
Acipenser oxyrhynchus (see listing under Marine and Estuarine Fishes)					
Ambloplites cavifrons PC: streams in Neuse and Tar systems	Roanoke Bass	SR*		S3	G3
Aplodinotus grunniens M: French Broad River	Freshwater Drum	T		S1	G5
Carpiodes carpio M: French Broad River	River Carpsucker	SC		S1	G5
Carpiodes velifer PC: Catawba, Pee Dee, and Cape Fear rivers	Highfin Carpsucker	SC		S2	G4G5
Clinostomus funduloides subsp. M: Little Tennessee drainage	Little Tennessee River Rosyside Dace	SC		S2	G5T?
Cottus carolinae M: French Broad River system	Banded Sculpin	T		S1	G5
Cyprinella monacha M: Little Tennessee River; formerly in French Broad drainage	Spotfin Chub	T	T	S1	G2
Cyprinella zanema PC: Catawba, Broad, Cape Fear, and Lumber drainages	Santee Chub	SR		S3	G3?
Elassoma boehlkei C: streams and canals in Waccamaw drainage	Carolina Pygmy Sunfish	T	C2	S1S2	G1G2
Etheostoma acuticeps M: streams in Nolichucky system (Toe and Cane rivers)	Sharphead Darter	T	3C	S1	G3G4
Etheostoma collis P: streams in the Piedmont	Carolina Darter	SC		S3	G3
Etheostoma inscriptum M: streams of Savannah drainage	Turquoise Darter	SC		S1	G4
Etheostoma jessiae M: streams in Hills River system	Blueside Darter	SC		S1	G4Q
Etheostoma kanawhae M: New drainage	Kanawha Darter	SR		S3	G2
Etheostoma maculatum (= E. sanguifluum) (see Etheostoma vulneratum)					

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Etheostoma mariae C: streams of Lumber drainage, mainly in the sandhills; perhaps in adjacent Pee Dee drainage	Pinewoods Darter	SC	3C	S3	G3
Etheostoma perlongum C: Lake Waccamaw (endemic to North Carolina)	Waccamaw Darter	T	3B	S1	G1Q
Etheostoma podostemone P: large streams in Dan River system	Riverweed Darter	SC		S2	G3
Etheostoma simoterum M: streams of French Broad drainage (formerly)	Tennessee Snubnose Darter	SC		SH	G5
Etheostoma vulneratum M: streams of Little Tennessee system; perhaps extirpated from French Broad system	Wounded Darter	SC		S2	G2
Exoglossum laurae M: New drainage	Tonguetied Minnow	SR		S2	G4
Exoglossum maxillingua P: streams of Dan River system	Cutlips Minnow	E		S1	G5
Fundulus waccamensis C: large natural lakes (Lakes Waccamaw and Phelps) (endemic to North Carolina)	Waccamaw Killifish	SC	C2	S1	G1
Heterandria formosa C: streams and lakes near Wilmington	Least Killifish	SC		S1	G5
Hiodon tergisus M: French Broad River	Mooneye	SC		S1	G5
Hybopsis monacha (see Cyprinella monacha)					
Hybopsis rubrifrons (see Notropis rubescens)					
Hybopsis zanema (see Cyprinella zanema)					
Hybopsis, new species [Cape Fear Chub] (merged with Cyprinella zanema)					
Hypentelium roanokense P: Dan drainage	Roanoke Hog Sucker	SR		S3	G3?
Ictiobus bubalus MP: French Broad River; Piedmont reservoirs	Smallmouth Buffalo	SR		S2	G5
Lampetra aepyptera CP: Tar and Neuse drainages	Least Brook Lamprey	SC		S2	G5
Lampetra appendix M: French Broad drainage	American Brook Lamprey	T		S1	G5
Lepomis megalotis M: French Broad drainage	Longear Sunfish	SR*		SH	G5
Lucania goodei C: stream in Wilmington area	Bluefin Killifish	SC		S1	G5
Luxilus chrysocephalus M: Cape River system	Striped Shiner	T		S1	G5
Menidia extensa C: Lake Waccamaw (endemic to North Carolina)	Waccamaw Silverside	T	T	S1	G1
Micropterus coosae M: Savannah drainage	Redeye Bass	SR		S1	G5
Moxostoma ariommum P: Dan drainage	Bigeye Jumprock	SC		S2	G2
Moxostoma carinatum (undescribed form) P: Pee Dee River	River Redhorse	SC		S1	G4T1
Moxostoma hamiltoni P: Dan drainage	Rustyside Sucker	E	3C	S1	G2
Notropis bifrenatus C: stream near lower Neuse River	Bridle Shiner	SC		SH	G5
Notropis chrysocephalus (see Luxilus)					
Notropis lutipinnis MP: Savannah, Little Tennessee, and Broad drainages [only the Savannah and Little Tennessee drainages are listed as SC]	Yellowfin Shiner	SC		S3	G4
Notropis mekistocholas P: Cape Fear drainage (endemic to North Carolina)	Cape Fear Shiner	E	E	S1	G1

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
Notropis rubescens M: Savannah drainage	Rosyface Chub	T		S1	G4
Noturus eleutherus M: French Broad drainage	Mountain Madtom	SC		SH	G5
Noturus flavus M: Cape River	Stonecat	E		S1	G5
Noturus furiosus CP: Tar and Neuse drainages (endemic to North Carolina)	Carolina Madtom [Neuse population] [Tar population]		3C SC SR	S3 S2 S2	G3 G3T2Q G3T2Q
Noturus gilberti P: Dan drainage	Orangefin Madtom	E	C2	S1	G2
Noturus, new species C: Cape Fear, Waccamaw, and Lumber drainages	Broadtail Madtom	SC		S2	G2
Percina aurantiaca M: Tennessee drainages	Tangerine Darter	SR		S3	G3G4
Percina burtoni M: South Toe River; formerly in French Broad drainage	Blotchside Darter	E		S1	G2
Percina caprodes M: Tennessee drainages	Logperch	T		S2	G5
Percina macrocephala M: French Broad River; probably extirpated	Longhead Darter	SC	C2	SH	G3
Percina oxyrhynchus M: New drainage	Sharpnose Darter	SC		S1	G4
Percina sciera M: French Broad drainage	Dusky Darter	E		S1	G5
Percina squamata M: Tennessee drainages	Olive Darter	SC	C2	S3	G3
Phenacobius teretulus M: New drainage	Kanawha Minnow	SC	C2	S3	G3
Polyodon spathula M: French Broad River	Paddlefish	E	C2	S1	G4
Semotilus lumbee C: streams in the sandhills	Sandhills Chub	SC	3C	S3	G3
Stizostedion canadense M: French Broad and Hiwassee rivers	Sauger	SR*		S2	G5
MARINE AND ESTUARINE FISHES					
Acipenser brevirostrum TC: brackish water of large rivers and estuaries; spawns in freshwater areas	Shortnose Sturgeon	E	E	S1	G3
Acipenser oxyrhynchus TC: coastal waters, estuaries, large rivers	Atlantic Sturgeon	SC		S3	G3
Eleotris pisonis T: fresh to brackish ponds, river mouths, and estuaries	Spinycheek Sleeper	SR		S2	G5
Evorthodus lyricus T: shallow tidal water, especially pools in salt marshes	Lyre Goby	SR		S2	GU
Gobionellus stigmaticus T: shallow salt or brackish water	Marked Goby	SR		S2	G?
Hypsoblennius ionthas T: shallow bays, estuaries, tidal creeks	Freckled Blenny	SR		S2	GU
Microphis brachyurus T: warm fresh to brackish water	Opossum Pipefish	SR		S1	G5
Oostethus brachyurus (see Microphis)					

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
MOLLUSKS -- FRESHWATER BIVALVES[11]					
Alasmidonta heterodon PC: Tar and Neuse drainages, mainly near Fall Line	Dwarf Wedgemussel	E	E	S1	G1
Alasmidonta raveneliana M: Tennessee drainages; Little Tennessee and Nolichucky rivers at present; formerly in Cane and North Toe rivers	Appalachian Elktoe	E	C2	S1	G1
Alasmidonta robusta P: Long Creek in Mecklenburg County (endemic to North Carolina; now believed extinct)	Carolina Elktoe	EX	3A	SX	GH
Alasmidonta undulata PC: most river systems in Piedmont and Coastal Plain	Triangle Floater	T		S2	G4
Alasmidonta varicosa PM: many Piedmont systems and along Blue Ridge escarpment of Catawba River system	Brook Floater	T	C2	S2	G3
Alasmidonta viridis M: Little Tennessee River	Slippershell Mussel	E		S1	G4
Alasmidonta, new species? (sp. 1) P: upper Yadkin River system (Davie County)	a bivalve	SR		SU	G1Q
Anodonta couperiana C: Bladen County; formerly in Greenfield Lake	Barrel Floater	E		S1	G3G4
Anodonta implicata C: Chowan, Meherrin, and lower Roanoke rivers	Alewife Floater	SC		S2	G5 (G4)
Elliptio dilatata M: Little Tennessee and New rivers	Spike	SC		S2	G5 (G3)
Elliptio folliculata C: lower Coastal Plain, mainly in Lake Waccamaw	Pod Lance	SC		S2	G3
Elliptio judithae [probably conspecific with E. roanokensis] CP: Neuse River; possibly Tar River (endemic to North Carolina)	Neuse Slabshell	E	C2	S1	G1Q
Elliptio lanceolata PC: Tar and Neuse systems, mainly near the Fall Line	Yellow Lance	T	C2	S2	G4 (G3)
Elliptio marsupiobesa [probably conspecific with E. icterina] C: Cape Fear River in Cumberland and Bladen counties (endemic to North Carolina)	Cape Fear Spike	T	C2	SU	G3Q
Elliptio peristus C: Cape Fear River, Great Coharie Creek	a bivalve	SR		SU	G1Q
Elliptio roanokensis PC: Neuse and Tar river systems	Roanoke Slabshell	T		S1	G2Q
Elliptio steinstansana PC: Tar River drainage, primarily Swift Creek (endemic to North Carolina)	Tar Spinymussel	E	E	S1	G1
Elliptio waccamawensis C: Lake Waccamaw and vicinity (endemic to North Carolina; possibly in adjacent South Carolina)	Waccamaw Spike	T	C2	S1	G1
Elliptio, new species? (sp. 3) C: Black River system (Great Coharie Creek)	a bivalve	SR		SU	G1Q
Elliptio, new species? (sp. 4) P: Deep River system (Chatham/Lee county line)	a bivalve	SR		SU	G1Q
Elliptio, new species? (sp. 5) C: Lake Waccamaw (endemic to North Carolina)	Waccamaw Lance Pearlymussel	SR	C2	S1S3	G1G3Q
Fusconaia barnesiana M: Little Tennessee River	Tennessee Pigtoe	E		S1	G3

[11]Global ranks in parentheses are those suggested by the N.C. Scientific Council on Freshwater and Terrestrial Mollusks and are not The Nature Conservancy's assigned ranks.

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Fusconaia masoni CP: most Atlantic drainages, in lower Piedmont and upper Coastal Plain; also in Black River in lower Coastal Plain	Atlantic Pigtoe	T	C2	S1	G2
Lampsilis cariosa PC: a number of river systems; mainly near the Fall Line	Yellow Lampmussel	T	C2	S1	G4
Lampsilis conspicuus P: Neuse, Flat, and upper Pee Dee rivers	a bivalve	SR		SU	G1G2Q
Lampsilis crocata C: Lake Waccamaw and vicinity; possibly Orton Pond	Waccamaw Lampmussel	SC		S2	G1Q (GU)
Lampsilis fasciola M: French Broad, Pigeon, and Little Tennessee rivers; currently known only in last river	Wavy-rayed Lampmussel	SC		S2	G4
Lampsilis fullerkati C: Lake Waccamaw and vicinity (endemic to North Carolina and adjacent South Carolina)	Waccamaw Fatmucket	T	C2	S1	G1
Lampsilis ochracea CP: a number of systems, primarily in the Coastal Plain; abundant in Lake Waccamaw	Tidewater Mucket	SC		S2	G4
Lampsilis radiata CP: a number of river systems	Eastern Lampmussel	SC		S2	G5 (G4)
Lampsilis, new species? (sp. 1) P: Deep River	a bivalve	SR		SU	G1G2Q
Lasmigona decorata P: Catawba and Pee Dee drainages in Union and Mecklenburg counties (endemic to this area and adjacent South Carolina)	Carolina Heelsplitter	E	PE	S1	G1
Lasmigona holstonia M: Watauga River; formerly in Valley Creek in Cherokee County	Tennessee Heelsplitter	E	C2	S1	G2
Lasmigona subviridus CPM: Tar, Neuse, and Cape Fear systems downstate; New and Watauga systems in mountains	Green Floater	E	C2	S1	G4 (G3)
Leptodea ochracea (see Lampsilis)					
Ligumia nasuta C: Chowan, Roanoke, and Pamlico systems	Eastern Pondmussel	SC		S2	G4 (G3)
Pegias fabula M: Little Tennessee River; formerly in Valley River in Cherokee County	Little-wing Pearlymussel	E	E	S1	G1
Strophitus undulatus P: Tar, Neuse, Cape Fear, and Pee Dee systems, perhaps other systems in Piedmont	Squawfoot	T		S2	G5 (G4)
Toxolasma pullus PC: a number of Atlantic drainages, most numerous in University Lake near Chapel Hill	Savannah Lilliput	T	C2	S2	G3
Tritogonia verrucosa M: New River near the Virginia border	Pistolgrip	E		S1	G4
Villosa constricta PC: most Atlantic drainages, mainly in lower Piedmont	Notched Rainbow	SR		S3?	G4
Villosa delumbis PC: most Atlantic drainages	Eastern Creekshell	SR		S3?	G3G4
Villosa nebulosa M: French Broad, Hiwassee, and Little Tennessee rivers; currently only known in the state from the last river	Alabama Rainbow	SC		S2	G3
Villosa vanuxemensis M: French Broad and Hiwassee systems	Mountain Creekshell	T		S1	G4
Villosa vaughaniana P: Pee Dee system (endemic to North Carolina and adjacent South Carolina)	Carolina Creekshell	SC		S2	G3

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
MOLLUSKS -- FRESHWATER GASTROPODS					
Amnicola sp. C: Lake Waccamaw and adjacent Big Creek (endemic to North Carolina)	Waccamaw Snail	SC		S1	G7 (G1Q)
Cincinnatia sp. C: Lake Waccamaw and adjacent Big Creek (endemic to North Carolina)	Waccamaw Siltsnail	SC		S1	G7 (G1Q)
Ferrissia hendersoni CP: scattered locales in Coastal Plain and Piedmont, but mainly on margins of Carolina bay lakes (apparently endemic to North Carolina)	Blackwater Ancylid	SC		S1	G7 (G1)
Goniobasis interrupta M: Hiwassee River and tributaries	Knotty Elimia	E	C2	S1	G7 (G1)
Helisoma eucosmium C: Greenfield Lake (endemic to North Carolina; believed to be extinct)	Greenfield Ramshorn Snail	EX	3A	SX	GH
Leptoxis dilatata M: New River in Ashe County	Seep Mudalia	T		S1	G7 (G3)
Leptoxis virgata M?: reported from Hiwassee River, possibly in error	Smooth Mudalia	SR	C2	SU	G7 (G2)
Planorbella magnifica C: Orton Pond and pond on Sand Hill Creek; formerly Greenfield Lake (endemic to North Carolina)	Magnificent Rams-horn	E	C2	S1	G1
MOLLUSKS -- TERRESTRIAL GASTROPODS					
Catinella avara C: shoreline of Lake Waccamaw	Suboval Ambersnail	T		S1	G5
Discus bryanti M: Watauga to Madison counties	Saw-tooth Disc	SC		S2	G7 (G3)
Glyphyalinia clingmani M: Black Mountains of Yancey County (endemic to North Carolina)	Fragile Glyph	E	C2	S1	G7 (G1)
Glyphyalinia junaluskana M: southwestern mountains	Dark Glyph	SC		S2	G7 (G3)
Glyphyalinia pentadelphia M: southwestern mountains	Pink Glyph	SC		S2	G7 (G3)
Glyphyalinia vanattai M: Avery, Mitchell, and Yancey counties	Honey Glyph	SC		S2	G7 (G2)
Haplotrema kendeighi M: southwestern mountains	Blue-footed Lancetooth	SC		S2	G7 (G2)
Helicodiscus bonamicus M: Nantahala Gorge vicinity (endemic to this area)	Spiral Coil	SC		S2	G7 (G2)
Helicodiscus fimbriatus M: extreme southwestern corner of the state, in Cherokee and Graham counties	Fringed Coil	SC		S2	G7 (G3)
Mesodon chilhoweensis M: southern half of the mountains	Queen Crater	SC		S2	G7 (G2)
Mesodon clarki M: southwestern mountains	Dwarf Proud Globe	SC		S2	G7 (G2)
Mesodon clarki nantahala M: Nantahala Gorge (endemic to this site)	Noonday Globe	T	T	S1	G7 (G2T1)
Mesodon ferrissi M: Great Smoky Mountains and Plott Balsams (endemic to these ranges)	Smokey Mountain Covert	T		S2	G7 (G2)
Mesodon jonesianus M: Newfound Gap area of Great Smoky Mountains National Park (endemic to this area)	Big-tooth Covert	T	3C	S2	G7 (G2)
Mesodon orestes M: Plott Balsam mountains (endemic to this area)	Engraved Covert	T	C2	S2	G7 (G2)
Mesodon subpallidus M: central mountains (Avery to Haywood counties)	Velvet Covert	SC		S2	G7 (G2)

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
Mesodon wheatleyi clingmanicus M: Clingmans Dome region of Great Smoky Mountains National Park (endemic to this area)	Clingman Covert	T	C2	S1	G4 (G1)
Pallifera hemphilli M: high elevation forests, mainly spruce-fir	Black Mantleslug	SC		S2	G3
Paravitrea andrewsae M: northern half of the mountains	High Mountain Supercoil	SC		S2	G7 (G3)
Paravitrea clappi M: high elevations in Great Smoky Mountains National Park	Mirey Ridge Supercoil	SC	3C	S2	G7 (G3)
Paravitrea lacteodens M: Graham County, possibly Cherokee County (endemic to this area)	Ramp Cove Supercoil	SC		S1	G7 (G1Q)
Paravitrea lamellidens M: southern half of the mountains	Lamellate Supercoil	SC		S2	G7 (G3)
Paravitrea placentula M: Mitchell and Swain counties	Glossy Supercoil	SC		S2	G3
Paravitrea ternaria M: Madison County (endemic to this county and Unicoi County, Tennessee)	Sculpted Supercoil	T	C2	S2	G7 (G2)
Paravitrea umbilicaris M: extreme southwestern mountains	Open Supercoil	SC		S2	G7 (G3)
Paravitrea varidens M: Mitchell and Yancey counties (endemic to North Carolina and adjacent Tennessee)	Roan Supercoil	T	C2	S2	G7 (G2)
Stenotrema depilatum M: Great Smoky Mountains National Park (essentially endemic to this area)	Great Smoky Slitmouth	SC		S2	G7 (G2)
Triodopsis fulcidens P: southwestern Piedmont (endemic to North Carolina)	Dwarf Threetooth	SC		S2	G7 (G2)
Triodopsis soelneri C: swampy habitats in the extreme southeastern corner of the state (endemic to North Carolina)	Cape Fear Threetooth	T	C2	S2	G2
Ventridens coelaxis M: northern mountains	Bidentate Dome	SC		S2	G3
Zonitoides patuloides M: southwestern mountains	Appalachian Gloss	SC		S2	G7 (G2)
MOLLUSKS -- MARINE BIVALVES					
Argopecten gibbus	Atlantic Calico Scallop	SR		S?	G7
Panopea bitruncata	Atlantic Geoduck	SR		S?	G3?
Paramya subovata	Subovate Softshell	SR		S?	G7
MOLLUSKS -- MARINE GASTROPODS					
Busycon canaliculatus	Channeled Whelk	SR		S?	G7
Busycon carica	Knobbed Whelk	SR		S?	G7
Busycon contrarium	Lightning Whelk	SR		S?	G7
Detracia clarki	Clark's Melampus	SR		S?	G7
Neritina usnea	Olive Nerite	SR		S?	G7

Scientific Name / Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
Metalepsis fishii no location data	a noctuid moth	SR		SU	G4G5
Metarranthis lateritiaria no location data	a geometrid moth	SR		S1S3	G3G4
Papaipema, new species? no location data	Southeastern Cane Borer	SR		SU	G4?
Phragmitiphila interrogans no location data	a noctuid moth	SR		SU	GU
Pyreferra ceromatica no location data	Annointed Sallow Moth	SR		SU	GU
Semiothisa fraserata M: Fraser fir forests	Fraser Fir Angle	SR		S1S3	G1G3
Spartiniphaga carterae C: wet savannas; host plant -- Calamovilfa, perhaps other grasses	Carter's Noctuid Moth	SR	C2	S2S3	G2
INSECTS -- BUTTERFLIES					
Amblyscirtes alternata C: open pine woods, savannas; host plants -- unknown, but presumably grasses	Least Florida Skipper	SR		S2?	G3G4
Amblyscirtes reversa CP: swamps, wet woods, or pocosin borders, near cane; host plant -- cane (Arundinaria)	Reversed Roadside Skipper	SR		S3?	G4
Atrytone arogos arogos C: savannas, open pinewoods, and other relatively undisturbed grasslands; host plants -- grasses, mainly broomsedge (Andropogon)	Arogos Skipper	SR	C2	S1	G4T3
Atrytonopsis loammi CT: grassy areas; host plants -- presumed to be Andropogon grasses	Loammi Skipper	SR		S1	GUQ
Autochton cellus MPC: moist woods near streams or ponds; host plants -- legumes, mainly hog peanut (Amphicarpa)	Golded-banded Skipper	SR		S2?	G4
Calephelis virginiensis C: savannas, flatwoods, other open pinewoods; host plant -- thistle (Cirsium horridulum)	Little Metalmark	SR		S3?	G4
Celastrina ebenina M: rich, moist deciduous forests; host plant -- goat's-beard (Aruncus dioicus)	Dusky Azure	SR		S1?	G4
Celastrina neglectamajor M: rich deciduous forests; host plant -- maple-leaf viburnum (Viburnum acerifolium)	Appalachian Blue	SR		S1?	G4
Enodia anthedon M: moist deciduous woods, especially near streams; host plants -- grasses	Northern Pearly Eye	SR		S1S2	G5
Erora laeta M: deciduous forests, especially along roads or edges at high elevations; host plants -- mainly beech (Fagus) and hazelnut (Corylus)	Early Hairstreak	SR		S2?	G4
Erynnis martialis MPC: upland woods, brushy fields; host plant -- New Jersey tea (Ceanothus americanus)	Mottled Dusky Wing	SR		S3?	G4
Euphydryas phaeton M: bogs, marshes, wet meadows; host plants -- varied, but mainly turtlehead (Chelone)	Baltimore	SR		S2S3	G4
Euphyes berryi C: wet areas near ponds, canals, or marshes; host plant -- not known; adults feed on pickerelweed (Pontederia)	Berry's Skipper	SR		S1	G3G4
Euphyes bimacula C: marshes, sedgy areas near wet woods; host plants -- sedges (Carex)	Two-spotted Skipper	SR		S2?	G4
Euphyes dion C: marshes, ditches, wet savannas, boggy areas;	Dion Skipper	SR		S3	G4

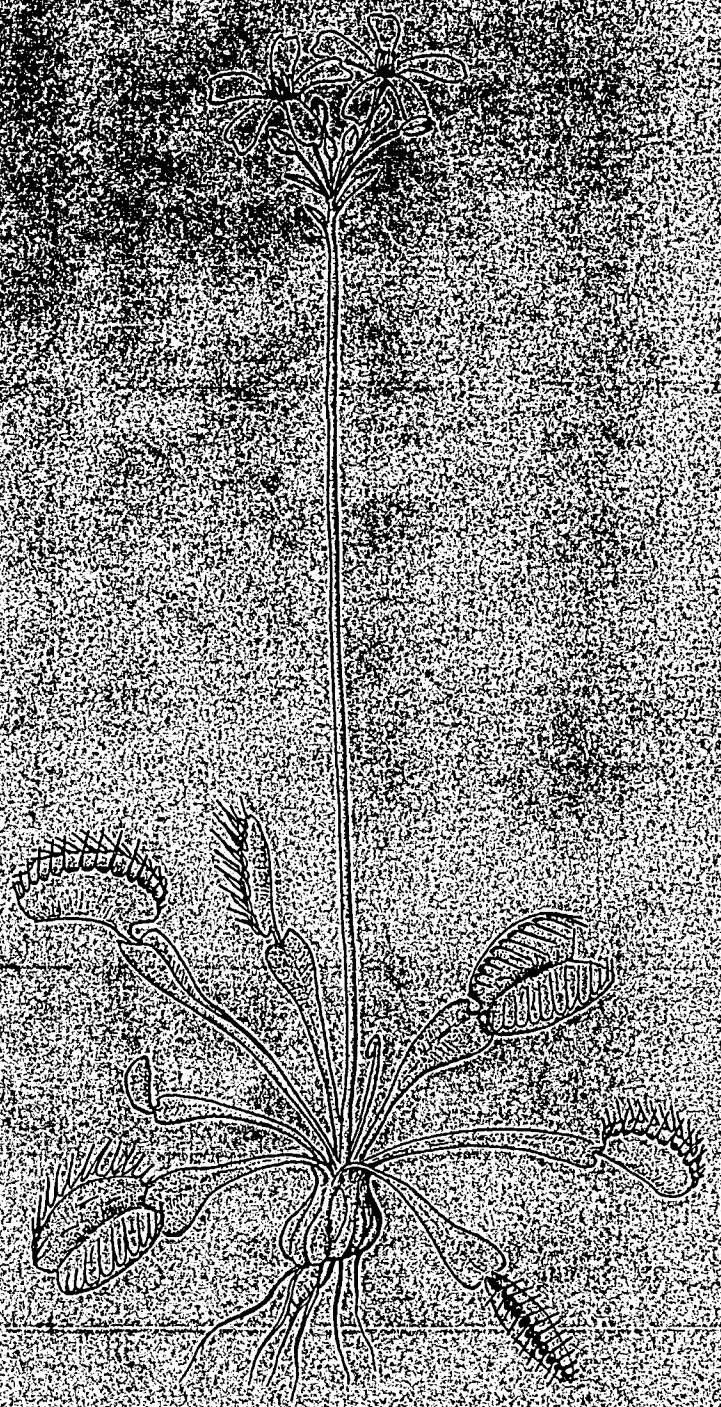
Scientific Name / Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
host plants -- sedges (Carex, Scirpus)					
Euphyes dukesi C: swamps (often near tupelo), marshes; host plants -- sedges (Carex)	Duke's Skipper	SR		S1?	G3G4
Fixsenia favonius T: maritime forests; host plant -- oaks, especially live oak (Quercus virginiana)	Southern Hairstreak	SR		S1	G4Q
Fixsenia ontario CT: oak-dominated woods, usually in dry sites; host plants -- oaks (Quercus)	Northern Hairstreak	SR		S3?	G4
Glaucopsyche lygdamus M: open upland woods, roadbanks, and borders; host plants -- legumes, especially Carolina vetch (Vicia caroliniana)	Silvery Blue	SR		S2S3	G5
Hesperia attalus slossonae C: pine/oak sandhills, flatwoods, savannas; host plants -- grasses	Dotted Skipper	SR		S1S3	G4T3
Hesperia meskei C: open pine woods, especially in Sandhills; host plants -- grasses	Meske's Skipper	SR		S1	G3?
Hesperia metea PC: dry barren sites, such as pine/oak sandhills and upland woods; host plants -- mainly broomsedge (Andropogon)	Cobweb Skipper	SR		S3?	G4G5
Hesperia sassacus M: old fields, clearings, wood margins, mainly at high elevations; host plants -- grasses	Indian Skipper	SR		S1?	G5
Incisalia augustus MPC: dry acidic areas with an abundance of ericads, such as pine/oak heaths; host plants -- ericaceous shrubs	Brown Elfin	SR		S3?	G5
Incisalia irus MPC: open woods and borders, usually in dry situations; host plants -- lupines (Lupinus) and wild indigos (Baptisia)	Frosted Elfin	SR		S3?	G4
Lethe (see Enodia)					
Megathymus yuccae C: dunes, flatwoods, old fields, and other places near yuccas; host plants -- Yucca species	Yucca Skipper	SR		S3?	G4
Mitoura hesseli C: Atlantic white cedar swamps; host plant -- white cedar (Chamaecyparis thyoides)	Hessel's Hairstreak	SR	3C	S2?	G3G4
Neonympha mitchellii francisci C: boggy areas, overgrown beaver ponds, and pocosin margins with sedges in sandhills; host plants -- sedges (taxon endemic to North Carolina)	Mitchell's Satyr St. Francis' Satyr	E ~~SR~~	~~C2~~ E	S1	G2T1?
Oligoria maculata CT: swamp edges, marshes, ditches, and savannas; host plants -- probably grasses	Twin-spot Skipper	SR		S3?	G5
Papilio cresphontes TCPM: primarily coastal in maritime forests or thickets; host plants -- prickly ash (Zanthoxylum), hoptree (Ptelea)	Giant Swallowtail	SR		S2	G5
Phyciodes batesii M: dry hillsides, upland pastures, at higher elevations; host plants -- asters, mainly Aster undulatus	Tawny Crescent	SR	C2	S1	G3G4
Phyciodes pascoensis M: rocky areas (in Appalachians), but habitat poorly known; host plants -- asters	Northern Pearl Crescent	SR		SU	G5
Phyciodes phaon CT: open, often dry areas, mainly on barrier islands; host plants -- fogfruit (Lippia)	Phaon Crescent	SR		S2?	G5
Poanes aaroni howardi T: salt or brackish marshes; host plants -- grasses,	Aaron's Skipper	SR		S1S2	G4T4

*see memo attached

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
perhaps mainly Spartina alterniflora					
Polites mystic P: wet meadows, marshes; host plants -- grasses	Long Dash	SR		SR	G5
Polygonia faunus M: spruce, fir, or hemlock forests, where mixed with hardwoods; host plants -- varied, but mainly birches, willows, and alders	Green Comma	SR		S3?	G5
Polygonia progne M: rich deciduous forests; host plants -- mainly gooseberries (Ribes), but also on wild azalea (Rhododendron nudiflorum)	Gray Comma	SR		S1?	G5
Pontia protodice MPC: fields, brushy areas, wooded borders; host plants -- mustard species (Family Brassicaceae)	Checkered White	SR		S2S3	G5
Problema bulenta T: fresh to brackish marshes with tall grasses; host plant -- southern wild rice (Zizaniopsis miliacea), probably other tall grasses	Rare Skipper	SR	C2	S1?	G2G3
Problema byssus C: savannas, marshes, and other high-quality grassy areas; host plants -- grasses	Byssus Skipper	SR		S2?	G3G4
Pyrgus wyandot M: openings and edges in wooded hilltops; host plants -- Rosaceae, such as wild strawberry (Fragaria)	Southern Grizzled Skipper	SR	C2	SH	G3Q
Satyrium caryaevorum M: deciduous forests; host plants -- primarily hickories (Carya), but other trees also	Hickory Hairstreak	SR		S1?	G4
Satyrium edwardsii MPC: scrubby or xeric oak woods; host plants -- mainly oaks (Quercus)	Edwards' Hairstreak	SR		S2?	G4
Satyrium kingi MC: forests, often moist, usually near sweetleaf; host plant -- sweetleaf (Symplocos)	King's Hairstreak	SR		S3?	G3G4
Speyeria diana MP: rich woods and adjacent edges and openings, often near streams; believed extirpated from the lower Piedmont; host plants -- violets (Viola)	Diana	SR	C2	S3	G3
Speyeria idalia M: wet or dry meadows, bogs, open hilltops; host plants -- violets (Viola)	Regal Fritillary	SR	C2	SH	G3

Scientific Name Province: Habitat	Common Name	Status N.C.	Status U.S.	Rank N.C.	Rank Global
	INSECTS -- BEETLES				
Adelopsis mitchellensis	a small carrion beetle	SR		S?	G?
Agathidium sp 1	a round fungus beetle	SR		S?	G?
Aglenus brunneus	a cylindrical bark beetle	SR		S?	G?
Agonum gracilentum	a ground beetle	SR		S?	G?
Anillinus carolinae	a ground beetle	SR		S?	G?
Anillinus sp 2 [from NC, sp B]	a ground beetle	SR		S?	G?
Anillinus sp 4 [from NC, sp D]	a carabid beetle	SR		S?	G?
Anillinus sp A	a ground beetle	SR		S?	G?
Arianops alticola	a short-winged mold beetle	SR		S?	G?
Arianops barbata	a short-winged mold beetle	SR		S?	G?
Arianops coweeti	a short-winged mold beetle	SR		S?	G?
Arianops fovealis	a short-winged mold beetle	SR		S?	G?
Arianops gigantea	a short-winged mold beetle	SR		S?	G?
Arianops laminata	a short-winged mold beetle	SR		S?	G?
Arianops nantahalae joanna	a short-winged mold beetle	SR		S?	G?
Arianops nantahalae nantahalae	a short-winged mold beetle	SR		S?	G?
Arianops nodosa	a short-winged mold beetle	SR		S?	G?
Arianops norithe	a short-winged mold beetle	SR		S?	G?
Arianops parki	a short-winged mold beetle	SR		S?	G?
Arianops plectrops	a short-winged mold beetle	SR		S?	G?
Arianops spinicollis	a short-winged mold beetle	SR		S?	G?
Arianops teyahalee	a short-winged mold beetle	SR		S?	G?
Arianops thornei	a short-winged mold beetle	SR		S?	G?
Arianops unicoi	a short-winged mold beetle	SR		S?	G?
Cicindela abdominalis	a tiger beetle	SR		SU	G5
Cicindela dorsalis	a tiger beetle	SR		SU	G4
Cicindela lepida	Little White Tiger Beetle	SR		S1?	G4
Cicindela patruela	a tiger beetle	SR		S2?	G3
Ctenisius sp A	a short-winged mold beetle	SR		S?	G?
Hetaerius sp A	Hister Beetle	SR		S?	G?
Lathrobium shermani	a rove beetle	SR		S?	G?
Lichnanthe vulpina	a scarab beetle	SR		S?	G?

NATURAL HERITAGE PROGRAM LIST OF THE RARE PLANT SPECIES OF NORTH CAROLINA



Compiled By
Alan S. Weakley,
Botanist

North Carolina Natural Heritage Program
Division of Parks and Recreation
N.C. Department of Environment, Health, and Natural Resources 1993

NATURAL HERITAGE PROGRAM LIST OF THE RARE PLANTS OF NORTH CAROLINA
1993 Edition

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* This list is dynamic, being revised frequently as further data become available. *If you are using a copy of this list which is more than a year old* (check the edition date at the top of the first page), *it may be out of date and you should contact the Natural Heritage Program for important updates*. Further information on these species may be obtained by contacting the North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources, P.O. Box 27687, Raleigh, NC 27611-7687 or the North Carolina Plant Conservation Program, Department of Agriculture, P.O. Box 27647, Raleigh, NC 27611-7647.

North Carolina Status. Endangered, Threatened, and Special Concern species have legally protected status in North Carolina through the Plant Conservation Program. The Natural Heritage Program maintains computer and map files on Endangered, Threatened, Candidate, and Significantly Rare species; paper files are maintained on Watch List species.

STATUS CODE	STATUS	DEFINITION
E	Endangered	"Any species or higher taxon of plant whose continued existence as a viable component of the State's flora is determined to be in jeopardy" (GS 19B 106: 202.12). (Endangered species may not be removed from the wild except when a permit is obtained for research, propagation, or rescue which will enhance the survival of the species.)
T	Threatened	"Any resident species of plant which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (GS 19B 106:202.12). (Regulations are the same as for Endangered species.)
SC	Special Concern	"Any species of plant in North Carolina which requires monitoring but which may be collected and sold under regulations adopted under the provisions of [the Plant Protection and Conservation Act]" (GS 19B 106:202.12). (Special Concern species which are not also listed as Endangered or Threatened may be collected from the wild and sold under specific regulations. Propagated material only of Special Concern species which are also listed as Endangered or Threatened may be traded or sold under specific regulations.)
C	Candidate	Species which are very rare in North Carolina, generally with 1-20 populations in the state, generally substantially reduced in numbers by habitat destruction (and sometimes also by direct exploitation or disease). These species are also either rare throughout their ranges (fewer than 100 populations total) or disjunct in North Carolina from a main range in a different part of the country or world. Also included are species which may have 20-50 populations in North Carolina, but fewer than 50 populations rangewide. These are species which have the preponderance of their distribution in North Carolina and whose fate depends largely on their conservation here. Also included are many species known to have once occurred in North Carolina but with no known extant occurrences in the state (historical or extirpated species); if these species are relocated in the state, they are likely to be listed as Endangered or Threatened. If present land use trends continue, candidate species are likely to merit listing as Endangered or Threatened.

SR	Significantly Rare	Species which are very rare in North Carolina, generally with 1-20 populations in the state, generally substantially reduced in numbers by habitat destruction (and sometimes also by direct exploitation or disease). These species are generally more common somewhere else in their ranges, occurring in North Carolina peripherally to their main ranges, mostly in habitats which are unusual in North Carolina. Also included are some species with 20-100 populations in North Carolina, if they also have only 50-100 populations rangewide and are declining.
W	Watch List	Any other species believed to be rare and of conservation concern in the state but not warranting active monitoring at this time (see the Watch List section in the Supplement for a more complete discussion).
P_	Proposed	A species which has been formally proposed for listing as Endangered, Threatened, or Special Concern, but has not yet completed the legally mandated listing process.

United States Status is designated by the U.S. Fish and Wildlife Service. Federally listed Endangered and Threatened species are protected under the provisions of the Endangered Species Act of 1973, as amended. Unless otherwise noted, definitions are taken from the *Federal Register*, Vol. 55, No. 35, February 21, 1990 (50 CFR Part 17).

STATUS CODE	STATUS	DEFINITION
E	Endangered	A taxon "which is in danger of extinction throughout all or a significant portion of its range" (Endangered Species Act, Section 3).
T	Threatened	A taxon "which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (Endangered Species Act, Section 3).
C1	Candidate 1	"Taxa for which the [Fish and Wildlife] Service has on file enough substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened. Development and publication of proposed rules on these taxa are anticipated; however, because of the large number of category 1 taxa, it will take several years to clear the backlog."
C2	Candidate 2	"Taxa for which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at this time....Further biological research and field study usually will be necessary to ascertain the status of [these taxa]....It is likely that some category 2 candidates will not warrent listing, while others will be found to be in greater danger of extinction than some taxa in category 1."

3A	Candidate 3A	"Taxa for which the Fish and Wildlife Service has persuasive evidence of extinction. If rediscovered, such taxa might acquire high priority for listing."
3B	Candidate 3B	"Names that, on the basis of current taxonomic understanding..., do not represent distinct taxa...."
3C	Candidate 3C	"Taxa that have proven to be more abundant or widespread than previously believed and/or those that are not subject to any identifiable threat. If further research or changes in habitat indicate a significant decline in any of these taxa, they may be reevaluated for possible inclusion in categories 1 or 2."
P_	Proposed	"Taxa already proposed to be listed as" endangered or threatened. Taxa formally proposed as endangered or threatened receive some legal protection. Species listed as proposed candidates are species which are in the process of being added to the federal candidate list.
_*	Possibly Extinct	Taxa with no known extant occurrences.

North Carolina Rank. North Carolina ranks are based on The Nature Conservancy's system of measuring rarity and threat status. This system is now widely used by other agencies and organizations, as the best available scientific and objective assessment of a species' rarity at the state level.

RANK	NUMBER OF EXTANT POPULATIONS	DESCRIPTION
S1	1-5	Critically imperiled in North Carolina because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation (local extinction) from the state.
S2	6-20	Imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state.
S3	21-100	Rare or uncommon in North Carolina.
S4	100-1000	Apparently secure in North Carolina, with many occurrences.
S5	1000+	Demonstrably secure in North Carolina.
SA	--	Accidental in state.
SH	0?	Of historical occurrence in North Carolina, perhaps not having been verified in the past 20 years, and suspected to be still extant.
SR	--	Reported from North Carolina, but without persuasive documentation which would provide a basis for either accepting or rejecting the report.
SX	0	Apparently extirpated from North Carolina.
SU	--	Possibly in peril in North Carolina but status uncertain; need more information.

S?	--	Unranked, or rank uncertain.

A rank involving two numbers indicates uncertainty of rank. For instance, a S2S3 rank indicates that the species may be a S2 or a S3, but that existing data do not allow that determination to be made.

Global Rank. Similar to North Carolina ranks, global ranks are assigned by a consensus of scientific experts, the various natural heritage programs, and The Nature Conservancy. They apply to the status of a species throughout its range, and are based on data on the species' status rangewide. This system is now widely used by other agencies and organizations, as the best available scientific and objective assessment of a species' rarity throughout its range.

RANK	NUMBER OF EXTANT POPULATIONS	DESCRIPTION
G1	1-5	Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction.
G2	6-20	Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3	21-100	Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single physiographic region) or because of other factors making it vulnerable to extinction throughout its range.
G4	100-1000	Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5	1000+	Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GH	0?	Of historical occurrence throughout its range, i.e., formerly part of the established biota, with the expectation that it might be rediscovered.
GX	0	Believed to be extinct throughout its range (e.g., passenger pigeon) with virtually no likelihood that it will be rediscovered.
GU	--	Possibly in peril range-wide, but status uncertain; need more information.
G?	--	Unranked, or rank uncertain.
G_Q	--	Questionable taxonomic assignment.
T_	--	The rank of a subspecies or variety. As an example, G4T1 would apply to a subspecies of a species with an overall rank of G4, but the subspecies warranting a rank of G1.

A rank involving two numbers indicates uncertainty of rank. For instance, a G2G3 rank indicates that the species may be a G2 or a G3, but that existing data do not allow that determination to be made.

Physiographic Province. The provinces in which the species is known to occur are indicated. This should not be regarded as the only province(s) of the state in which the species could occur; our knowledge of the flora of North Carolina is still very imperfect. The provinces are abbreviated as follows:

M	Mountains (Blue Ridge)	All parts of North Carolina west of the foot of the Blue Ridge Escarpment.
P	Piedmont	All parts of North Carolina east of the foot of the Blue Ridge Escarpment and west of the Fall Line, including outlying "foothill" ranges, such as the Brushy, Uwharrie, and Sauratown Mountains. This province is shallowly underlain by crystalline metamorphic, igneous, or (rarely) consolidated sedimentary rocks.
S	Sandhills	Portions of Cumberland, Harnett, Hoke, Lee, Moore, Richmond, Scotland, and Montgomery counties consisting mostly of deep aeolian sands of the Middendorf and Pinehurst formations (Cretaceous to Tertiary age). The Sandhills are really part of the coastal plain but are here distinguished because of their distinctive geomorphology and vegetation. Areas somewhat resembling the Sandhills region but occurring in other parts of the state (such as Carolina bay rims and aeolian or beach ridge deposits in the outer Coastal Plain) are considered part of the Coastal Plain Province.
C	Coastal Plain	All parts of North Carolina east of the fall line, excluding the Sandhills, generally consisting of unconsolidated sands, silts, clays, and peats, though rarely shallowly underlain by consolidated coquina limestone ("marl").

Habitat. The known habitats are described; as with provinces, these should not be regarded as the only possible habitats of the species in the state.

Counties of known occurrence. Following the description of habitats is a listing of the known counties of occurrence. Counties with populations documented as extant in the last ten years (1983-1993) are marked with an asterisk (*). If there is some question as to the validity of the county report, it is marked with a question mark (?). The botanical exploration of North Carolina is far from complete, and many additional county records will be found, generally (but not always) in proximity to counties listed.

Scientific Name / Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Botrychium matricariifolium (not in RAB) MP: cove forests (Avery*, Burke*, Swain)	Daisy-leaf Moonwort	SR	-	S1	G5
Botrychium multifidum (not in RAB) M: grassy balds (Avery, Mitchell)	Leathery Grape Fern	C	-	S1	G5
Botrychium onaidense MP: cove forests, bogs (Avery, Buncombe, Burke*, Forsyth, Haywood, Jackson, Mitchell, Yancey)	Blunt-lobed Grape Fern	C	-	S1	G3?
Botrychium simplex var. *simplex* (not in RAB) M: open, grassy sites (Haywood*, Jackson*)	Least Moonwort	C	-	S1	G5T5
Brachyelytrum septentrionale (not in RAB) M: northern hardwood forests (Ashe, Avery, Transylvania)	Northern Shorthusk	SR	-	S1	G4G5
Bromus ciliatus M: high elevation moist woods and seeps (Ashe*, Mitchell)	Fringed Brome	SR	-	S1	G5
Buchnera americana (not including *B. floridana*) MPS: glades, open forests, streambanks, probably primarily over mafic or calcareous rocks (Buncombe, Cumberland, Durham, Forsyth, Henderson, Jackson, Johnston, Orange, Polk, Sampson, Swain, Wake)	American Bluehearts	C	-	SH	G3?
Buckleya distichophylla M: bluffs, dry slopes, forests on lower slopes (Buncombe*, Haywood*, Macon*, Madison*, Swain)	Piratebush	E	C2	S2	G2
Bulbostylis warei C: open sites (Brunswick)	Ware's Hairsedge	C	-	SH	G3G4
Bumelia (see *Sideroxylon*)					
Cacalia (see *Arnoglossum, Rugelia, Synosma*)					
Calamagrostis cainii (not in RAB) M: high elevation rocky summits (Buncombe*, Yancey*)	Cain's Reedgrass	E	C2	S1	G1
Calamagrostis canadensis M: high elevation openings (Alleghany, Ashe, Avery*, Haywood, Mitchell, Rutherford?, Watauga)	Canada Reedgrass	SR	-	S1	G5
Calamagrostis porteri (not in RAB) M: middle elevation ridgetop forests (Clay, Surry, Rutherford*, Transylvania)	Porter's Reedgrass	SR	-	S1	G4
Calamintha georgiana (= *Satureja georgiana*) SC: sandhills (Anson, Pender*, Robeson)	Georgia Calamint	SR	-	S1	G5
Calamovilfa brevipilis (see Watch List)					
Caltha palustris M: boggy sites (Ashe, Avery, Buncombe, Madison, Watauga*, Yancey)	Marsh Marigold	SR	-	S1	G5
Calystegia catesbiana ssp. *sericata* (= *C. sericata*) MP: open, sunny sites (Burke*, Clay*, Cleveland*, Jackson*, Macon*, Polk*, Rutherford*, Transylvania*)	Blue Ridge Bindweed	C	-	S2	G3T2T3
Camassia scilloides (not in NC in RAB) CP: rich levees, slopes, and bottomlands (Northampton*, Vance*)	Wild Hyacinth	T	-	S1	G4G5
Campanula aparinoides M: bogs and other wet, open sites (Alleghany*, Ashe*, Avery*, Burke*, Clay, Haywood, Henderson*, Jackson*, Mitchell, Transylvania, Wilkes, Yancey*)	Marsh Bellflower	SR	-	S2	G5
Campanula rotundifolia (not in RAB) M: high elevation rocky summits (Ashe*)	Bluebells	C	-	S1	G5
Cardamine clematitis (not including *C. flagellifera*) M: high elevation seeps, shaded outcrops, and streambanks (Avery*, Caldwell*, Graham*, Jackson*, Mitchell*, Swain, Watauga, Yancey)	Mountain Bittercress	C	C2	S2?	G2
Cardamine dissecta (= *Cardamine angustata* var. *multifida*) PM: rich woods, cove forests, bottomlands (Anson*, Guilford, Mecklenburg, Montgomery, Randolph*, Rowan, Rutherford?)	Dissected Toothwort	C	-	S1	G3G4

Scientific Name / Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Cardamine douglassii P: bottomlands, rich lower slopes (Durham*, Granville*, Harnett*, Lee*, Northampton*, Orange, Wake*)	Douglass's Bittercress	SR	-	S2	G5
Cardamine longii (not in RAB) C: tidal marshes and tidal cypress-gum forests (Jones, Pender)	Long's Bittercress	SR	3C	S1	G3G4Q
Cardamine micranthera P: seeps, streamside sandbars, and floodplain depressions (Forsyth, Stokes*)	Small-Anthered Bittercress	E	E	S1	G1
Cardamine rotundifolia MP: seeps, banks of mountain brooks (Ashe, Mitchell, Stokes*, Watauga)	Mountain Watercress	C	-	S1	G4
Carduus (see *Cirsium*)					
Carex aenea M: grassy balds (Avery*, Mitchell*)	Bronze Sedge	E	-	S1	G5
Carex argyrantha M: wet meadows (Ashe)	Hay Sedge	SR	-	S1	G5
Carex barrattii MS: bogs, open wet areas (Harnett, Henderson)	Barrett's Sedge	E	3C	SH	G4
Carex biltmoreana M: granitic domes and other cliffs and outcrops (Buncombe*, Haywood*, Jackson*, Macon*, Polk*, Rutherford*, Transylvania*)	Biltmore Sedge	SR	3C	S3	G3
Carex bushii PM: open wet areas (Ashe, Durham, Granville, Johnston, Nash, Orange, Rowan)	Bush's Sedge	SR	-	S1	G4
Carex buxbaumii MP: bogs and fens (Alleghany*, Ashe*, Forsyth, Henderson*, Watauga*, Yancey*)	Brown Bog Sedge	C	-	S1	G5
Carex canescens ssp. *disjuncta* CS: open wet areas (Hertford*, Scotland*, Tyrrell*)	Silvery Sedge	C	-	S1	G5T4?
Carex careyana (not in RAB) M: rich cove forests (Jackson*)	Carey's Sedge	C	-	S1	G5
Carex chapmanii C: moist bottomlands and slopes, perhaps associated with marl (Bladen, Brunswick, Carteret*, Columbus*, Craven*, Gates*, Jones*, New Hanover, Pender*)	Chapman's Sedge	C	C2	S2	G2G3
Carex cherokeensis MP: floodplains (Cherokee, Polk)	Cherokee Sedge	SR	-	SH	G4G5
Carex conoidea M: bogs (Ashe*, Iredell)	Cone-shaped Sedge	T	-	S1	G4
Carex cristatella M: grassy balds, bogs (Jackson, Swain)	Small Crested Sedge	SR	-	SH	G5
Carex crus-corvi C: swamp forests (Columbus, Edgecombe, Martin, Pitt)	Crowfoot Sedge	SR	-	S1	G5
Carex decomposita C: blackwater swamp forests (New Hanover, Warren)	Cypress Knee Sedge	SR	3C	SH	G3G4
Carex deflexa (not in RAB) M: high elevation seepy forests (Haywood?, Jackson?)	A Sedge	C	-	S1	G5
Carex eburnea M: calcareous outcrops (Madison)	Bristle-leaf Sedge	SR	-	S1	G5
Carex exilis S: seepage bogs (Cumberland*, Harnett*, Hoke*, Moore)	Coastal Sedge	T	-	S1	G5
Carex hitchcockiana (not in RAB) M: moist to dryish forests over calcareous or mafic rocks (Jackson*)	Hitchcock's Sedge	C	-	S1	G5
Carex hormathodes (not in RAB) C: marshes (Currituck*)	A Sedge	SR	-	S1	G4G5
Carex impressinervia (not in RAB) P: wet forests (Montgomery)	Ravine Sedge	C	C2	S1	G2?

Scientific Name / Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Corydalis micrantha ssp. *micrantha* (not in RAB) PM: thin, circumneutral soils on rock outcrops or cliffs (Alexander*, Jackson, Madison, Swain)	Slender Corydalis	C	-	S1	G5T4
Crinum americanum (not in RAB) C: tidal swamp forests, tidal marshes (New Hanover)	Swamp-lily	C	-	S1	G5
Croton monanthogynus M: calcareous rock outcrops (Madison)	Prairie-tea Croton	SR	-	S1	G5
Cyperus dentatus C: marshes (Brunswick, Currituck, Dare)	Toothed Flatsedge	C	-	S1?	G4
Cyperus granitophilus (not in RAB) P: granite flatrocks, other rock outcrops (Alexander, Forsyth, Franklin*, Wake*, Yadkin)	Granite Flatsedge	SR	3C	S1	G3Q
Cyperus houghtonii P: dry soil (Iredell)	Houghton's Flatsedge	C	-	SH	G4
Cyperus lecontei C: limesink ponds (Brunswick, New Hanover, Onslow*)	Leconte's Flatsedge	SR	-	S1	G4?
Cyperus tetragonus C: maritime forests and barrier island grasslands (Brunswick*, Carteret, Dare*, New Hanover, Onslow)	Four-angled Flatsedge	SR	-	S2	G4?
Cypripedium reginae M: habitat not known (Jackson, Macon)	Showy Ladyslipper	C	-	SH	G4
Cystopteris tennesseensis CM: calcareous rock outcrops (Craven*, Graham, Jones*, Onslow*)	Tennessee Bladder-fern	E-SC	-	S1	G5
Cystopteris tenuis (not in RAB) M: high elevation rocky summits, cliffs (Mitchell*)	Upland Bladder-fern	SR	-	S1	G4G5
Dalibarda repens M: bogs and moist woods under rhododendrons (Alleghany*, Ashe*, Transylvania*)	Robin Runaway	E	-	S1	G5
Danthonia epilis (not in RAB) S: seepage bogs (Cumberland*, Harnett*, Montgomery?, Scotland*)	Bog Oatgrass	C	-	S1	G3?
Delphinium exaltatum MP: grassy balds, glades, woodlands, mostly over mafic rock (Alleghany, Durham*, Granville*, Haywood, Iredell, Jackson*, McDowell, Mecklenburg, Mitchell, Watauga*)	Tall Larkspur	E-SC	C2	S1	G3
Deschampsia cespitosa ssp. *glauca* (= *D. caespitosa* var. *g.*) M: olivine barrens, high elevation outcrops of mafic rock (Clay)	Tufted Hairgrass	C	-	S1	G5T5
Desmodium ochroleucum P: sandy or rocky woodland openings (Davie, Durham*, Orange, Wake)	Creamy Tick-trefoil	C	-	S1?	G2G3
Desmodium sessilifolium P: open woodlands (Cabarrus, Mecklenburg)	Sessile Tick-trefoil	C	-	SH	G3G4
Dicentra eximia MP: rock outcrops (Buncombe*, Burke*, Haywood*, Macon*, Madison*, Orange*, Rutherford*, Swain*, Watauga, Yancey*)	Bleeding Heart	SR	-	S2	G4
Dichanthelium erectifolium (= *Panicum erectifolium*) C: savannas (Brunswick*, New Hanover, Onslow*, Sampson*, Scotland*)	Erectleaf Witch Grass	SR	-	S2	G4
Dichanthelium sp. 1 (= *Panicum hirsti*; not in RAB) C: cypress savannas (Onslow*)	Hirsts' Panic Grass	C	C2	S1	G1
Didiplis diandra (= *Peplis diandra*) CS: sluggish streams and ponds (Chowan, Edgecombe, Harnett, Hertford, Moore, Nash, Perquimans, Wake, Warren)	Water Purslane	SR	-	S1	G5
Diervilla rivularis (= *D. sessilifolia* var. *rivularis*) M: forests (Yancey)	Riverbank Bush-honeysuckle	C	-	SH	G3

Scientific Name / Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Dionaea muscipula CS: savannas, seepage bogs, pocosin edges (Beaufort*, Bladen*, Brunswick*, Carteret*, Columbus*, Craven, Cumberland*, Duplin, Hoke*, Jones, Lenoir, Moore, New Hanover*, Onslow*, Pamlico, Pender*, Robeson, Sampson*)	Venus Flytrap, Meadow Clams	C-SC	3C/PC2	S3	G3
Disporum maculatum M: drier cove forests and northern hardwoods forests, ridgesides (Buncombe*, Clay*, Haywood*, Jackson*, Macon*, Madison*, Yancey)	Nodding Mandarin	C	-	S2	G3G4
Dodecatheon meadia var. *meadia* PM: rich, rocky woods, over mafic or calcareous rocks (Anson, Buncombe*, Davidson, Granville, Haywood*, Iredell, Jackson*, Macon*, Mecklenburg*, Orange, Rutherford*, Stanly, Watauga)	Eastern Shooting Star	SR	-	S2	G5T5
Draba ramosissima MP: calcareous and mafic rock outcrops (Buncombe*, Haywood*, Madison*)	Branching Draba	SR	-	S2	G4
Draba reptans P: habitat not known (Lincoln)	Creeping Draba	C	-	SH	G5
Drosera filiformis C: clay-based Carolina bays, wet savannas, ditches (Bladen, Brunswick, Columbus*, Duplin, Sampson*)	Threadleaf Sundew	SR	-	S1	G5
Dryopteris goldiana MCP: rich, moist woods (Ashe, Buncombe*, Burke*, Haywood*, Jackson*, Macon*, Mitchell, Orange)	Goldie's Woodfern	SR	-	S2	G4
Echinacea laevigata P: glades, woodlands, and open areas over mafic rocks (Durham*, Granville*, Mecklenburg, Montgomery, Orange, Rockingham*)	Smooth Coneflower	E-SC	E	S1	G3
Echinacea purpurea M: open woods and clearings (Burke, Jackson, Madison*, Polk, Rutherford) (native occurrences only)	Purple Coneflower	SR	-	S1	G4G5
Echinodorus parvulus (not in RAB) C: drawdown zones of clay-based Carolina bays and blackwater rivers (Brunswick*, Robeson*)	Dwarf Burhead, Mudbabies	C	-	S1	G2
Eleocharis cellulosa C: interdune ponds, brackish marshes (Carteret*, Dare, Hyde*, Onslow)	Gulfcoast Spikerush	SR	-	S1	G4G5
Eleocharis elongata (not in RAB) C: limesink ponds (Brunswick*, Onslow*)	Florida Spikerush	C	-	S1	G5?
Eleocharis equisetoides (see Watch List)					
Eleocharis halophila C: brackish and freshwater marshes (Dare*, Hyde)	Saltmarsh Spikerush	T	-	S1	G4
Eleocharis melanocarpa (see Watch List)					
Eleocharis montevidensis C: maritime wet grassland (Currituck, Onslow*)	Sand Spikerush	SR	-	S1	G5
Eleocharis robbinsii C: limesink ponds, clay-based Carolina bays, peat-burn lakes, millponds, beaver ponds, artificial lakes (Bladen, Brunswick*, Carteret*, Craven, Cumberland*, Harnett*, Hoke*, Moore*, New Hanover, Onslow*, Sampson*, Scotland*)	Robbins's Spikerush	C	-	S2	G4G5
Eleocharis rostellata C: brackish marshes, limesink ponds? (Beaufort, Brunswick, Camden*, Carteret, Currituck*, Dare*, Hyde*)	Beaked Spikerush	SR	-	S2	G5
Elymus trachycaulus ssp. *trachycaulus* (= *Agropyron t.*) M: olivine barrens (Clay*)	Slender Wheatgrass	C	-	S1	G5T5

Scientific Name Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Isoetes piedmontana (not in RAB) P: granite flatrocks and diabase glades (Franklin*, Granville*, Rowan*, Wake)	Piedmont Quillwort	T	-	S1	G4
Isoetes riparia C: tidal freshwater marshes and swamp forests (Craven, Currituck, Pender, Pitt, Tyrrell)	Riverbank Quillwort	SR	-	S1	G4
Isoetes virginica (not in RAB) P: upland depression swamp forests, clayey soils (Caswell, Chatham, Mecklenburg, Rowan, Union)	Virginia Quillwort	C	C2	S1	G1G2Q
Isopyrum (see *Enemion*)					
Isotria medeoloides MPS: forests, especially with white pine (Burke*, Cumberland, Harnett, Haywood*, Henderson*, Jackson*, Macon*, Orange?, Surry)	Small Whorled Pogonia	E	E	S1	G3
Iva microcephala (not in NC in RAB) C: clay-based Carolina bays (Robeson*, Scotland*)	Small-Headed Marsh Elder	C	-	S1	G5
Jeffersonia diphylla M: rich cove forests, especially over calcareous rocks (Jackson*)	Twin Leaf	SR	-	S1	G5
Juglans cinerea (see Watch List)					
Juncus caesariensis (not in RAB) M: seepage bog (Clay*)	Rough Rush	C	C2	S1	G2
Juncus pymnocarpus (see Watch List)					
Juncus trifidus (= *J. t.* var. *monanthos*) M: high elevation rocky summits (Ashe*, Buncombe*, Mitchell*)	Highland Rush	E	C2	S1	G5
Juniperus communis var. *depressa* MP: high elevation granitic domes, low elevation rocky summits (Buncombe, Gaston*, Macon*)	Dwarf Juniper	C	-	S1	G5T5
Kalmia cuneata CS: pocosins (Bladen*, Cumberland*, Hoke*, Moore*, Pender*, Richmond*, Scotland*)	White Wicky	E-SC	C2	S2	G3
Lachnocaulon beyrichianum C: sandhills, sandhill/pocosin ecotones (Bladen, Brunswick*, Carteret*, New Hanover*, Pender)	Southern Bogbutton	C	3C	S1	G2G3
Lechea maritima var. *virginica* (not in RAB) C: barren dunefields with *Hudsonia tomentosa* (Dare*)	Maritime Pinweed	SR	-	S1	G5T4
Lechea torreyi CS: sandhills, savannas (Brunswick*, Moore, Pender)	Torrey's Pinweed	C	-	S1	G4G5
Leptochloa fascicularis var. *maritima* (not in RAB) C: fresh to brackish tidal marshes (Currituck*, Dare, Hyde*, New Hanover)	Long-awned Sprangletop	SR	-	S1	G5T3
Liatris aspera M: glades, open woods, fens (Ashe*, Burke, Cleveland?, Henderson, Jackson, Macon, McDowell, Polk, Transylvania)	Rough Blazing Star	SR	-	S1	G4G5
Liatris helleri M: high elevation rocky summits, cliffs (Ashe*, Avery*, Burke*, Caldwell*, Mitchell, Watauga*)	Heller's Blazing Star	T-SC	T	S1	G1
Liatris microcephala M: rock outcrops, glades, dry woodlands (mostly over mafic rocks?) (Macon, Polk, Rutherford*)	Small-head Blazing-star	C	-	S1	G3G4
Liatris squarrulosa (= *Liatris earlei*) PSM: diabase glades, open woods especially over mafic rocks; also sandhills (Cumberland, Durham*, Granville*, Harnett, Orange, Richmond, Stokes, Swain)	Earle's Blazing Star	SR	-	S2	G4G5
Liatris turgida M: dry rocky woods (Buncombe, Burke, Macon*, Polk, Rutherford?)	Shale-barren Blazing Star	SR	-	S1?	G3

Scientific Name Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Liparis caroliniana C: freshwater marshes, pools, tidal marshes (Brunswick*, Camden*, Currituck*, Dare*, New Hanover*, Pasquotank*, Perquimans*, Washington*)	Carolina Grasswort	T	3C	S3	G3
Lilium canadense ssp. *canadense* M: bogs, wet meadows (Watauga)	Yellow Canada Lily	C	-	SH	G5T4?
Lilium canadense ssp. *editorum* (not in RAB) MP: bogs, wet meadows (Alleghany, Avery, Henderson, Rutherford, Stanly, Watauga)	Red Canada Lily	C	-	SH	G5T4?
Lilium grayi M: bogs, wet meadows, seeps, grassy balds, high elevation forests (Alleghany*, Ashe*, Avery*, Buncombe*, Henderson?, McDowell*, Mitchell*, Watauga*, Yancey*)	Gray's Lily	T-SC	C2	S3	G3
Lilium philadelphicum var. *philadelphicum* M: grassy balds, glades (Alleghany, Ashe*, Avery, Haywood, Mitchell, Polk, Swain, Watauga*, Yancey*)	Wood Lily	C	-	S1	G5
Lilium sp. 2 (not in RAB; possibly = *L. iridollae*) S: peaty seepage bogs (Cumberland*, Harnett*, Hoke*, Moore*)	Sandhills Bog Lily	C	-	S1	GU
Limosella australis (= *L. subulata*) C: tidal marshes (Currituck*)	Awl-leaf Mudwort	C	-	S1	G4G5
Lindera melissifolia (= *L. melissaefolia*) C: Carolina bays, upland depressions, and other wet areas (Bladen*, Cumberland*, Sampson*)	Southern Spicebush	E	E	S1	G2
Lindera subcoriacea (not in RAB) SP: streamhead pocosins, white cedar swamps, bogs (Anson*, Cumberland*, Hoke*, Lee*, Montgomery*, Moore*, Robeson*, Scotland*)	Bog Spicebush	E	C2	S2	G2
Linum floridanum var. *chrysocarpum* (not in RAB) C: pine savannas (Brunswick, Pender*)	Yellow-fruited Flax	SR	-	S1	G5T3?
Linum sulcatum var. *sulcatum* P: diabase glades (Granville)	Glade Flax	C	-	SH	G5T5
Liparis loeselii MC: seeps, bay swamps (Ashe, Avery, Dare*, Jackson, Rutherford, Swain*, Watauga)	Fen Orchid	C	-	S1	G5
Lipocarpha micrantha (= *Hemicarpha micrantha*) C: drawdown zones of blackwater rivers, salt marshes (Columbus*, Dare)	Small-flowered Hemicarpha	SR	-	S1	G4
Listera australis (see Watch List)					
Listera cordata M: habitat not known (Avery)	Heart-leaved Twayblade	C	-	SH	G5
Lithospermum canescens P: diabase glades, open woods over diabase (Durham*, Granville*)	Hoary Puccoon	SR	-	S1	G5
Litsea aestivalis C: limesink ponds, other pools (Bladen*, Brunswick*, Carteret*, Cumberland*, Gates*, New Hanover, Onslow*, Sampson*, Wayne*)	Pondspice	C	C2	S2	G4G5
Lobelia boykinii (not in NC in RAB) C: clay-based Carolina bays, wet pine savannas (Bladen, Cumberland*, Hoke*, Onslow*, Scotland*)	Boykin's Lobelia	C	C2	S1	G2
Lonicera canadensis M: bogs, moist woods (Jackson*, Macon*, Mitchell, Swain, Watauga*, Yancey)	American Fly-honeysuckle	SR	-	S1	G5
Lonicera flava MP: thin soils around rock outcrops, mainly mafic (Buncombe*, Burke*, Henderson*, Jackson*, McDowell*, Polk*, Rutherford*)	Yellow Honeysuckle	SR	-	S1	G5?
Lophiola aurea (= *Lophiola americana*) C: very wet, mucky habitats in pine savannas (Brunswick*, Columbus, New Hanover*)	Golden Crest	E	-	S1	G4

Scientific Name / Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Panax quinquefolius (see Watch List)					
Panax trifolius (= *P. trifolium*) MP: cove forests, northern hardwoods, other rich forests (Ashe*, Caldwell, Caswell, Cherokee*, Clay*, Durham, Graham*, Haywood*, Jackson, Macon, Orange, Swain, Wake*, Watauga)	Dwarf Ginseng	SR	-	S2	G5
Panicum flexile PM: glades and openings over mafic rocks (Ashe, Durham, Granville*, Orange)	Wiry Panic Grass	SR	-	S1	G3G5
Panicum lithophilum (not in RAB) MP: soil islands on granite domes (Alexander?, Transylvania)	Flatrock Panic Grass	C	-	S1	G2?Q
Panicum tenerum CS: wet savannas, sandhill seeps, limesink ponds (Brunswick*, Carteret*, Columbus, Cumberland*, Moore, New Hanover*, Onslow*, Sampson*, Scotland*)	Southeastern Panic Grass	SR	-	S2	G4
Panicum (also see *Dichanthelium*)					
Parnassia caroliniana CS: wet savannas (Bladen*, Brunswick*, Columbus*, Cumberland*, Harnett*, Hoke*, Lee, Onslow*, Pender*)	Carolina Grass-of-Parnassus	E	C2	S2	G2
Parnassia grandifolia MCP: fens and seeps over calcareous or mafic rocks (Alleghany?, Ashe*, Avery, Brunswick*, Buncombe, Clay*, Columbus, Haywood*, McDowell*, Transylvania*)	Large-lvd. Grass-of-Parnassus	C	-	S1	G2G3
Parthenium auriculatum (= *P. integrifolium* var. *a.*) PM: glades and openings over mafic rocks (Burke*, Durham*, Franklin*, Granville*, Guilford, Macon, Mecklenburg, Orange, Person, Rockingham, Union*, Warren)	Glade Wild Quinine	C	-	S1	G3?
Parthenium integrifolium var. *mabryanum* (see Watch List)					
Parthenium radfordii (see Watch List)					
Paspalum bifidum (see Watch List)					
Pedicularis lanceolata M: bottomlands, swampy woods (Buncombe, Cherokee, Clay, Haywood*, Jackson, Macon)	Swamp Lousewort	C	-	S1	G5
Pellaea wrightiana P: rock outcrops, mafic or with nutrient-rich seepage (Alexander*, Stanly*)	Wright's Cliff-brake	E-SC	-	S1	G5
Peltandra sagittifolia (= *P. sagittaefolia*) C: pocosins, other wet, peaty sites (Brunswick*, Carteret, Columbus, Craven, Dare, Jones, New Hanover*, Onslow*, Pender*)	Spoonflower	SR	-	S2	G3G4
Peplis (see *Didiplis*)					
Phacelia ranunculacea PC: bottomlands, rich lower slopes (Alamance*, Chatham*, Harnett*, Lee*, Moore*, Vance*)	Buttercup Phacelia	C	-	S2	G4
Phaseolus sinuatus SC: sandhills (Cumberland*, Harnett*, Hoke*, Moore*, Richmond*, Scotland*)	Sandhills Bean	C	-	S2	G2G3
Phegopteris connectilis (= *Thelypteris phegopteris*) M: spray zone of waterfalls, spruce-fir forests, high elevation seepage bogs (Haywood*, Jackson*, Macon*, Swain, Transylvania)	Northern Beech Fern	C	-	S1	G5
Phlox subulata M: outcrops and glades, especially over mafic rocks (Ashe*, Buncombe*, Jackson, Madison, Yancey)	Moss Pink	SR	-	S1	G5
Physalis lanceolata SC: sandhills (Cumberland, Harnett, Hoke*, Lee, Montgomery, Moore*, New Hanover, Richmond*, Robeson, Sampson, Scotland, Wayne)	Sandhill Ground Cherry	C	PC2	S2?	G3?
Pinguicula pumila C: savannas (Brunswick*, Carteret*, New Hanover, Pender*)	Small Butterwort	SR	-	S2	G4

Scientific Name / Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Plantago cordata P: beds of small, slate-bottomed, perennial streams (Davidson*)	Heart-leaf Plantain	E	3C	S1	G3
Plantago sparsiflora C: wet savannas (Bladen, Brunswick*, Columbus*, Pender*)	Pineland Plantain	E	C2	S1	G2
Platanthera flava var. *herbiola* (not in RAB) M: bogs and moist forests (Buncombe, Clay, Forsyth?, Graham, Haywood*, Jackson, Macon, Yancey)	Northern Green Orchid	SR	3C	S2?	G4T4
Platanthera grandiflora (= *Habenaria psycodes* var. *g.*) M: bogs, seeps, grassy balds, high elevation moist forests and banks (Avery*, Buncombe, Clay, Haywood*, McDowell, Watauga, Yancey)	Large Purple-fringed Orchid	SR	-	S2	G5
Platanthera integra (= *Habenaria integra*) CMP: savannas (Brunswick*, Carteret*, Cherokee?, Columbus*, Craven, Forsyth?, Henderson?, Onslow, Pamlico, Pender, Robeson, Rowan?)	Yellow Fringeless Orchid	T	3C	S1	G5
Platanthera integrilabia (= *Habenaria bleph.* var. *l.*) M: bogs (Cherokee, Henderson)	White Fringeless Orchid	E	C2	SX	G2
Platanthera nivea (= *Habenaria nivea*) C: wet savannas (Beaufort, Bladen, Brunswick*, Columbus, Craven*, Dare, Hoke, New Hanover*, Pender*, Robeson)	Snowy Orchid	T	-	S1	G5
Platanthera peramoena (= *Habenaria peramoena*) MP: bogs, forests (Buncombe, Burke, Caldwell, Clay, Durham*, Forsyth, Guilford*, Haywood, Henderson, Jackson*, Macon, Mitchell, Orange*, Swain, Transylvania*, Warren, Watauga, Yancey)	Purple Fringeless Orchid	C	3C	S1	G5
Poa paludigena (not in RAB) M: bogs (Avery*)	Bog Bluegrass	E	C2	S1	G2
Poa palustris M: spruce-fir forests, grassy balds (Avery, Haywood, Henderson, Macon, Mitchell, Polk, Swain, Watauga, Yancey)	Swamp Bluegrass	SR	-	S1	G5
Poa saltuensis (= *Poa languida*) M: olivine barrens (Clay*)	A Bluegrass	C	-	S1	G5?
Polygala grandiflora SC: sandhills (Richmond*, Robeson, Scotland*)	Showy Milkwort	SR	-	S1	G5?
Polygala hookeri C: savannas (Bladen, Brunswick*, Carteret*, Columbus, Craven, New Hanover, Onslow, Pender*, Sampson)	Hooker's Milkwort	C	-	S2	G3
Polygonella articulata C: sandhills (Gates)	Coast Jointweed	C	-	SH	G5
Polygonum glaucum C: ocean and sound beaches (Beaufort, Brunswick*, Carteret*, Dare, Hyde, New Hanover, Onslow)	Seabeach Buckwheat	C	-	S1	G3
Polygonum hirsutum CS: limesink ponds, clay-based Carolina bays, drawdown zones of blackwater riverbanks (Brunswick*, Carteret, Onslow, Richmond*, Scotland*)	Hairy Smartweed	SR	-	S1	G4G5
Ponthieva racemosa C: blackwater forests and swamps, especially over marl (Beaufort, Brunswick, Craven, Jones*, Onslow*, Pender*)	Shadow-witch	SR	-	S2	G4G5
Porteranthus stipulatus (= *Gillenia stipulata*) P: forests and open woods, mainly over mafic rocks (Cabarrus, Chatham, Davidson, Durham, Granville*, Lee, Montgomery, Moore, Orange, Person*, Union, Wake*)	Indian Physic	SR	-	S2	G5
Portulaca smallii P: granite flatrocks and diabase glades (Cabarrus*, Forsyth, Franklin*, Granville*, Rowan*, Wake*)	Small's Portulaca	T	3C	S2	G3
Potamogeton confervoides SC: beaverponds and old millponds on blackwater creeks (Cumberland*, Gates, Moore, Richmond, Scotland)	Conferva Pondweed	C	C2	S1	G5

Scientific Name / Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Prenanthes roanensis					
M: grassy balds, high elevation forests and outcrops (Alleghany*, Ashe*, Avery*, Buncombe*, Graham*, Haywood*, Jackson*, McDowell, Mitchell*, Surry, Swain, Transylvania*, Yancey*)	Roan Rattlesnakeroot	SR	3C	S3	G3
Prunus pumila var. *susquehanae*					
MP: rocky forests (Durham, Henderson)	Susquehanna Cherry	C	-	SH	G5T4
Psilocarya (see *Rhynchospora*)					
Psilotum nudum (not in NC in RAB)					
C: acid swamp (Chowan*)	Whiskfern	C	-	S1	G5
Psoralea (see *Orbexilum*, *Pediomelum*)					
Pteroglossaspis ecristata (= *Eulophia ecristata*)					
C: pinelands (Bladen, Cumberland, Hoke*, New Hanover)	Spiked Meduse	E	C2	S1	G3G4
Ptilimnium costatum					
C: tidal swamps or marshes (New Hanover*)	Ribbed Bishopweed	C	-	S1	G3G4
Ptilimnium nodosum (including *Ptilimnium fluviatile*)					
P: rocky riverbeds (Chatham*, Granville*, Lee)	Harperella	E	E	S1	G2
Ptilimnium sp. 1 (not in RAB)					
C: tidal freshwater marshes (Brunswick*, New Hanover*, Pender)	Carolina Bishopweed	C	-	S1	G2
Pycnanthemum torreyi (not in RAB)					
PM: dry upland forests and woodlands, over mafic rocks (Alexander, Ashe, Granville, Orange, Wilkes)	Torrey's Mountain-mint	C	-	S1	G2
Pyrola elliptica (not in RAB)					
M: moist forests (Ashe)	A Shinleaf	C	-	SH	G5
Pyxidanthera barbulata var. *brevifolia*					
S: sandhills (Cumberland*, Harnett*, Hoke*, Moore*)	Sandhills Pyxie-moss	E	3B/PC2	S2	G4T2
Quercus austrina					
CP: bluff and bottomland forests (Bladen, Harnett, Johnston, Montgomery*, Sampson, Union, Wayne)	Bluff Oak	SR	-	S1	G5
Quercus ilicifolia					
P: dry summits and rocky woods on Piedmont monadnocks (Burke*, Gaston*, Stokes*, Surry*)	Bear Oak	SR	-	S1	G5
Quercus prinoides					
PM: dry, rocky slopes (Buncombe, Caldwell, Cleveland, Gaston, Guilford, Iredell, Jackson, Person, Polk, Rutherford, Stanly)	Dwarf Chinquapin Oak	C	-	SH	G5
Ranunculus ambigens					
CP: open wet areas (Bertie, Orange, Perquimans)	Water-plantain Spearwort	C	-	SH	G4G5
Ranunculus flabellaris					
C: pools in blackwater swamps (Edgecombe, Gates*)	Yellow Water-crowfoot	C	-	S1	G5
Ranunculus hederaceus					
C: marshes (Currituck)	Ivy Buttercup	C	-	SH	G5
Ranunculus micranthus					
P: rich woods (Durham, Forsyth)	Rock Buttercup	SR	-	SH	G5?
Rhexia aristosa					
C: clay-based Carolina bays and limesink ponds (Bladen, Brunswick, Cumberland, Hoke*, Onslow*, Robeson*, Scotland*)	Awned Meadow-beauty	T	C2	S3	G3
Rhexia cubensis					
C: limesink ponds (Brunswick*, Carteret*, New Hanover*, Onslow*)	West Indies Meadow-beauty	SR	-	S1	G5
Rhododendron cumberlandense (not in RAB)					
M: grassy or shrub balds (Graham, Macon*, Transylvania)	Cumberland Azalea	SR	3C	S1	G2Q
Rhododendron prinophyllum (= *Rhododendron roseum*)					
M: high elevation forests (Ashe*)	Early Azalea, Election Pink	SR	-	S1	G5
Rhododendron vaseyi					
M: wet swampy places, high elevation rocky areas, openings, or forests (Avery*, Caldwell*, Haywood*, Jackson*, Macon*, McDowell, Mitchell, Transylvania*, Watauga*, Yancey)	Pink-shell Azalea	SR	3C	S3	G3

Scientific Name / Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Rhus michauxii					
SCP: sandhills, sandy forests, woodland, woodland edges (Davie*, Durham, Franklin*, Hoke*, Johnston, Lee*, Lincoln, Moore*, Orange, Richmond*, Robeson*, Scotland*, Union, Wake*, Wilson)	Michaux's Sumac	E-SC	E	S2	G2
Rhynchospora alba					
MCS: fens, bogs, pocosin openings, limesink ponds (Alleghany*, Ashe*, Brunswick*, Craven?, Cumberland?, Dare?, Mitchell*, Pender?, Tyrrell?, Watauga*)	Northern White Beaksedge	C	-	S2	G5
Rhynchospora brevisete					
S: savannas (Brunswick, Carteret*, Columbus*, Craven, Onslow*, Pender*)	Shortbristled Beaksedge	C	-	S1	G3G4
Rhynchospora crinipes (not in RAB)					
S: seepy banks of blackwater rivers (Hoke*, Moore*)	Alabama Beaksedge	C	C2	S1	G1
Rhynchospora decurrens					
C: swamp forests (Columbus)	Swamp Forest Beaksedge	C	C2*	SH	GH
Rhynchospora divergens (not in NC in RAB)					
C: wet savannas (Columbus*, Brunswick*)	Whiteseeded Beaksedge	SR	-	S1	G4
Rhynchospora globularis var. *pinetorum* (not in RAB)					
C: wet savannas (Brunswick*, Columbus*, Pender*)	Small's Beaksedge	SR	-	S1	G5T3?
Rhynchospora harperi (not in RAB)					
C: limesink ponds and cypress savannas (Carteret*, Onslow*)	Harper's Beaksedge	C	-	S1	G3
Rhynchospora macra (not in RAB)					
S: seepage bogs (Cumberland*, Harnett*, Hoke*, Moore*)	Southern White Beaksedge	E	-	S1	G3G4
Rhynchospora odorata					
C: maritime wet grasslands (Brunswick, Carteret*, Hyde*, Pender)	Fragrant Beaksedge	SR	-	S1	G4
Rhynchospora oligantha					
CSP: savannas, seepage bogs (Brunswick*, Carteret*, Columbus*, Cumberland*, Harnett*, Hoke*, Moore*, Onslow*, Pender*)	Feather-bristle Beaksedge	C	-	S2	G4
Rhynchospora pallida (see Watch List)					
Rhynchospora plesiantha					
C: limesink ponds (Brunswick*, Carteret*, New Hanover*, Onslow*)	Coastal Beaksedge	C	-	S1	G3
Rhynchospora scirpoides (= *Psilocarya scirpoides*)					
C: beaver ponds, limesink ponds, wet savannas (Brunswick*, Carteret*, Columbus, Harnett, Hoke*, Moore*, New Hanover*, Onslow*, Richmond*, Scotland*, Tyrrell)	Long-beak Baldsedge	SR	-	S2	G4
Rhynchospora stenophylla (see Watch List)					
Rhynchospora thornei (not in RAB)					
C: wet savannas (Onslow*, Pender*)	Thorne's Beaksedge	C	PC2	S1	G1
Rhynchospora tracyi					
C: clay-based Carolina bays, limesink ponds (Brunswick*, New Hanover*, Onslow*, Scotland*)	Tracy's Beaksedge	SR	-	S2	G4
Robinia hispida var. *fertilis* (not in RAB)					
M: acidic cove forests, northern hardwoods forests, high elevation granitic domes (Alleghany, Avery, Burke, Graham, Macon, McDowell)	Fruitful Locust	C	-	S1	G5T2
Robinia hispida var. *kelseyi* (= *Robinia kelseyi*)					
M: high elevation red oak forests, dry rocky woods (Buncombe, Burke, Haywood, Henderson, Madison, Polk, Rutherford, Transylvania)	Kelsey's Locust	C	-	S1	G5TUQ
Robinia viscosa var. *hartwegii* (= *Robinia hartwigii*)					
M: high elevation granitic domes (Jackson*, Macon*)	Hartweg's Locust	C	PC2	S1?	G3T1
Rubus idaeus ssp. *strigosus* (= *R. i.* var. *canadensis*)					
M: high elevation spruce-fir forests and openings (Buncombe*, Haywood*, Jackson*, Swain*, Yancey*)	Red Raspberry	SR	-	S2?	G5T5
Rudbeckia heliopsidis					
C: moist pine flatwoods and woodland borders (Harnett*, Moore)	Sun-facing Coneflower	E	C2	S1	G2

Scientific Name Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Stellaria alsine M: seeps (Madison)	Longstalk Starwort	SR	-	S1	G5
Stellaria corei (see Watch List)					
Stenanthium robustum (not in RAB) M: bogs and wet meadows (Alleghany*, Ashe*, Avery*, Macon)	Bog Featherbells	SR	-	S1	G?
Streptopus amplexifolius M: spruce-fir forests, northern hardwoods forests (Buncombe*, Jackson*, Macon, Mitchell, Swain, Yancey)	White Mandarin	C	-	S1	G5
Stylisma aquatica (= *Bonamia aquatica*) C: clay-based Carolina bays, moist sandy pinelands (Brunswick, Scotland*)	Water Dawnflower	SR	-	S1	G3G4
Stylisma pickeringii var. *pickeringii* (= *Bonamia p.*) SC: sandhills (Cumberland*, Harnett*, Hoke*, Moore*, New Hanover, Richmond*, Scotland*)	Pickering's Dawnflower	E	C2	S2	G4?T2
Swertia (see *Frasera*)					
Synandra hispidula M: rich cove forests (Swain)	Synandra	C	3C	SH	G3
Syngonanthus flavidulus (see Watch List)					
Synosma suaveolens (= *Cacalia suaveolens*) M: bottomlands (Buncombe, Henderson, Transylvania)	Sweet Indian-plantain	C	PC2	SH	G3?
Taxus canadensis (not in RAB) M: bogs, swamp forests under spruce (Ashe*, Watauga*)	Canada Yew	SR	-	S1	G5
Thalictrum cooleyi C: wet savannas (Brunswick*, Columbus*, New Hanover, Onslow*, Pender*)	Cooley's Meadowrue	E	E	S1	G1
Thaspium pinnatifidum M: calcareous slopes (Haywood*, Jackson, Madison*, Swain)	Mountain Thaspium	C	-	S1	G3G4
Thelypteris simulata (not in RAB) M: bogs (Alleghany*, Avery*)	Bog Fern	T	-	S1	G5
Thelypteris (also see *Phegopteris*)					
Thermopsis fraxinifolia MP: dry ridges (Buncombe, Burke*, Caldwell, Henderson, Jackson, McDowell, Polk, Stokes, Surry, Transylvania*, Yancey)	Ash-leaved Golden-banner	C	-	S2?	G3?
Thermopsis mollis PM: dry ridges and open woodlands (Buncombe, Burke*, Catawba*, Chatham, Cleveland*, Durham, Forsyth, Franklin, Gaston, Granville*, Guilford, Henderson, Iredell, Lincoln, Rutherford*, Stokes, Surry, Transylvania, Wake, Warren*)	Appalachian Golden-banner	SR	-	S2?	G3G4
Tofieldia glabra CS: savannas, sandhill seeps, moist sandhill/pocosin ecotones (Beaufort, Bladen, Brunswick*, Carteret*, Columbus*, Craven, Cumberland*, Duplin, Harnett*, Hoke*, Johnston, Martin, Moore, New Hanover*, Onslow*, Pamlico, Pender*, Richmond*, Robeson, Sampson, Scotland*, Wilson)	Carolina Asphodel	C	C2	S3	G3
Tofieldia glutinosa (= *T. racemosa* var. *glutinosa*) MP: bogs, seepages (especially over mafic rocks) (Ashe*, Caldwell, Haywood*, Henderson, Jackson*, Transylvania*)	Sticky Bog Asphodel	C	-	S1	G5
Torreyochloa pallida (= *Glyceria pallida*) CM: blackwater pools, old millponds, and small stream swamps (Avery, Columbus, Currituck*, Duplin, Gates)	Pale Mannagrass	SR	-	S1	G5?
Tradescantia virginiana P: rich woods on circumneutral soils (Caswell, Harnett*, Montgomery*, Moore*, Orange, Rockingham, Stanly)	Virginia Spiderwort	SR	-	S1	G5
Trichomanes boschianum M: spray zone of waterfalls, seeps over rock (Jackson*, Macon*, Polk)	Appalachian Filmy-fern	T	-	S1	G4

Scientific Name Province: Habitat (Counties of Occurrence)	Common Name	Status NC	Status US	Rank NC	Rank Global
Trichomanes petersii M: moist rocks in humid gorges (Graham, Macon*, Transylvania*)	Dwarf Filmy-fern	T	-	S1	G3
Trichostema brachiatum (not in RAB, = *Isanthus brachiatus*) PM: diabase glades, other dry calcareous or mafic outcrops (Granville*, Madison, Orange, Rockingham*, Yancey)	Glade Bluecurls	C	-	S1	G4G5
Trichostema sp. 1 (not in RAB) C: dunes, openings in maritime forest and scrub (Brunswick*, Carteret*, Dare*, Hyde*, New Hanover*)	Dune Bluecurls	C	C2	S2	G2
Tridens ambiguus (not in NC in RAB) C: clay-based Carolina bays (Scotland*)	Pineland Triodia	SR	-	S1	G3G4
Tridens carolinianus S: sandhills and pine flatwoods (Brunswick, Cumberland*, Harnett*, Hoke*, Moore*, Richmond*, Scotland*)	Carolina Triodia	C	PC2	S2	G2G3
Tridens strictus C: pine flatwoods (Duplin, Hoke, Pender, Robeson)	Spike Triodia	C	-	SH	G5
Trientalis borealis (not in RAB) M: coves (Graham*, Haywood*)	Starflower	C	-	S1	G5
Trifolium carolinianum C: savannas, sandy open areas (Duplin, New Hanover, Onslow)	Carolina Clover	C	-	SH	G5
Trillium discolor M: rich coves in the Savannah River drainage (Jackson*, Transylvania*)	Mottled Trillium	T	-	S1	G3
Trillium flexipes (not in RAB) M: rich coves (Henderson, Swain)	Bent White Trillium	C	-	SH	G5
Trillium pusillum var. 1 (not in RAB) M: rich cove forests (Clay*, Haywood)	Alabama Least Trillium	E	C2	S1	G3T3
Trillium pusillum var. *pusillum* CP: ecotones between savannas and nonriverine wet hardwood forests, over marl (Halifax*, Johnston*, Nash*, Pender*, Wake)	Carolina Least Trillium	E	C2	S1	G3T1
Trillium pusillum var. *virginianum* (not in RAB) C: mesic to swampy hardwood forests (Camden*, Currituck*, Gates*)	Virginia Least Trillium	E	C2	S1	G3T2
Trillium recurvatum (not in RAB) M: rich coves (Madison*)	Prairie Trillium	C	-	S1	G5
Trillium sessile (not in RAB) C: rich alluvial levees and slopes (Halifax*, Northampton*)	Sessile-flowered Trillium	SR	-	S1	G4G5
Trillium simile (not in RAB) MP: rich coves (Burke*, Haywood*, Madison*, McDowell*, Polk*, Rutherford*, Swain)	Sweet White Trillium	SR	-	S1	G3
Trisetum spicatum M: grassy balds and/or high elevation rocky summits (Mitchell)	Soft Trisetum	E	-	SX	G5T4T5
Uniola (see *Chasmanthium*)					
Urtica chamaedryoides C: rich alluvial levees (Bertie*, Halifax*)	Dwarf Stinging Nettle	SR	-	S1	G4G5
Utricularia geminiscapa (not in RAB) SC: seepage areas on Suffolk Scarp, beaver ponds (Beaufort, Hoke*, Moore*)	Two-flowered Bladderwort	C	-	S1	G4G5
Utricularia minor (not in RAB) M: bogs (Watauga)	Small Bladderwort	C	-	SH	G5
Utricularia olivacea C: limesink ponds, beaver ponds (Brunswick*, Carteret*, Craven, Cumberland*, Hoke*, New Hanover*, Onslow*, Pender*)	Dwarf Bladderwort	T	-	S2	G4
Utricularia resupinata (not in RAB) C: natural lakes (blackwater) (Washington)	Northeastern Bladderwort	SR	-	S1	G4?
Vaccinium hirsutum M: ridgetop red oak forests (Cherokee*, Graham*, Swain)	Hairy Blueberry	C	-	S2	G3?

TO: Superfund Section Staff

FROM: Jeanette Stanley
Environmental Chemist
NC Superfund Section

DATE: June 20, 1994

SUBJECT: Endangered Species

I spoke with Steve Hall, Biologist, Natural Heritage, (919) 733-7701. We discussed the listing of the St. Francis' satyr butterfly on the endangered species list. The News & Observer article discussing this listing is attached.

He said that the Fort Bragg area is the only known area in North Carolina for this butterfly, also known as the Mitchell's satyr, or *Neonympha mitchellii francisci*. Mr Hall said that the only other US location of this species is on the Michigan/Indiana border.

The locations of this species in the Fort Bragg area are not shown on the maps provided to the public at Natural Heritage. While there is a critical habitat for this butterfly, it has not been officially declared a critical habitat. This is because doing so requires that habitats be marked on maps and released to the public. Poaching of endangered species has become such a problem that such measures were deemed necessary to protect the butterfly from extinction.

If NC Superfund personnel have Fort Bragg within their target distance limit, they should call Mr. Hall to discuss the location of this species. This is the only endangered species in North Carolina that has been protected by this secrecy.

MEMORANDUM

To: NC Superfund Section Staff

From: Stuart F. Parker, Jr., Stuart F. Parker
Hydrogeologist
NC Superfund Section

Date: April 14, 1994

Re: Update on Critical Habitats in NC.

SFP telephoned the Raleigh and Asheville offices of the US Fish and Wildlife Service on April 14, 1994, to determine whether any additions or deletions have occurred to the 4 critical habitats listed in NC since Pat DeRosa's inquiry on May 18, 1989.

Kate Looney (919-856-4520) and Nora Murdoch (714-665-1195), fish and wildlife biologists with the respective offices, reported that no changes had been made as of this date. The 4 species, Hudsonia montana (mountain golden heather), Hybopsis monacha (spotfin chub), Menidia extensa (waccamaw silverside), and Notropis mekistocholas (Cape Fear shiner), are listed at the same locations as in May 1989. See attached material for details.

May 18, 1989

TO: Superfund Branch Staff

FROM: Pat DeRosa PD

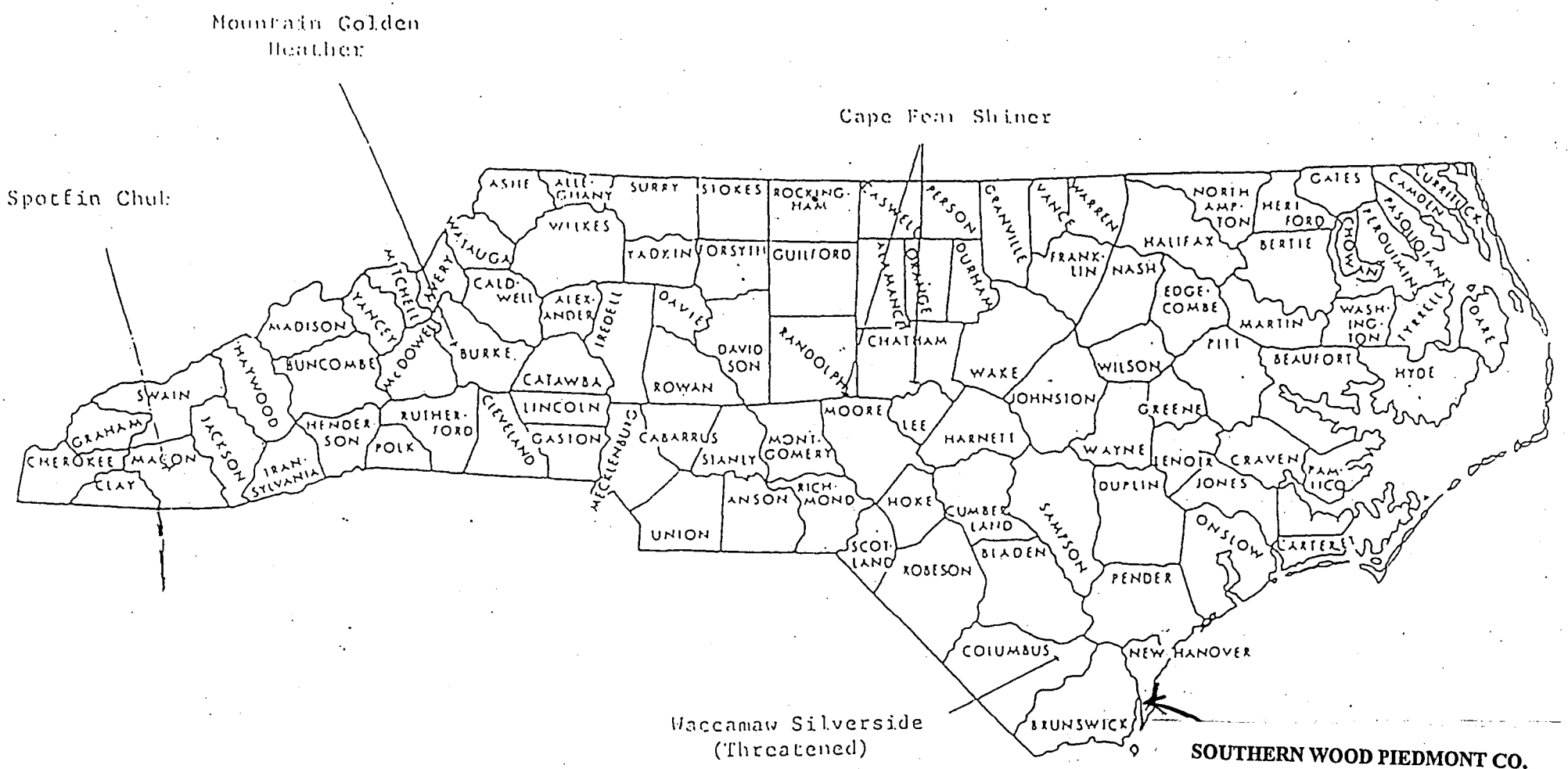
RE: Critical Habitats of Federally Listed Endangered Species in North Carolina

On May 18, 1989, I spoke by telephone with John Fridell, US Fish and Wildlife Service, Asheville, NC (704) 259-0321 to request an update on critical habitats in North Carolina. Mr. Fridell said the Fish and Wildlife Service has been reorganized into a western and eastern office in North Carolina. His office now handles only western North Carolina. He said there have been no changes in the designated critical habitats identified in western North Carolina.

I then spoke by telephone with Debby Mignogno, US Fish and Wildlife Service, Raleigh, NC (919) 856-4520 regarding critical habitats in eastern North Carolina. Ms. Mignogno sent the attached maps of the 2 critical habitats designated in eastern North Carolina. Please note that the Waccamaw Silverside is listed as threatened, not endangered.

PD/pb/critical.hab

ENDANGERED SPECIES IN NC



SOUTHERN WOOD PIEDMONT CO.
WILMINGTON, NC
NCD 058 517 467

1 inch = approx. 53 miles

RECEIVED
MAY 19 1989
6/88
SUPERFUND BRANCH

~~CAPE~~ FEAR SHINER

Notropis mekistocholas

Order: Cypriniformes

Family: Cyprinidae

Status: Endangered (Federal Register 9/25/87)

Range: The Cape Fear shiner is known from four small populations in the Cape Fear River drainage in Randolph, Moore, Lee, Harnett, and Chatham Counties, North Carolina.

The strongest population is located around the junction of the Rocky River and Deep River in Chatham and Lee Counties where the fish inhabits the Deep River from the upstream limits of the backwaters of Locksville Dam upstream to the Rocky River; then upstream from the Rocky River to Bear Creek, and upstream from Bear Creek to the Chatham County Road 2156 Bridge. A few individuals have been collected just downstream of the Locksville Dam, but because of the limited extent of Cape Fear shiner habitat at this site, it is not believed this is a separate population. Instead, it is thought these fish represent a small number of individuals that periodically drop down from the population above Locksville Dam pool.

The second population is located above the Rocky River Hydroelectric Dam. This population was historically the best, but the area yielded only one specimen after extensive surveys by Pottern and Huish (1985). The third population is found in the Deep River system in Randolph and Moore Counties. This population is believed to be small (Pottern and Huish 1985, 1986). In a 1985 survey, three individuals were found above the Highfalls Hydroelectric Reservoir; one in Fork Creek, Randolph County, and two in the Deep River, Moore County. The species was also found downstream of the Highfalls Dam. However, the extent of suitable habitat in this stream reach is limited, and it is thought that these individuals likely result from downstream movement from above the reservoir where Cape Fear shiner habitat is more extensive. The fourth population is found in Neal Creek, which flows into the Cape Fear River near Lillington in Harnett County.

Three historic populations have apparently been extirpated: one in Robeson Creek, Chatham County, believed lost when Jordan Lake flooded part of the creek; and one each in Parkers Creek and Kenneth Creek in Harnett County, which disappeared for unknown reasons. Other undiscovered populations or population segments have likely been lost due to reservoir construction in the Deep, Haw, and Cape Fear Rivers.

CAPE FEAR SHINER - N. mekistocholas 6/88

Description: The Cape Fear shiner is small, rarely exceeding 2 inches in length. The fish's body is flushed with a pale silvery yellow, and a black band runs along its sides (Snelson 1971). The fins are yellowish and somewhat pointed. The upper lip is black, and the lower lip bears a thin black bar along its margin. The Cape Fear shiner, unlike most other members of the large genus Notropis, feeds extensively on plant material, and its digestive tract is modified for this diet by having an elongated, convoluted intestine.

Reasons for Current Status: The Cape Fear shiner may always have existed in low numbers. However, its recent reduction in range and its small population size (Pottern and Huish 1985, 1986) increases the species' vulnerability to a catastrophic event, such as a toxic chemical spill. Dam construction in the Cape Fear system has probably had the most serious impact on the species by inundating the species' rocky riverine habitat; and changes in flow regulation at existing hydroelectric facilities could further threaten the species.

The deterioration of water quality has likely been another factor in the species' decline. The North Carolina Department of Natural Resources and Community Development (1983) classified water quality in the Deep River, Rocky River, and Bear Creek as good to fair, and referred to the Rocky River below Siler City as an area where their sampling indicates degradation. That report also stated: "Within the Cape Fear Basin, estimated average annual soil losses from cropland ranged from 3 tons per acre in the lower basin to 12 tons in the headwaters." The North Carolina State Division of Soil and Water Conservation considers 5 tons of soil loss per acre as the maximum allowable.

Potential threats to the species and its habitat could come from such activities as road construction, stream channel modification, changes in stream flows for hydroelectric power, impoundments, land use changes, wastewater discharges, and other projects in the watershed if such activities are not planned and implemented with the survival of the species and the protection of its habitat in mind.

Habitat: The species is generally associated with gravel, cobble, and boulder substates and has been observed to inhabit slow pools, riffles, and slow runs (Snelson 1971, Pottern and Huish 1985). In these habitats, the species is typically associated with schools of other related species, but it is never the numerically dominant species. Juveniles are often found in slackwater, among large rock outcrops in midstream, and in flooded side channels and pools (Pottern and Huish 1985).

Critical Habitat: (1) North Carolina, Chatham County. Approximately 4.1 miles of the Rocky River from North Carolina State Highway 902 Bridge downstream to Chatham County Road 1010 Bridge; (2) North Carolina,

Chatham and Lee Counties. Approximately 0.5 river mile of Bear Creek, from Chatham County Road 2156 Bridge downstream to the Rocky River, then downstream in the Rocky River (approximately 4.2 river miles) to the Deep River, then downstream in the Deep River (approximately 2.6 river miles) to a point 0.3 river mile below the Moncure, North Carolina, U.S. Geological Survey Gaging Station; and (3) North Carolina. Randolph and Moore Counties. Approximately 1.5 miles of Fork Creek, from a point 0.1 river mile upstream of Randolph County Road 2873 Bridge downstream to the Deep River then downstream approximately 4.1 river miles of the Deep River in Randolph and Moore Counties, North Carolina, to a point 2.5 river miles below Moore County Road 1456 Bridge.

Constituent elements include clean streams with gravel, cobble, and boulder substrates with pools, riffles, shallow runs and slackwater areas with large rock outcrops and side channels and pools with water of good quality with relatively low silt loads.

Feeding Habits: Plant material forms the primary part of the diet.

Reproduction and Development: No information is presently available on breeding behavior, fecundity, or longevity.

Population Level: Total numbers are unknown, but all populations appear to be small. Surveys conducted in 1984 and 1985 yielded 101 individuals from the population located around the junction of the Rocky River and Deep River in Chatham and Lee Counties, 1 specimen from the Rocky River near State Highway Bridge 902 in Chatham County, and 6 specimens from the Deep River system in Randolph and Moore Counties.

Management and Protection: Assuring survival of the Cape Fear shiner will require, at a minimum, maintaining good water quality and the natural conditions of the remaining habitat. Providing for a higher level of security will necessitate determining limiting factors and reestablishing additional populations into suitable waters within the historic range.

References:

North Carolina Department of Natural Resources and Community Development. 1983. Status of Water Resources in the Cape Fear River Basin. 135 pp.

Pottern, G.B., and M.T. Huish. 1985. Status survey of the Cape Fear shiner (Notropis mekistocholas). U.S. Fish and Wildlife Service Contract No. 14-16-0009-1522. 44 pp.

Pottern, G.B., and M.T. Huish. 1986. Supplement to the status survey of the Cape Fear shiner (Notropis mekistocholas). U.S. Fish and Wildlife Service Contract No. 14-16-0009-1522. 11 pp.

Snelson, F.F. 1971. Notropis mekistocholas, a new cyprinid fish endemic to the Cape Fear River basin. North Carolina. Copeia 1971:449-462.

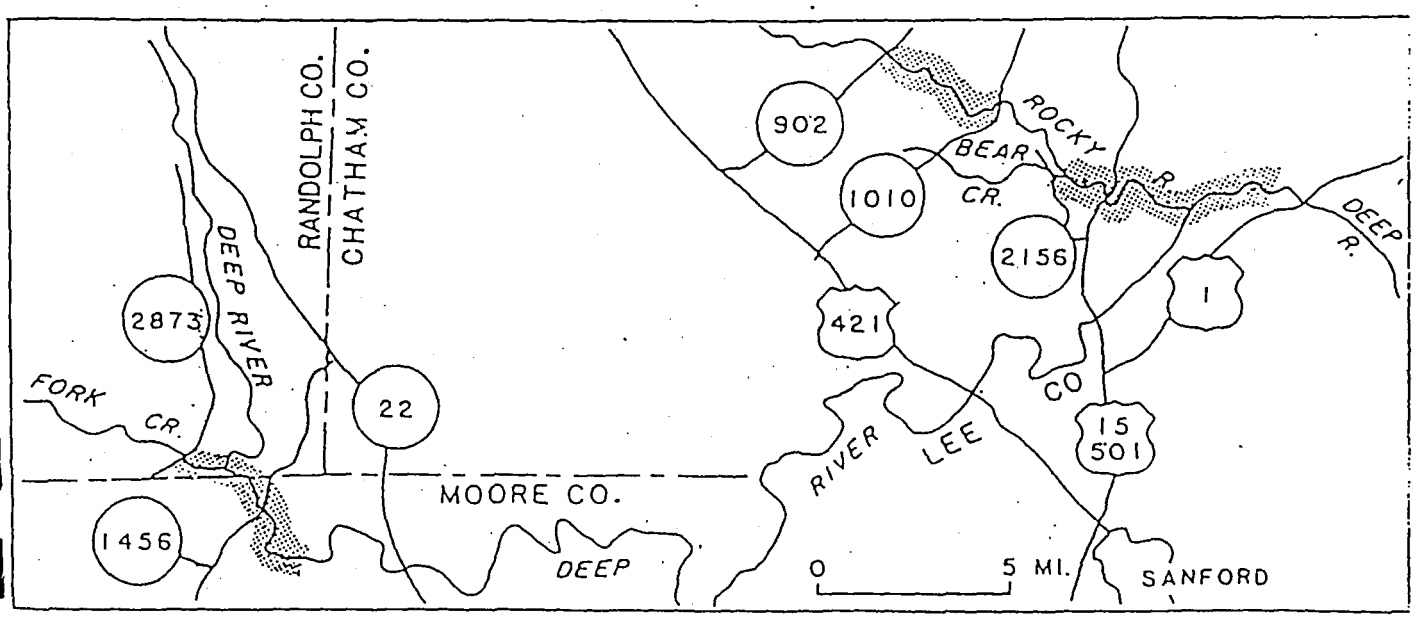
U.S. Fish and Wildlife Service. 1987. Endangered and threatened wildlife and plants; determination of endangered species status and designation of critical habitat for the Cape Fear shiner. Federal Register 52(186):36034-36039.

NORTH CAROLINA - Critical Habitat

Notropis mekistocholas, "Cape Fear shiner"

(1) Chatham County. Approximately 4.1 miles of the Rocky River from North Carolina State Highway 902 Bridge downstream to Chatham County Road 1010 Bridge;
(2) Chatham and Lee Counties. Approximately 0.5 river mile of Bear Creek, from Chatham County Road 2156 Bridge downstream to the Rocky River, then downstream in the Rocky River (approximately 4.2 river miles) to the Deep River, then downstream in the Deep River (approximately 2.6 river miles) to a point 0.3 river mile below the Moncure, North Carolina, U.S. Geological Survey Gaging Station; and
(3) Randolph and Moore Counties. Approximately 1.5 miles of Fork Creek, from a point 0.1 river mile upstream of Randolph County Road 2873 Bridge downstream to the Deep River then downstream approximately 4.1 river miles of the Deep River in Randolph and Moore Counties, North Carolina, to a point 2.5 river miles below Moore County Road 1456 Bridge.

Constituent elements include clean streams with gravel, cobble, and boulder substrates with pools, riffles, shallow runs and slackwater areas with large rock outcrops and side channels and pools with water of good quality with relatively low silt loads.



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MAY 19 1989
SUPERFUND BRANCH

7/87

WACCAMAW SILVERSIDE

Menidia extensa

Order: Mugiliformes

Family: Atherinidae

Status: Threatened (Federal Register 4/8/87)

Range: Known only from Lake Waccamaw and the upper Waccamaw River in Columbus County, North Carolina. The silverside is found in the upper Waccamaw River only during periods of high water and is not a permanent resident. Lake Waccamaw (not to be confused with the town of Lake Waccamaw) is the property of the State of North Carolina and is administered by the North Carolina Department of Natural Resources and Community Development's Division of Parks and Recreation.

Description: The Waccamaw silverside, also known as "skipjack" or "glass minnow," is a small (growing to about 2.5 inches), slim, almost transparent fish with a silvery stripe along each side. Its body is laterally compressed, the eyes are large, and the jaw is sharply angled upward.

Reasons for Current Status: The primary threat is the deterioration of water quality in Lake Waccamaw resulting from nutrient buildup. Although specific sources are currently unidentified, runoff and leachate from surrounding development may be contributing to the buildup. Nutrients in the lake increased since 1973, and it now appears that any further increase could tip the scales toward water quality conditions that would threaten the species. The existing data, as interpreted by Casterlin et al. (1986), indicate that phosphate concentrations and loading rates in the lake more than tripled in the years between 1973 and 1981. They further state that "continued high rates of phosphorus input (organic pollution) will likely bring the lake to a hyper-eutrophic state . . . by the end of the century." Water quality could also be affected by habitat alteration from development and other changes in land use, both around the lake and in its watershed (especially Big Creek), if these activities are not planned and implemented with the protection of the Lake Waccamaw ecosystem in mind.

A permit to propagate hybrid bass at several sites in the Lake Waccamaw watershed has been granted by the North Carolina Wildlife Resources Commission. Although the permit stipulates certain precautionary measures, escape of non-native predators from such a project into the system could upset the existing predator-prey relationships in the lake to the detriment of the Waccamaw silverside and other fishes now present in the lake.

A final factor that could threaten the Waccamaw silverside relates to its very short life cycle. The fish spawn when one-year-old and most die shortly thereafter. Failure to spawn in any one year could jeopardize the species. Water quality problems related to nutrient loading, even on a short-term basis, could cause the extinction of this fish.

WACCAMAW SILVERSIDE - *M. extensa*

Habitat: Lake Waccamaw is a natural lake with an approximate surface area of 8,934 acres and an average depth of 7.5 feet. Although it is fed by acidic swamp streams, the lake has a virtually neutral pH. This neutral condition, unusual among North Carolina's coastal plain lakes, is believed to be caused by the buffering effect of the calcareous Waccamaw Limestone formation, which underlies the lake and is exposed on the north shore. The Waccamaw silverside inhabits open water throughout the lake, where schools are commonly found near the surface over shallow, dark-bottomed areas.

Critical habitat: North Carolina, Columbus County. Lake Waccamaw in its entirety to mean high water level, and Big Creek from its mouth at Lake Waccamaw upstream approximately 0.6 kilometers (0.4 miles) to where the creek is crossed by County Road 1947.

Constituent elements include high quality clear open water, with a neutral pH and clean sand substrate.

Reproduction and Development: Spawning occurs from April through June, but reaches to peak when water temperatures are between 68 and 72F. Fully developed larvae form small isolated schools by early May. No parental care of the young has been noted. The silversides reach sexual maturity by the following spring, spawn, and then shortly thereafter most of the adults die off. A few may survive a second winter.

Population level: Estimated to be in the millions.

Management (Activities, Recommendations, Implications): The taking of silversides for fish bait or for scientific purposes is not considered a threat to the species. These activities may continue in accordance with State regulations. Activities which could affect water and substrate quality by increasing siltation and/or nutrient loading, or by altering temperature or pH, will require monitoring and control as necessary and feasible. Some of the activities that could prove detrimental include indiscriminate logging, land use changes, stream alteration such as channelization or impoundment, bridge and road construction, improper pesticide/herbicide application, and point and nonpoint pollution discharge.

References:

Casterlin, M.E., W.W. Reynolds, D.G. Lindquist, and C.G. Yarbrough. 1986. Algal and Physicochemical Indicators of Eutrophication in a Lake Harboring Endemic Species: Lake Waccamaw, North Carolina. Journal of the Elisha Mitchell Scientific Society 100(3):83-103.

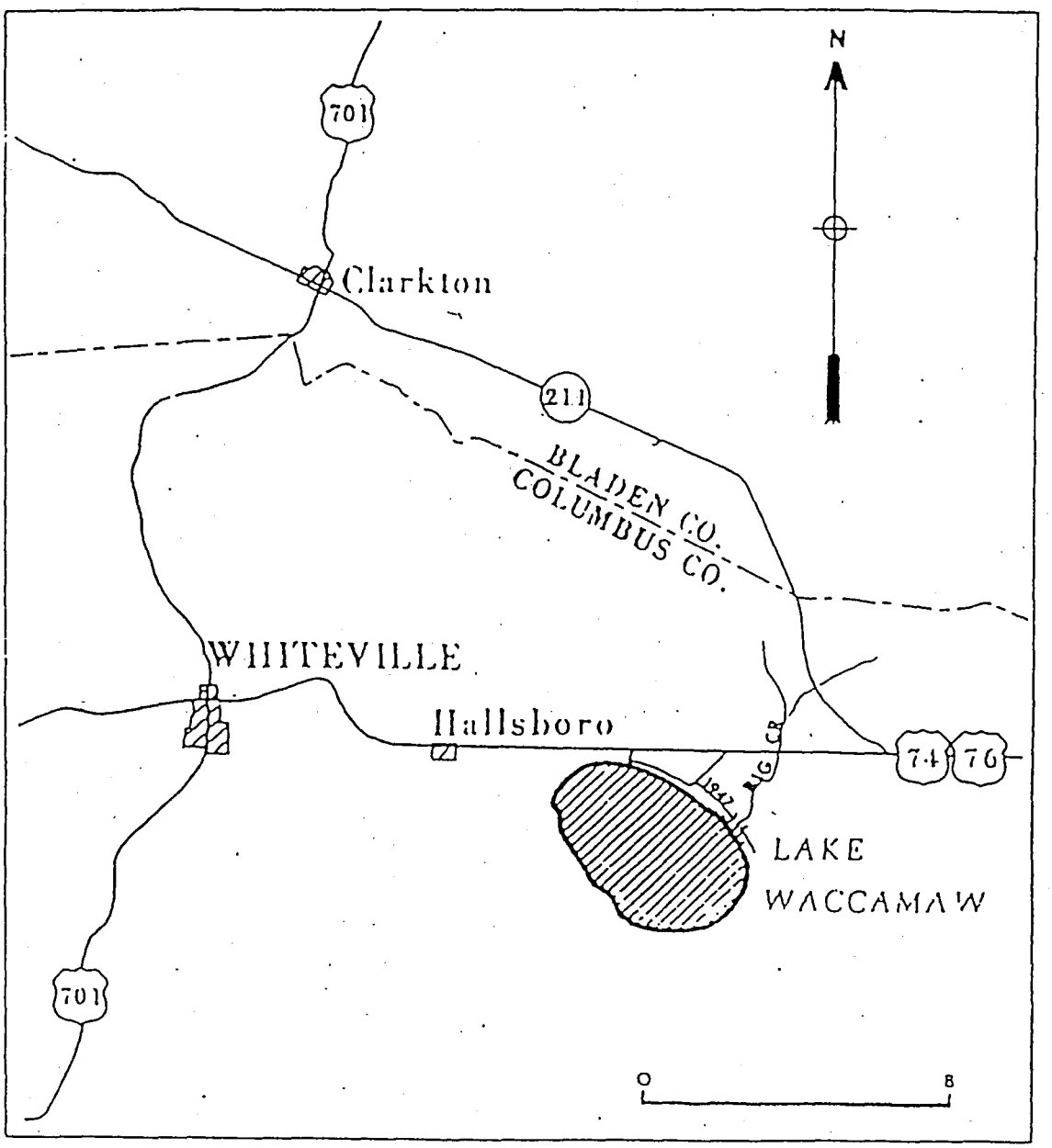
Davis, J.R. and D.E. Louder. 1969. Life History of *Menidia extensa*. Transactions of the American Fisheries Society 98(3):466-472.

NORTH CAROLINA - Critical Habitat

Menidia extensa, "Waccamaw ~~silverside~~"

Columbus County. Lake Waccamaw in its entirety to mean high water level, and Big Creek from its mouth at Lake Waccamaw upstream approximately 0.6 kilometer (0.4 mile) to where the creek is crossed by County Road 1947.

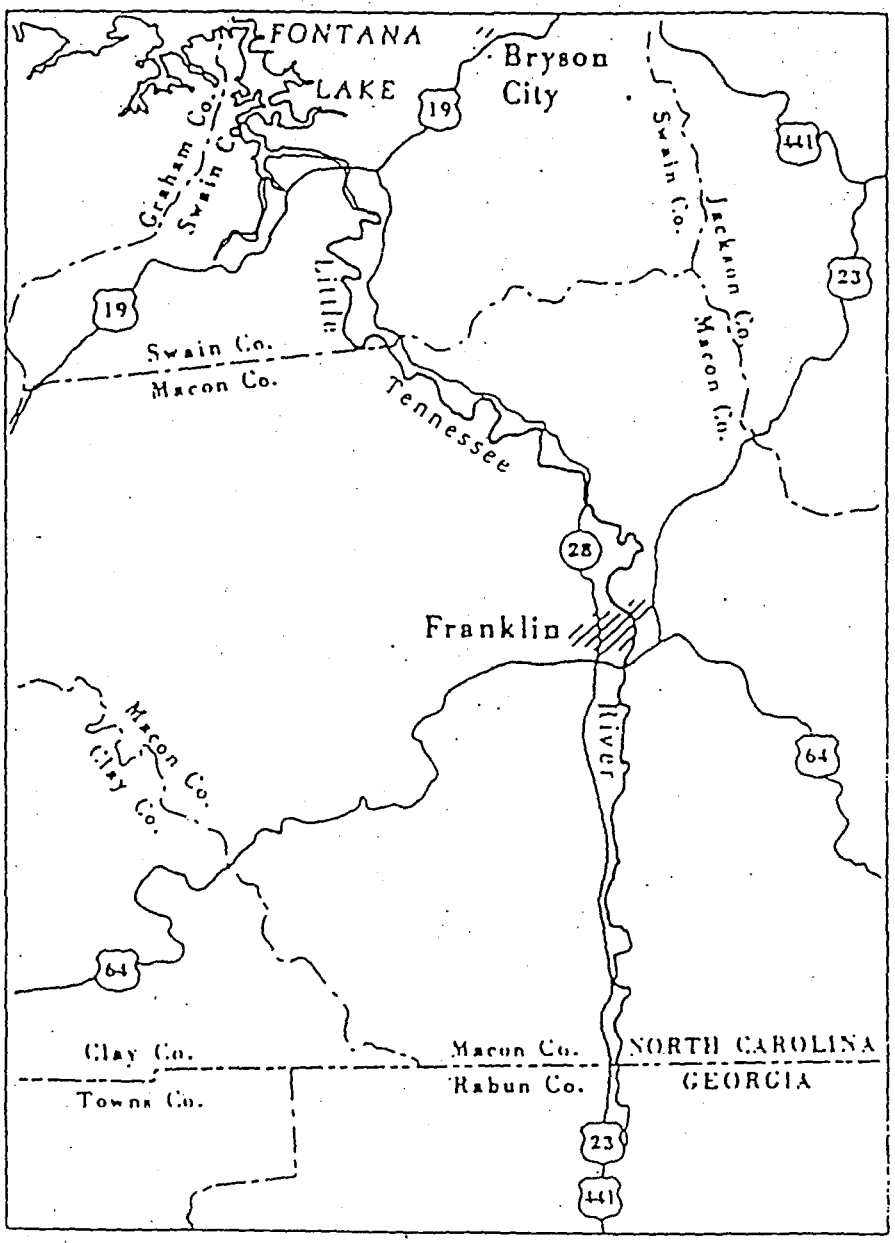
Constituent elements include high quality clear open water, with a neutral pH and clean sand substrate.



NORTH CAROLINA - Critical Habitat

Hybopsis monacha, "spotfin chub"

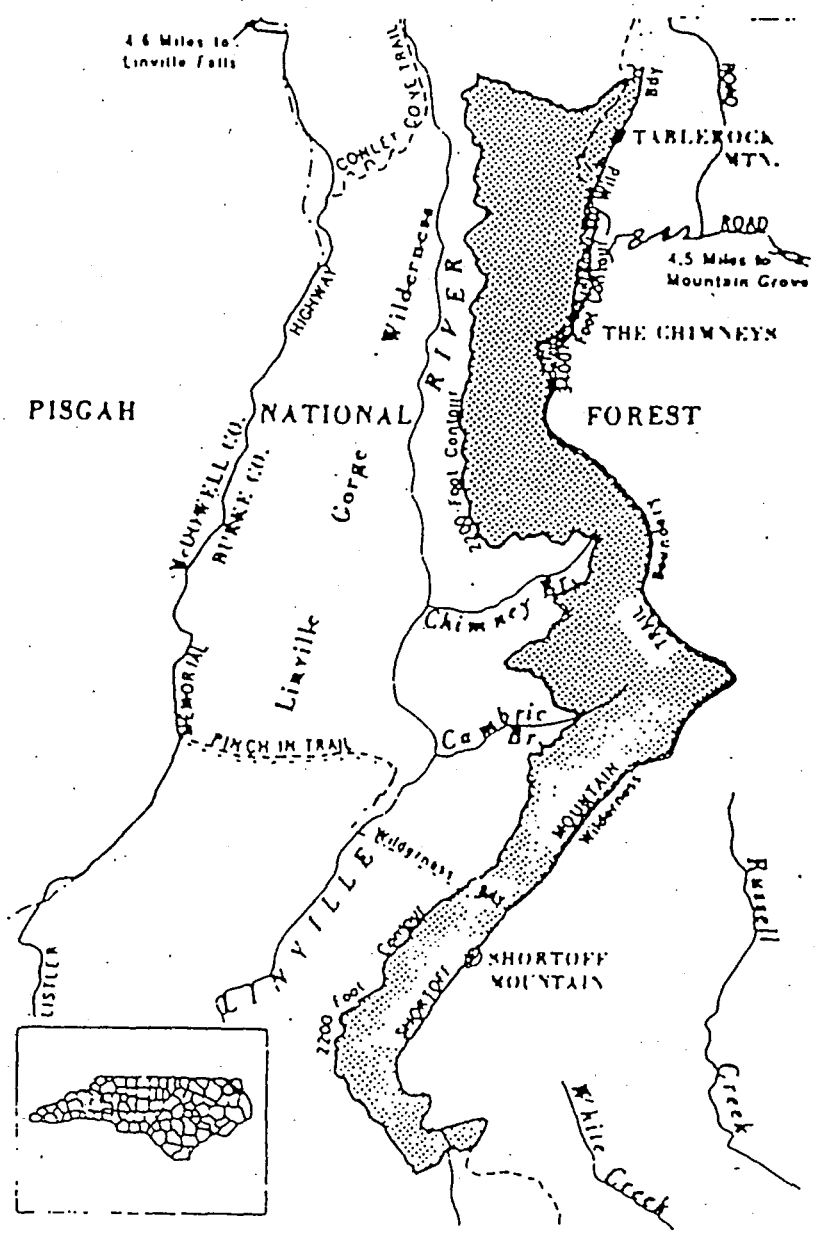
Macon and Swain Counties. Little Tennessee River, main channel from the backwaters of Fontana Lake upstream to the North Carolina-Georgia state line.



NORTH CAROLINA - Critical Habitat

Hudsonia montana, "mountain golden heather"

Burke County. The area bounded by the following: on the west by the 2200' contour; on the east by the Linville Gorge Wilderness Boundary north from the intersection of the 2200' contour and the Shortoff Mountain Trail to where it intersects the 3400' contour at "The Chimneys"--then follow the 3400' contour north until it reintersects the Wilderness Boundary--then follow the Wilderness Boundary again northward until it intersects the 3200' contour extending west from its intersection with the Wilderness Boundary until it begins to turn south--at this point the Boundary extends due east until it intersects the 2200' contour.



P.O. Box 5447
Spartanburg, S.C. 29304
Phone: (803) 599-1070
FAX: (803) 599-1087

Ref. 49

NCD058517467
Lee Crosby
Jerry Rhodes

Southern Wood Piedmont Company

RECEIVED
JAN 29 1992
HAZARDOUS WASTE SECTION

January 22, 1992

North Carolina DEHNR
Solid & Hazardous Waste Management
Box 2091
Raleigh, NC 27602

Attn: Mr. Doug Holyfield

Dear Mr. Holyfield:

The information enclosed consists of the following analytical reports from SWP, Wilmington:

1. Landfarm Areas #1 and #2
2. Cape Fear River Samples
3. On Site Monitoring Wells

If you have any questions after your review feel free to contact me at (803) 599-1082.

Sincerely,

Sandra B. Watson

Sandra B. Watson
Environmental Chemist

5383bw

CC: T. M. Davis

James W. Andrews, Ph.D.
President

Janette Davis Long
Vice-President

SAVANNAH LABORATORIES AND ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue (31404)
P. O. Box 13548 • Savannah, GA 31416-0548
(912) 354-7858

DW
TMD
MDP
File

RECEIVED
FEB 26 1990
ENVIRONMENTAL AFFAIRS

LOG NO: SO-03604
Received: 01 FEB 90

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477, I-85 and Sigsbee Rd.
Spartanburg, SC 29304
CC: Steve Blevins

Project: Cape Fear River

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	SAMPLED BY
03604-1	# 36 State Ports Authority ("A" # 8588)	Client
03604-2	# 37 Greenfield Creek ("B" # 8589)	
03604-3	# 38 SWP Old Slip ("C" # 8590)	
03604-4	# 39 US # 74 New Bridge ("D" 8591)	

PARAMETER	03604-1	03604-2	03604-3	03604-4
K001 (Method 8270)				
2-Chlorophenol, mg/l	ND	ND	ND	ND
Phenol, mg/l	ND	ND	ND	ND
2,4-Dimethylphenol, mg/l	ND	ND	ND	ND
Trichlorophenols, mg/l	ND	ND	ND	ND
p-Chloro-m-cresol, mg/l	ND	ND	ND	ND
Tetrachlorophenols, mg/l	ND	ND	ND	ND
2,4-Dinitrophenol, mg/l	ND	ND	ND	ND
Pentachlorophenol, mg/l	ND	ND	ND	ND
Naphthalene, mg/l	ND	ND	ND	ND
Acenaphthene, mg/l	ND	ND	ND	ND
Acenaphthylene, mg/l	ND	ND	ND	ND
Phenanthrene, mg/l	ND	ND	ND	ND
Anthracene, mg/l	ND	ND	ND	ND
Fluoranthene, mg/l	ND	ND	ND	ND
Chrysene, mg/l	ND	ND	ND	ND
Benzo(a)Anthracene, mg/l	ND	ND	ND	ND
Benzo(b,k)fluoranthene, mg/l	ND	ND	ND	ND
Benzo(a)pyrene, mg/l	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene, mg/l	ND	ND	ND	ND
Dibenzo(a,h)anthracene, mg/l	ND	ND	ND	ND
Carbazole, mg/l	ND	ND	ND	ND
Dilution factor	1	1	1	1

James W. Andrews, Ph.D.
President

Janette Davis Long
Vice-President

SAVANNAH LABORATORIES AND ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue (31404)
P. O. Box 13548 • Savannah, GA 31416-0548
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RECEIVED
FEB 26 1990
ENVIRONMENTAL AFFAIRS

LOG NO: S0-03604
Received: 01 FEB 90

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477, I-85 and Sigsbee Rd.
Spartanburg, SC 29304
CC: Steve Blevins

Project: Cape Fear River

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	SAMPLED BY
03604-1	# 36 State Ports Authority ("A" # 8588)	Client
03604-2	# 37 Greenfield Creek ("B" # 8589)	
03604-3	# 38 SWP Old Slip ("C" # 8590)	
03604-4	# 39 US # 74 New Bridge ("D" 8591)	

PARAMETER	03604-1	03604-2	03604-3	03604-4
Arsenic, mg/l	ND	ND	ND	ND
Chromium, mg/l	ND	ND	ND	ND
Copper, mg/l	ND	ND	ND	ND

SL SAVANNAH LABORATORIES
& ENVIRONMENTAL SERVICES, INC.
5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

RECEIVED
AUG 27 1990
ENVIRONMENTAL AFFAIRS

TMD

LOG NO: SO-09218

Received: 01 AUG 90

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477, I-85 and Sigsbee Rd.
Spartanburg, SC 29304

CC: Steve Blevins

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	SAMPLED BY
09218-1	#40 State Port Authority ("A" 8817)	Client
09218-2	#41 Greenfield Creek ("B" 8818)	
09218-3	#42 SWP Old Slip ("C" 8819)	
09218-4	#43 US #74 New Bridge ("D" 8820)	

PARAMETER	09218-1	09218-2	09218-3	09218-4
K001 (Method 8270)				
2-Chlorophenol, mg/l	ND	ND	ND	ND
Phenol, mg/l	ND	ND	ND	ND
2,4-Dimethylphenol, mg/l	ND	ND	ND	ND
Trichlorophenols, mg/l	ND	ND	ND	ND
p-Chloro-m-cresol, mg/l	ND	ND	ND	ND
Tetrachlorophenols, mg/l	ND	ND	ND	ND
2,4-Dinitrophenol, mg/l	ND	ND	ND	ND
Pentachlorophenol, mg/l	ND	ND	ND	ND
Naphthalene, mg/l	ND	ND	ND	ND
Acenaphthene, mg/l	ND	ND	ND	ND
Acenaphthylene, mg/l	ND	ND	ND	ND
Phenanthrene, mg/l	ND	ND	ND	ND
Anthracene, mg/l	ND	ND	ND	ND
Fluoranthene, mg/l	ND	ND	ND	ND
Chrysene, mg/l	ND	ND	ND	ND
Benzo(a)Anthracene, mg/l	ND	ND	ND	ND
Benzo(b,k)fluoranthene, mg/l	ND	ND	ND	ND
Benzo(a)pyrene, mg/l	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene, mg/l	ND	ND	ND	ND
Dibenzo(a,h)anthracene, mg/l	ND	ND	ND	ND
Carbazole, mg/l	ND	ND	ND	ND
Dilution factor	1	1	1	1

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& ENVIRONMENTAL SERVICES, INC.

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ENVIRONMENTAL AFFAIRS

LOG NO: SO-09218

Received: 01 AUG 90

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477, I-85 and Sigsbee Rd.
Spartanburg, SC 29304

CC: Steve Blevins

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	SAMPLED BY
09218-1	#40 State Port Authority ("A" 8817)	Client
09218-2	#41 Greenfield Creek ("B" 8818)	
09218-3	#42 SWP Old Slip ("C" 8819)	
09218-4	#43 US #74 New Bridge ("D" 8820)	

PARAMETER	09218-1	09218-2	09218-3	09218-4
Arsenic, mg/l	ND	ND	ND	ND
Chromium, mg/l	ND	0.046	0.011	ND
Copper, mg/l	ND	0.052	ND	ND

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ENVIRONMENTAL AFFAIRS

LOG NO: SO-09218

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Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477, I-85 and Sigsbee Rd.
Spartanburg, SC 29304

CC: Steve Blevins

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , REPORT FOR LIQUID SAMPLES	SAMPLED BY
09218-5	Detection Limits	Client
09218-6	Accuracy (Mean % Recovery)	
09218-7	Precision (% RPD)	

PARAMETER	09218-5	09218-6	09218-7
K001 (Method 8270)			
2-Chlorophenol, mg/l	0.010	87 %	5.8 %
Phenol, mg/l	0.010	44 %	2.3 %
,4-Dimethylphenol, mg/l	0.010	75 %	15 %
Trichlorophenols, mg/l	0.010	97 %	0 %
p-Chloro-m-cresol, mg/l	0.010	74 %	9.5 %
Tetrachlorophenols, mg/l	0.010	91 %	14 %
2,4-Dinitrophenol, mg/l	0.050	86 %	8.2 %
Pentachlorophenol, mg/l	0.050	78 %	23 %
Naphthalene, mg/l	0.010	65 %	6.2 %
Acenaphthene, mg/l	0.010	93 %	12 %
Acenaphthylene, mg/l	0.010	75 %	15 %
Phenanthrene, mg/l	0.010	98 %	2.0 %
Anthracene, mg/l	0.010	87 %	0 %
Fluoranthene, mg/l	0.010	112 %	6.3 %
Chrysene, mg/l	0.010	103 %	4.9 %
Benzo(a)Anthracene, mg/l	0.010	102 %	15 %
Benzo(b,k)fluoranthene, mg/l	0.010	118 %	19 %
Benzo(a)pyrene, mg/l	0.010	126 %	19 %
Indeno(1,2,3-cd)pyrene, mg/l	0.010	133 %	25 %
Dibenzo(a,h)anthracene, mg/l	0.010	136 %	27 %
Carbazole, mg/l	0.010	112 %	30 %
Arsenic, mg/l	0.010	88 %	0 %
Chromium, mg/l	0.010	86 %	4.7 %

SL SAVANNAH LABORATORIES
& ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

TMD
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RECEIVED
JAN 17 1992
ENVIRONMENTAL AFFAIRS

LOG NO: S1-38049

Received: 19 DEC 91

Ms. Sandra Watson
Southern Wood Piedmont. (WI)
P.O. Box 5477, I-85 and Sigsbee Rd.
Spartanburg, SC 29304

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
38049-1	#44 State Port (# 9151)	12-17-91
38049-2	#45 Greenfield Creek (# 9192)	12-17-91
38049-3	#46 SWP Old Slip (# 9193)	12-17-91
38049-4	#47 US 74 New Bridge (# 9194)	12-17-91

PARAMETER	38049-1	38049-2	38049-3	38049-4
KOO1 (Method 8270)				
2-Chlorophenol, mg/l	ND	ND	ND	ND
Phenol, mg/l	ND	ND	ND	ND
2,4-Dimethylphenol, mg/l	ND	ND	ND	ND
Trichlorophenols, mg/l	ND	ND	ND	ND
p-Chloro-m-cresol, mg/l	ND	ND	ND	ND
Tetrachlorophenols, mg/l	ND	ND	ND	ND
2,4-Dinitrophenol, mg/l	ND	ND	ND	ND
Pentachlorophenol, mg/l	ND	ND	ND	ND
Naphthalene, mg/l	ND	ND	ND	ND
Acenaphthene, mg/l	ND	ND	ND	ND
Acenaphthylene, mg/l	ND	ND	ND	ND
Phenanthrene, mg/l	ND	ND	ND	ND
Anthracene, mg/l	ND	ND	ND	ND
Fluoranthene, mg/l	ND	ND	ND	ND
Chrysene, mg/l	ND	ND	ND	ND
Benzo(a)Anthracene, mg/l	ND	ND	ND	ND
Benzo(b,k)fluoranthene, mg/l	ND	ND	ND	ND
Benzo(a)pyrene, mg/l	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene, mg/l	ND	ND	ND	ND
Dibenzo(a,h)anthracene, mg/l	ND	ND	ND	ND
Carbazole, mg/l	ND	ND	ND	ND
Dilution factor	1	1	1	1

SL SAVANNAH LABORATORIES
& ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

RECEIVED
JAN 17 1992
ENVIRONMENTAL AFFAIRS

LOG NO: S1-38049

Received: 19 DEC 91

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477, I-85 and Sigsbee Rd.
Spartanburg, SC 29304

Project: Wilmington, NC
Sampled By: Client

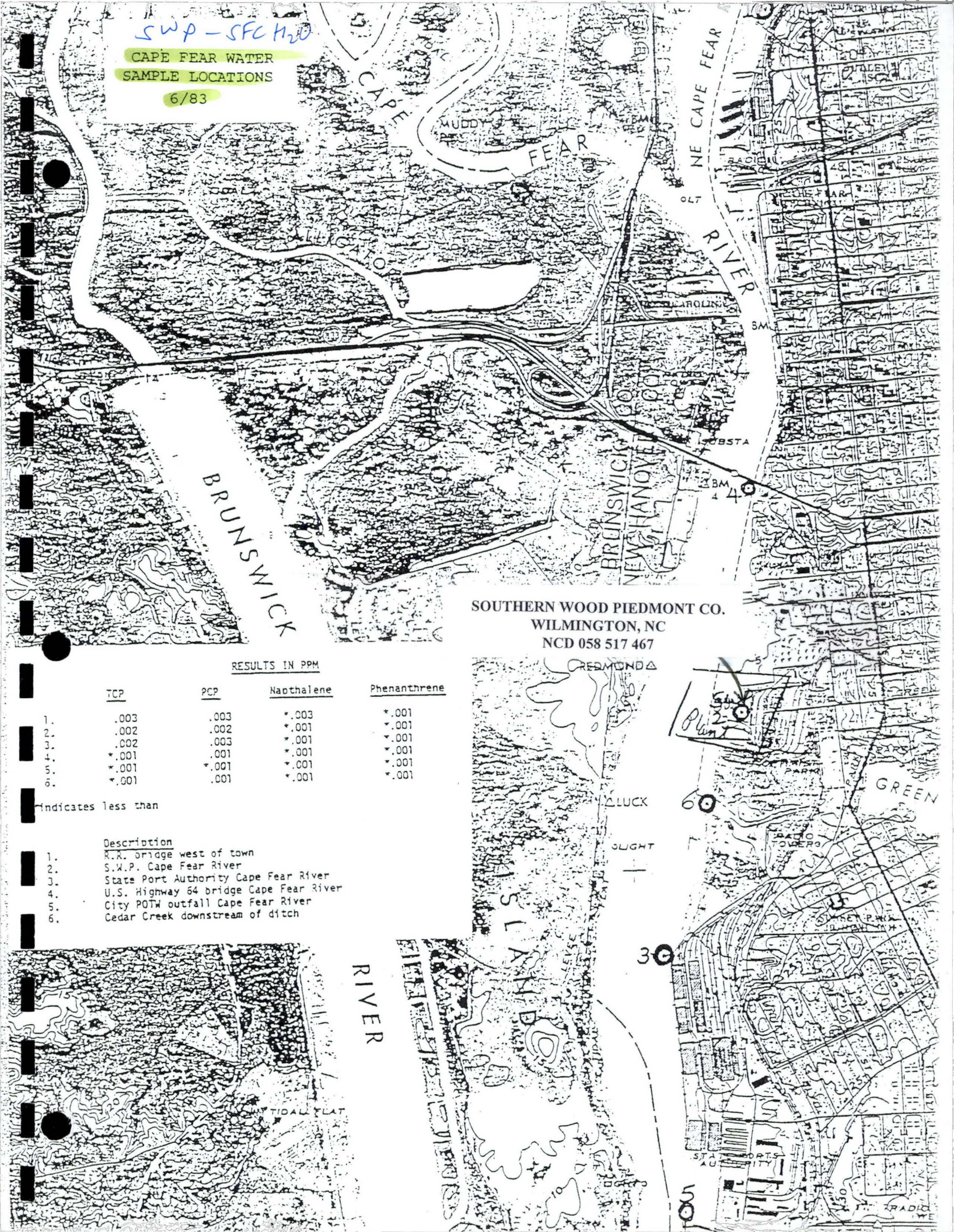
REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
38049-1	#44 State Port (# 9151)	12-17-91
38049-2	#45 Greenfield Creek (# 9192)	12-17-91
38049-3	#46 SWP Old Slip (# 9193)	12-17-91
38049-4	#47 US 74 New Bridge (# 9194)	12-17-91

PARAMETER	38049-1	38049-2	38049-3	38049-4
Arsenic, mg/l	ND	ND	ND	ND
Chromium, mg/l	ND	ND	ND	ND
Copper, mg/l	ND	ND	ND	ND

SWP – SFC H2O

CAPE FEAR WATER
SAMPLE LOCATIONS
6/83



SOUTHERN WOOD PIEDMONT CO.
WILMINGTON, NC
NCD 058 517 467

RESULTS IN PPM

	TCP	PCP	Napthalene	Phenanthrene
1.	.003	.003	*.003	*.001
2.	.002	.002	*.001	*.001
3.	.002	.003	*.001	*.001
4.	*.001	.001	*.001	*.001
5.	*.001	*.001	*.001	*.001
6.	*.001	.001	*.001	*.001

*indicates less than

Description

1. R.R. bridge west of town
2. S.W.P. Cape Fear River
3. State Port Authority Cape Fear River
4. U.S. Highway 64 bridge Cape Fear River
5. City POTW outfall Cape Fear River
6. Cedar Creek downstream of ditch

Ref. 50

PHASE II GROUNDWATER QUALITY ASSESSMENT
WILMINGTON, NORTH CAROLINA FACILITY

Prepared For

Southern Wood Piedmont Company
Spartanburg, South Carolina

Prepared By The

ViroGroup
Air • Water • Soil
TECHNOLOGY

ETE Division

MAY 1994
SCANNED
HW FILE ROOM

JAN 1994

LIST OF ATTACHMENTS

ATTACHMENTS

ATTACHMENT A - Well Abandonment Records

ATTACHMENT B - Boring and Construction Logs

Well Log Database Table
Boring Logs

ATTACHMENT C - Wetland Well Installation Authorization Letters

ATTACHMENT D - Recovery Tests Summary and Graphs

Hydraulic Conductivity and Seepage Velocity Summary Table
Slug Test Methods and Assumptions
Slug Test Data Plots and Calculations

ATTACHMENT E - Soil Sample Laboratory Summary and Results

Site-Specific Soil Sample List
Soil Sample Summary Table
Soil Sample Parameters Summary Tables
Soil Sample Collection Summary Sheets
Soil Sample Laboratory Results and Chain-of-Custody

ATTACHMENT F - Ground Water Sample Laboratory Summary and Results

Site-Specific Ground Water Sample List
Ground Water Sample Summary Table
Ground Water Sample Parameters Summary Tables
Ground Water Sample Collection Summary Sheets
Ground Water Sample Laboratory Results and Chain-of-Custody

ATTACHMENT E

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
ITAGE LABORATORIES, INC. 1132 POMPANO ST. CHARLOTTE, NC 28216 (93-1853	11-DEC-92	2024	B118583
	Complete	PO Number	
	04-JAN-93	530-06-501	
	Printed	Sampled	
	05-JAN-93	09-DEC-92 14:00	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-1
LOG #: 10782

OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.11		Grams
AL WEIGHT OR VOLUME	50		mL

ROMIUM FAA SW846-7190

alyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0
Pre FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
ROMIUM	5.5	0.75	mg/kg

COPPER FAA SW846-7210

alyst: L. SURRATT Analysis Date: 16-DEC-92 Instrument: FAA Test: M112.1.0
rep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
PPER	6.1	0.75	mg/kg

LEAD FAA SW846-7420

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M116.1.0
rep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
LEAD	14	5	mg/kg

AA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
ITIAL WEIGHT OR VOLUME	2.0		Grams
FINAL WEIGHT OR VOLUME	50		mL

RECEIVED
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ENVIRONMENTAL AFFAIRS

 (continued on next page)

ITAGE LABORATORIES, INC. Lab Sample ID: B118583

RSENIC GFAA SW846-7060
lyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
p: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
RSENIC	3.5	1.2	mg/kg

Analysis performed by 3 point MSA

OGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021
lyst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: 0461.1.0

Parameter	Result	Det. Limit	Units
HLORODIFLUOROMETHANE	BDL	0.005	mg/kg
OROMETHANE	BDL	0.005	mg/kg
INYL CHLORIDE	BDL	0.005	mg/kg
OMOMETHANE	BDL	0.005	mg/kg
OROETHANE	BDL	0.005	mg/kg
RICHLOROFLUOROMETHANE	BDL	0.005	mg/kg
,1-DICHLOROETHENE	BDL	0.001	mg/kg
HLOROMETHANE (METHYLENE CHLORIDE)	0.024	0.001	mg/kg
NS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
,1-DICHLOROETHANE	BDL	0.001	mg/kg
OROFORM	BDL	0.001	mg/kg
,1-TRICHLOROETHANE	BDL	0.001	mg/kg
ARBON TETRACHLORIDE	BDL	0.001	mg/kg
ENZENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
RICHLOROETHENE	BDL	0.001	mg/kg
,2-DICHLOROPROPANE	BDL	0.001	mg/kg
OMODICHLOROMETHANE	BDL	0.001	mg/kg
S-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
TOLUENE	0.002	0.001	mg/kg
,1,2-TRICHLOROETHANE	BDL	0.001	mg/kg
BROMOCHLOROMETHANE	BDL	0.001	mg/kg
HLOROBENZENE	BDL	0.001	mg/kg
ETHYLBENZENE	BDL	0.001	mg/kg
P-XYLENE	0.002	0.001	mg/kg
XYLENE	0.001	0.001	mg/kg
1,1,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
THYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
2 CHLOROETHYLVINYLETHER	BDL	0.001	mg/kg
1,2-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550
Analyst: S. WILLIAMS Analysis Date: 11-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
ITIAL WEIGHT OR VOLUME	30.00		Grams
NAL VOLUME	1.0		mL

MI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270
alyst: R. ROBERTS Analysis Date: 28-DEC-92 Instrument: GC/MS SVOA Test: 0505.3.0
Prep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
ENAPHTHENE	0.51	0.33	mg/kg
ANTHRACENE	BDL	0.33	mg/kg
BENZ(A)ANTHRACENE	1.1	0.33	mg/kg
NZO(A)PYRENE	0.42	0.33	mg/kg
(B)FLUORANTHENE	BDL	0.33	mg/kg
BENZO(K)FLUORANTHENE	1.5	0.33	mg/kg

 (continued on next page)

ITAGE LABORATORIES, INC. Lab Sample ID: B118583

Parameter	Result	Det. Limit	Units
(2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
BAZOLE	BDL	0.33	mg/kg
HRYSENE	1.1	0.33	mg/kg
BENZ(A,H)ANTHRACENE	BDL	0.33	mg/kg
THENE	3.8	0.33	mg/kg
ENO(1,2,3-CD)PYRENE	BDL	0.33	mg/kg
APHTHALENE	BDL	0.33	mg/kg
NANTHRENE	1.5	0.33	mg/kg
HLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
-CHLOROPHENOL	BDL	0.33	mg/kg
-DIMETHYLPHENOL	BDL	0.33	mg/kg
-DINITROPHENOL	BDL	1.6	mg/kg
ENTACHLOROPHENOL	BDL	1.6	mg/kg
HENOL	BDL	0.33	mg/kg
RACHLOROPHENOL	BDL	0.33	mg/kg
,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,4,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
RROGATE RECOVERY			

FLUOROPHENOL	54		% Rec
ENOL-D5	57		% Rec
TROBENZENE-D5	78		% Rec
2-FLUOROBIPHENYL	101		% Rec
4,6-TRIBROMOPHENOL	59		% Rec
RPHENYL-D14	106		% Rec

Sample reanalyzed with no improvement in internal standard areas.

Sample Comments

BDL Below Detection Limit

Sample chain of custody number 16791.

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Quality Assurance Officer: Chelmsuth MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
ERITAGE LABORATORIES, INC. 4132 POMPANO ST. HARLOTTE, NC 28216 (393-1853	11-DEC-92	2024	B118584
	Complete	PO Number	
	04-JAN-93	530-06-501	
	Printed	Sampled	
	05-JAN-93	09-DEC-92 14:45	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-2
LOG #: 10783

OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.10		Grams
INAL WEIGHT OR VOLUME	50		mL

ROMIUM FAA SW846-7190

alyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0

Pre FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
ROMIUM	14	0.75	mg/kg

OPPER FAA SW846-7210

alyst: L. SURRATT Analysis Date: 16-DEC-92 Instrument: FAA Test: M112.1.0

rep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
PPER	46	0.75	mg/kg

LEAD FAA SW846-7420

alyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M116.1.0

rep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
EAD	290	5	mg/kg

GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
ITIAL WEIGHT OR VOLUME	2.09		Grams
FINAL WEIGHT OR VOLUME	50		mL

TAGE LABORATORIES, INC. Lab Sample ID: B118584

SENIC GFAA SW846-7060
yst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
SENIC	5.2	1.2	mg/kg

nalysis performed by 3 point MSA

GENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021
yst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: 0461.1.0

Parameter	Result	Det. Limit	Units
HLORODIFLUOROMETHANE	BDL	0.005	mg/kg
ROMETHANE	BDL	0.005	mg/kg
INYL CHLORIDE	BDL	0.005	mg/kg
ROMOMETHANE	BDL	0.005	mg/kg
ROETHANE	BDL	0.005	mg/kg
CHLOROFLUOROMETHANE	BDL	0.005	mg/kg
,1-DICHLOROETHENE	BDL	0.001	mg/kg
HLOROMETHANE (METHYLENE CHLORIDE)	0.006	0.001	mg/kg
NS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
,1-DICHLOROETHANE	BDL	0.001	mg/kg
OROFORM	BDL	0.001	mg/kg
,1-TRICHLOROETHANE	BDL	0.001	mg/kg
RBON TETRACHLORIDE	BDL	0.001	mg/kg
ENZENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
CHLOROETHENE	BDL	0.001	mg/kg
,2-DICHLOROPROPANE	BDL	0.001	mg/kg
MODICHLOROMETHANE	BDL	0.001	mg/kg
-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
OLU E	BDL	0.001	mg/kg
1,2 TRICHLOROETHANE	BDL	0.001	mg/kg
ROMOCHLOROMETHANE	BDL	0.001	mg/kg
LOROBENZENE	BDL	0.001	mg/kg
THYLBENZENE	BDL	0.001	mg/kg
-XYLENE	BDL	0.001	mg/kg
YLENE	BDL	0.001	mg/kg
1,1,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
THYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
HLOROETHYLVINYLETHER	BDL	0.001	mg/kg
1,2-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

MS SONICATION EXTRACTION FOR ORGANICS SW846-3550
alyst: S. WILLIAMS Analysis Date: 11-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	30.00		Grams
NAL VOLUME	1.0		mL

MI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270
alyst: R. ROBERTS Analysis Date: 28-DEC-92 Instrument: GC/MS SVOA Test: 0505.3.0
Prep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
ENAPHTHENE	BDL	0.33	mg/kg
THRACENE	BDL	0.33	mg/kg
BENZ(A)ANTHRACENE	0.54	0.33	mg/kg
NZO(A)PYRENE	BDL	0.33	mg/kg
(B)FLUORANTHENE	0.75	0.33	mg/kg
BENZO(K)FLUORANTHENE	BDL	0.33	mg/kg

 (continued on next page)

ITAGE LABORATORIES, INC. Lab Sample ID: B118584

Parameter	Result	Det. Limit	Units
(2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
BAZOLE	BDL	0.33	mg/kg
IRYSENE	0.53	0.33	mg/kg
BENZ(A,H)ANTHRACENE	BDL	0.33	mg/kg
ANTHENE	0.87	0.33	mg/kg
DENO(1,2,3-CD)PYRENE	BDL	0.33	mg/kg
PHTHALENE	BDL	0.33	mg/kg
NANTHRENE	0.56	0.33	mg/kg
HLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
-CHLOROPHENOL	BDL	0.33	mg/kg
-DIMETHYLPHENOL	BDL	0.33	mg/kg
-DINITROPHENOL	BDL	1.6	mg/kg
ENTACHLOROPHENOL	BDL	1.6	mg/kg
HENOL	BDL	0.33	mg/kg
RACHLOROPHENOL	BDL	0.33	mg/kg
,4,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,4,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
ROGATE RECOVERY			

LUOROPHENOL	43		% Rec
NOL-D5	47		% Rec
ITROBENZENE-D5	55		% Rec
FLUOROBIPHENYL	82		% Rec
,6-TRIBROMOPHENOL	47		% Rec
RPHENYL-D14	99		% Rec

ample reanalyzed with no improvement in internal standard areas.

Sample Comments

BDL Below Detection Limit

ample chain of custody number 16791.

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ality Assurance Officer: Helmuth MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
RITAGE LABORATORIES, INC. 132 POMPANO ST. HARLOTTE, NC 28216 0 93-1853	11-DEC-92	2024	B118585
	Complete	PO Number	
	04-JAN-93	530-06-501	
	Printed	Sampled	
	05-JAN-93	09-DEC-92 15:15	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-3
LOG #: 10784

OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.12		Grams
NAL WEIGHT OR VOLUME	50		mL

ROMIUM FAA SW846-7190

alyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0
Pre AA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
ROMIUM	2.1	0.75	mg/kg

COPPER FAA SW846-7210

alyst: L. SURRATT Analysis Date: 16-DEC-92 Instrument: FAA Test: M112.1.0
rep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
PPER	8.0	0.75	mg/kg

EAD FAA SW846-7420

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M116.1.0
rep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
EAD	61	5.0	mg/kg

AA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
ITIAL WEIGHT OR VOLUME	2.16		Grams
INAL WEIGHT OR VOLUME	50		mL

RSENIC GFAA SW846-7060

Analyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
Prep: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
RSENIC	BDL	1.2	mg/kg

ALOGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021

Analyst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: O461.1.0

Parameter	Result	Det. Limit	Units
ICHLORODIFLUOROMETHANE	BDL	0.005	mg/kg
HLOROMETHANE	BDL	0.005	mg/kg
IYL CHLORIDE	BDL	0.005	mg/kg
RMOMETHANE	BDL	0.005	mg/kg
HLOROETHANE	BDL	0.005	mg/kg
RICHLOROFLUOROMETHANE	BDL	0.005	mg/kg
-DICHLOROETHENE	BDL	0.001	mg/kg
ICHLOROMETHANE (METHYLENE CHLORIDE)	0.015	0.001	mg/kg
RANS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
OROFORM	BDL	0.001	mg/kg
,1,1-TRICHLOROETHANE	BDL	0.001	mg/kg
ARBON TETRACHLORIDE	BDL	0.001	mg/kg
ZENE	BDL	0.001	mg/kg
,2-DICHLOROETHANE	BDL	0.001	mg/kg
RICHLOROETHENE	BDL	0.001	mg/kg
-DICHLOROPROPANE	BDL	0.001	mg/kg
ROMODICHLOROMETHANE	BDL	0.001	mg/kg
IS-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
UENE	BDL	0.001	mg/kg
,2-TRICHLOROETHANE	BDL	0.001	mg/kg
IBROMOCHLOROMETHANE	BDL	0.001	mg/kg
HLOROBENZENE	BDL	0.001	mg/kg
YLBENZENE	BDL	0.001	mg/kg
M/P-XYLENE	BDL	0.001	mg/kg
O-XYLENE	BDL	0.001	mg/kg
,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
THYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
2-CHLOROETHYLVINYLETHER	BDL	0.001	mg/kg
-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550

Analyst: S. WILLIAMS Analysis Date: 11-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	30.00		Grams
FINAL VOLUME	1.0		mL

MI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270

Analyst: R. ROBERTS Analysis Date: 28-DEC-92 Instrument: GC/MS SVOA Test: O505.3.0
Prep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
ACENAPHTHENE	BDL	0.33	mg/kg
NTHRACENE	BDL	0.33	mg/kg
NZ(A)ANTHRACENE	BDL	0.33	mg/kg
ENZO(A)PYRENE	BDL	0.33	mg/kg
BENZO(B)FLUORANTHENE	BDL	0.33	mg/kg
NZO(K)FLUORANTHENE	BDL	0.33	mg/kg
S(-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
CARBAZOLE	BDL	0.33	mg/kg

ITAGE LABORATORIES, INC. Lab Sample ID: B118585

Parameter	Result	Det. Limit	Units
YSENE	BDL	0.33	mg/kg
NZ(A,H)ANTHRACENE	BDL	0.33	mg/kg
UORANTHENE	BDL	0.33	mg/kg
1,2,3-CD)PYRENE	BDL	0.33	mg/kg
THALENE	BDL	0.33	mg/kg
ENANTHRENE	BDL	0.33	mg/kg
CHLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
LOROPHENOL	BDL	0.33	mg/kg
-DIMETHYLPHENOL	BDL	0.33	mg/kg
,4-DINITROPHENOL	BDL	1.6	mg/kg
TACHLOROPHENOL	BDL	1.6	mg/kg
NOL	BDL	0.33	mg/kg
ETRACHLOROPHENOL	BDL	0.33	mg/kg
,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
URROGATE RECOVERY			

LUOROPHENOL	54		% Rec
HENOL-D5	56		% Rec
ROBENZENE-D5	77		% Rec
LUOROBIPHENYL	97		% Rec
,4,6-TRIBROMOPHENOL	52		% Rec
RPHENYL-D14	102		% Rec

Sample Comments

BDL Below Detection Limit

ple chain of custody number 16791.

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ality Assurance Officer: MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
RITAGE LABORATORIES, INC. 4132 POMPANO ST. CHARLOTTE, NC 28216 (704)393-1853	11-DEC-92	2024	B118586
	Complete	PO Number	
	04-JAN-93	530-06-501	
	Printed	Sampled	
	05-JAN-93	09-DEC-92 16:00	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-4
LOG #: 10785

OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.04		Grams
INAL WEIGHT OR VOLUME	50		mL

ROMIUM FAA SW846-7190

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
ROMIUM	11	0.75	mg/kg

COPPER FAA SW846-7210

Analyst: L. SURRATT Analysis Date: 16-DEC-92 Instrument: FAA Test: M112.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
PPER	14	0.75	mg/kg

LEAD FAA SW846-7420

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M116.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
LEAD	25	5.0	mg/kg

AA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
ITIAL WEIGHT OR VOLUME	2.10		Grams
FINAL WEIGHT OR VOLUME	50		mL

 (continued on next page)

ITAGE LABORATORIES, INC. Lab Sample ID: B118586

RSENIC GFAA SW846-7060

lyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
p: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
SENIC	3.6	1.2	mg/kg

ALOGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021

Analyst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: 0461.1.0

Parameter	Result	Det. Limit	Units
HLORODIFLUOROMETHANE	BDL	0.005	mg/kg
HLOROMETHANE	BDL	0.005	mg/kg
YL CHLORIDE	BDL	0.005	mg/kg
MOMETHANE	BDL	0.005	mg/kg
HLOROETHANE	BDL	0.005	mg/kg
ICHLOROFLUOROMETHANE	BDL	0.005	mg/kg
-DICHLOROETHENE	BDL	0.001	mg/kg
CHLOROMETHANE (METHYLENE CHLORIDE)	0.017	0.001	mg/kg
RANS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
OROFORM	BDL	0.001	mg/kg
,1,1-TRICHLOROETHANE	BDL	0.001	mg/kg
RBON TETRACHLORIDE	BDL	0.001	mg/kg
ZENE	BDL	0.001	mg/kg
,2-DICHLOROETHANE	BDL	0.001	mg/kg
RICHLOROETHENE	BDL	0.001	mg/kg
-DICHLOROPROPANE	BDL	0.001	mg/kg
MODICHLOROMETHANE	BDL	0.001	mg/kg
IS-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
UENE	BDL	0.001	mg/kg
,2-TRICHLOROETHANE	BDL	0.001	mg/kg
IBROMOCHLOROMETHANE	BDL	0.001	mg/kg
LOROBENZENE	BDL	0.001	mg/kg
YLBENZENE	BDL	0.001	mg/kg
M/P-XYLENE	0.001	0.001	mg/kg
O-XYLENE	BDL	0.001	mg/kg
,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
THYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
-CHLOROETHYLVINYLETHER	BDL	0.001	mg/kg
-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

C/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550

Analyst: S. WILLIAMS Analysis Date: 11-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
NITIAL WEIGHT OR VOLUME	30.00		Grams
INAL VOLUME	1.0		mL

MI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270

Analyst: R. ROBERTS Analysis Date: 28-DEC-92 Instrument: GC/MS SVOA Test: 0505.3.0
Prep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
CENAPHTHENE	0.59	0.33	mg/kg
NTHRACENE	BDL	0.33	mg/kg
NZ(A)ANTHRACENE	1.1	0.33	mg/kg
NZO(A)PYRENE	2.0	0.33	mg/kg
ENZO(B)FLUORANTHENE	BDL	0.33	mg/kg
NZO(K)FLUORANTHENE	4.9	0.33	mg/kg
S(2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
ARBAZOLE	BDL	0.33	mg/kg

 (continued on next page)

ERITAGE LABORATORIES, INC. Lab Sample ID: B118586

Parameter	Result	Det. Limit	Units
YSENE	1.6	0.33	mg/kg
BENZ(A,H)ANTHRACENE	3.7	0.33	mg/kg
LUORANTHENE	1.8	0.33	mg/kg
(1,2,3-CD)PYRENE	2.0	0.33	mg/kg
HTHALENE	BDL	0.33	mg/kg
HENANTHRENE	BDL	0.33	mg/kg
CHLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
HLOROPHENOL	BDL	0.33	mg/kg
,4-DIMETHYLPHENOL	BDL	0.33	mg/kg
,4-DINITROPHENOL	BDL	1.6	mg/kg
TACHLOROPHENOL	BDL	1.6	mg/kg
NOL	BDL	0.33	mg/kg
ETRACHLOROPHENOL	BDL	0.33	mg/kg
,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
URROGATE RECOVERY			

LUOROPHENOL	42		% Rec
HENOL-D5	46		% Rec
ROBENZENE-D5	66		% Rec
LUOROBIPHENYL	101		% Rec
,4,6-TRIBROMOPHENOL	50		% Rec
RPHENYL-D14	82		% Rec

Sample Comments

BDL Below Detection Limit

Sample chain of custody number 16791.

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Quality Assurance Officer: Helmuth MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
ITAGE LABORATORIES, INC. 132 POMPANO ST. HARLOTTE, NC 28216 (93-1853	11-DEC-92	2024	B118587
	Complete	PO Number	
	04-JAN-93	530-06-501	
	Printed	Sampled	
	05-JAN-93	09-DEC-92 17:30	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-5
LOG #: 10786

OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.04		Grams
AL WEIGHT OR VOLUME	50		mL

OMIUM FAA SW846-7190

lyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0
Pre AA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
OMIUM	5.2	0.75	mg/kg

OPPER FAA SW846-7210

lyst: L. SURRATT Analysis Date: 16-DEC-92 Instrument: FAA Test: M112.1.0
ep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
PER	2.4	0.75	mg/kg

FAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.14		Grams
INAL WEIGHT OR VOLUME	50		mL

ENIC GFAA SW846-7060

Analyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
Prep: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
RSENIC	1.5	1.2	mg/kg

ITAGE LABORATORIES, INC. Lab Sample ID: B118587

EAD GFAA SW846-7421
lyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M116.2.0
p: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
EAD	3.4	1.2	mg/kg

Analysis performed by 3 point MSA

OGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021
lyst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: 0461.1.0

Parameter	Result	Det. Limit	Units
ICHLORODIFLUOROMETHANE	BDL	0.005	mg/kg
OROMETHANE	BDL	0.005	mg/kg
INYL CHLORIDE	BDL	0.005	mg/kg
ROMOMETHANE	BDL	0.005	mg/kg
OROETHANE	BDL	0.005	mg/kg
CHLOROFLUOROMETHANE	BDL	0.005	mg/kg
,1-DICHLOROETHENE	BDL	0.001	mg/kg
HLOROMETHANE (METHYLENE CHLORIDE)	0.012	0.001	mg/kg
NS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
,1-DICHLOROETHANE	BDL	0.001	mg/kg
LOROFORM	BDL	0.001	mg/kg
,1-TRICHLOROETHANE	BDL	0.001	mg/kg
ARBON TETRACHLORIDE	BDL	0.001	mg/kg
ENZENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
CHLOROETHENE	BDL	0.001	mg/kg
,2-DICHLOROPROPANE	BDL	0.001	mg/kg
MODICHLOROMETHANE	BDL	0.001	mg/kg
-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
OL E	0.001	0.001	mg/kg
,1,2-TRICHLOROETHANE	BDL	0.001	mg/kg
ROMOCHLOROMETHANE	BDL	0.001	mg/kg
OROBENZENE	BDL	0.001	mg/kg
THYLBENZENE	BDL	0.001	mg/kg
-XYLENE	0.001	0.001	mg/kg
YLENE	BDL	0.001	mg/kg
,1,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
HYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
HLOROETHYLVINYLETHER	BDL	0.001	mg/kg
,2-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

MS SONICATION EXTRACTION FOR ORGANICS SW846-3550
lyst: S. WILLIAMS Analysis Date: 11-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
ITIAL WEIGHT OR VOLUME	30.00		Grams
NAL VOLUME	1.0		mL

EMI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270
alyst: R. ROBERTS Analysis Date: 16-DEC-92 Instrument: GC/MS SVOA Test: 0505.3.0
Prep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
ENAPHTHENE	4.4	0.33	mg/kg
THRACENE	* 45	3.3	mg/kg
ENZ(A)ANTHRACENE	5.8	0.33	mg/kg
NZO(A)PYRENE	3.1	0.33	mg/kg
(B)FLUORANTHENE	BDL	0.33	mg/kg
ENZO(K)FLUORANTHENE	3.8	0.33	mg/kg

 (continued on next page)

ERITAGE LABORATORIES, INC. Lab Sample ID: B118587

Parameter	Result	Det. Limit	Units
I (2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
ARBAZOLE	* 18	3.3	mg/kg
HRYSENE	4.5	0.33	mg/kg
I A,H)ANTHRACENE	BDL	0.33	mg/kg
L RANTHENE	* 38	3.3	mg/kg
NDENO(1,2,3-CD)PYRENE	0.67	0.33	mg/kg
A HTHALENE	1.8	0.33	mg/kg
H NANTHRENE	* 42	3.3	mg/kg
-CHLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
CHLOROPHENOL	BDL	0.33	mg/kg
, -DIMETHYLPHENOL	BDL	0.33	mg/kg
,4-DINITROPHENOL	BDL	1.6	mg/kg
ENTACHLOROPHENOL	BDL	1.6	mg/kg
P NOL	BDL	0.33	mg/kg
T RACHLOROPHENOL	BDL	0.33	mg/kg
,4,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
2 ,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
SURROGATE RECOVERY			
2 LUOROPHENOL	45		% Rec
PHENOL-D5	57		% Rec
NITROBENZENE-D5	68		% Rec
2 LUOROBIPHENYL	87		% Rec
2 ,6-TRIBROMOPHENOL	108		% Rec
TERPHENYL-D14	118		% Rec

*Note: * - Results taken from 1:10 (GB3443.c) Run on 12/29/92*

Sample Comments

** See Note for Parameter*
B Below Detection Limit

Sample chain of custody number 16791.

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Quality Assurance Officer: Helmuth MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
HERITAGE LABORATORIES, INC. 4132 POMPANO ST. CHARLOTTE, NC 28216 (704)393-1853	11-DEC-92	2024	B118588
	Complete: 04-JAN-93	PO Number: 530-06-501	
	Printed: 05-JAN-93	Sampled: 09-DEC-92 18:15	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-6
LOG #: 10787

FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	2.07		Grams
FINAL WEIGHT OR VOLUME	50		mL

CHROMIUM FAA SW846-7190

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
CHROMIUM	3.1	0.75	mg/kg

Note: Matrix interference suspected due to low matrix spike and matrix duplicate spike recovery.

COPPER FAA SW846-7210

Analyst: L. SURRATT Analysis Date: 16-DEC-92 Instrument: FAA Test: M112.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
COPPER	2.8	0.75	mg/kg

GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	2.23		Grams
FINAL WEIGHT OR VOLUME	50		mL

ARSENIC GFAA SW846-7060

Analyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0

Prep: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
ARSENIC	BDL	1.2	mg/kg

 (continued on next page)

E TAGE LABORATORIES, INC. Lab Sample ID: B118588

EAD GFAA SW846-7421
Analyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M116.2.0
Prep: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
EAD	3.1	1.1	mg/kg

ALOGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021
Analyst: P. WINTERS Analysis Date: 17-DEC-92 Instrument: GC/PID ELCD Test: O461.1.0

Parameter	Result	Det. Limit	Units
ICHLORODIFLUOROMETHANE	BDL	0.005	mg/kg
HLOROMETHANE	BDL	0.005	mg/kg
YL CHLORIDE	BDL	0.005	mg/kg
MOMETHANE	BDL	0.005	mg/kg
HLOROETHANE	BDL	0.005	mg/kg
RICHLOROFLUOROMETHANE	BDL	0.005	mg/kg
-DICHLOROETHENE	BDL	0.001	mg/kg
ICHLOROMETHANE (METHYLENE CHLORIDE)	0.014	0.001	mg/kg
RANS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
OROFORM	BDL	0.001	mg/kg
,1,1-TRICHLOROETHANE	BDL	0.001	mg/kg
ARBON TETRACHLORIDE	BDL	0.001	mg/kg
ZENE	BDL	0.001	mg/kg
,2-DICHLOROETHANE	BDL	0.001	mg/kg
RICHLOROETHENE	BDL	0.001	mg/kg
-DICHLOROPROPANE	BDL	0.001	mg/kg
MODICHLOROMETHANE	BDL	0.001	mg/kg
IS-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
UENE	0.003	0.001	mg/kg
,2-TRICHLOROETHANE	BDL	0.001	mg/kg
IBROMOCHLOROMETHANE	BDL	0.001	mg/kg
LOROBENZENE	BDL	0.001	mg/kg
YLBENZENE	BDL	0.001	mg/kg
M/P-XYLENE	0.001	0.001	mg/kg
O-XYLENE	BDL	0.001	mg/kg
,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
THYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
2-CHLOROETHYLVINYLETHER	BDL	0.001	mg/kg
-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550
Analyst: S. WILLIAMS Analysis Date: 11-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	30.00		Grams
FINAL VOLUME	1.0		mL

SEMI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270
Analyst: R. ROBERTS Analysis Date: 16-DEC-92 Instrument: GC/MS SVOA Test: O505.3.0
Prep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
ACENAPHTHENE	2.9	0.33	mg/kg
ANTHRACENE	* 36	3.3	mg/kg
BENZ(A)ANTHRACENE	* 7.4	3.3	mg/kg
BENZO(A)PYRENE	1.9	0.33	mg/kg
BENZO(B)FLUORANTHENE	BDL	0.33	mg/kg
BENZO(K)FLUORANTHENE	3.6	0.33	mg/kg
BIS(2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
CARBAZOLE	4.4	0.33	mg/kg

TAGE LABORATORIES, INC. Lab Sample ID: B118588

Parameter	Result	Det. Limit	Units
YSENE	5.5	0.33	mg/kg
NZ(A,H)ANTHRACENE	BDL	0.33	mg/kg
UORANTHENE	* 52	3.3	mg/kg
(1,2,3-CD)PYRENE	0.72	0.33	mg/kg
ALENE	BDL	0.33	mg/kg
ENANTHRENE	* 36	3.3	mg/kg
-CHLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
HLOROPHENOL	BDL	0.33	mg/kg
-DIMETHYLPHENOL	BDL	0.33	mg/kg
,4-DINITROPHENOL	BDL	1.6	mg/kg
TACHLOROPHENOL	BDL	1.6	mg/kg
NOL	BDL	0.33	mg/kg
ETRACHLOROPHENOL	BDL	0.33	mg/kg
,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
URROGATE RECOVERY			
LUOROPHENOL	38		% Rec
HENOL-D5	54		% Rec
ROBENZENE-D5	66		% Rec
LUOROBIPHENYL	90		% Rec
,4,6-TRIBROMOPHENOL	93		% Rec
RPHENYL-D14	** 139		% Rec

*e: * - Result taken from 1:10 dilution (GB3444.c) Run on 12/29/92*
*** - Recovery 85% in dilution*

Sample Comments

See Note for Parameter
See Note for Parameter
Below Detection Limit

ample chain of custody number 16791.

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ithout the written approval of the lab.

ality Assurance Officer: Chelmsville MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
ITAGE LABORATORIES, INC. 1132 POMPANO ST. LOTTE, NC 28216 393-1853	15-DEC-92	2024	B118673
	Complete	PO Number	
	04-JAN-93	530-06-506	
	Printed	Sampled	
	05-JAN-93	14-DEC-92 07:30	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-8
LOG #: 10789

OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.14		Grams
NAL WEIGHT OR VOLUME	50		mL

OMIUM FAA SW846-7190

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0
Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
OMIUM	4.2	0.75	mg/kg

OPPER FAA SW846-7210

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M112.1.0
Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
PER	1.9	0.75	mg/kg

FAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
NITIAL WEIGHT OR VOLUME	2.06		Grams
INAL WEIGHT OR VOLUME	50		mL

SENIC GFAA SW846-7060

Analyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
Prep: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
RSENIC	BDL	1.2	mg/kg

ITAGE LABORATORIES, INC. Lab Sample ID: B118673

AD GFAA SW846-7421
yst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M116.2.0
p: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
	2.3	1.2	mg/kg

Analysis performed by 3 point MSA

OGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021
yst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: O461.1.0

Parameter	Result	Det. Limit	Units
HLORODIFLUOROMETHANE	BDL	0.005	mg/kg
ROMETHANE	BDL	0.005	mg/kg
INYL CHLORIDE	BDL	0.005	mg/kg
MOMETHANE	BDL	0.005	mg/kg
OROETHANE	BDL	0.005	mg/kg
RICHLOROFLUOROMETHANE	BDL	0.005	mg/kg
,1-DICHLOROETHENE	BDL	0.001	mg/kg
HLOROMETHANE (METHYLENE CHLORIDE)	* 0.007	0.001	mg/kg
NS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
,1-DICHLOROETHANE	BDL	0.001	mg/kg
OROFORM	BDL	0.001	mg/kg
,1-TRICHLOROETHANE	BDL	0.001	mg/kg
ARBON TETRACHLORIDE	BDL	0.001	mg/kg
NZENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
RICHLOROETHENE	BDL	0.001	mg/kg
,2-DICHLOROPROPANE	BDL	0.001	mg/kg
MODICHLOROMETHANE	BDL	0.001	mg/kg
-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
OLU E	BDL	0.001	mg/kg
,2-TRICHLOROETHANE	BDL	0.001	mg/kg
ROMOCHLOROMETHANE	BDL	0.001	mg/kg
HLOROBENZENE	BDL	0.001	mg/kg
THYLBENZENE	BDL	0.001	mg/kg
-XYLENE	BDL	0.001	mg/kg
-XYLENE	BDL	0.001	mg/kg
,1,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
HYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
HLOROETHYLVINYLETHER	BDL	0.001	mg/kg
,2-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

*e: * - Also found in the blank at 0.006 ppm.*

C/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550
lyst: S. WILLIAMS Analysis Date: 16-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
NITIAL WEIGHT OR VOLUME	30.32		Grams
AL VOLUME	1.0		mL

EMI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270
lyst: R. ROBERTS Analysis Date: 21-DEC-92 Instrument: GC/MS SVOA Test: O505.3.0
ep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
CENAPHTHENE	1.0	0.33	mg/kg
THRACENE	BDL	0.33	mg/kg
ZO(A)ANTHRACENE	BDL	0.33	mg/kg
ENZO(A)PYRENE	BDL	0.33	mg/kg

ERITAGE LABORATORIES, INC. Lab Sample ID: B118673

Parameter	Result	Det. Limit	Units
ZO(B)FLUORANTHENE	BDL	0.33	mg/kg
ZO(K)FLUORANTHENE	BDL	0.33	mg/kg
IS(2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
LE	BDL	0.33	mg/kg
NE	BDL	0.33	mg/kg
IBENZ(A,H)ANTHRACENE	BDL	0.33	mg/kg
ORANTHENE	BDL	0.33	mg/kg
NO(1,2,3-CD)PYRENE	BDL	0.33	mg/kg
APHTHALENE	BDL	0.33	mg/kg
HENANTHRENE	BDL	0.33	mg/kg
HLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
HLOROPHENOL	BDL	0.33	mg/kg
,4-DIMETHYLPHENOL	BDL	0.33	mg/kg
-DINITROPHENOL	BDL	0.33	mg/kg
TACHLOROPHENOL	BDL	0.33	mg/kg
HENOL	BDL	0.33	mg/kg
TRACHLOROPHENOL	BDL	0.33	mg/kg
,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,4,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
ROGATE RECOVERY			
2-FLUOROPHENOL	25		% Rec
NOL-D5	27		% Rec
TROBENZENE-D5	35		% Rec
2-FLUOROBIPHENYL	49		% Rec
2,4,6-TRIBROMOPHENOL	36		% Rec
RPHENYL-D14	51		% Rec

Sample Comments

See Note for Parameter
Below Detection Limit

mple chain of custody number 17170.

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ality Assurance Officer: Helmuth MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
HERITAGE LABORATORIES, INC. 4132 POMPANO ST. CHARLOTTE, NC 28216 (704) 393-1853	15-DEC-92	2024	B118675
	Complete	PO Number	
	30-DEC-92	530-06-506	
	Printed	Sampled	
	05-JAN-93	14-DEC-92 09:45	

Report To	Bill To
SANDRA WATSON SOUTHERN WOOD PIEDMONT P.O. BOX 5447 SPARTANBURG, SC 29304	SOUTHERN WOOD PIEDMONT P.O. BOX 5447 SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-10
LOG #: 10791

FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	2.02		Grams
FINAL WEIGHT OR VOLUME	50		mL

CHROMIUM FAA SW846-7190

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
CHROMIUM	2.6	0.75	mg/kg

COPPER FAA SW846-7210

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M112.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
COPPER	3.9	0.75	mg/kg

LEAD FAA SW846-7420

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M116.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
LEAD	6.2	5.0	mg/kg

FAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	2.08		Grams
FINAL WEIGHT OR VOLUME	50		mL

 (continued on next page)

ITAGE LABORATORIES, INC. Lab Sample ID: B118675

RSENIC GFAA SW846-7060

yst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
p: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
RSENIC	BDL	1.2	mg/kg

LOGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021

Analyst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: 0461.1.0

Parameter	Result	Det. Limit	Units
HLORODIFLUOROMETHANE	BDL	0.005	mg/kg
HLOROMETHANE	BDL	0.005	mg/kg
INYL CHLORIDE	BDL	0.005	mg/kg
MOMETHANE	BDL	0.005	mg/kg
HLOROETHANE	BDL	0.005	mg/kg
RICHLOROFLUOROMETHANE	BDL	0.005	mg/kg
-DICHLOROETHENE	BDL	0.001	mg/kg
HLOROMETHANE (METHYLENE CHLORIDE)	* 0.008	0.001	mg/kg
RANS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
OROFORM	BDL	0.001	mg/kg
,1,1-TRICHLOROETHANE	BDL	0.001	mg/kg
ARBON TETRACHLORIDE	BDL	0.001	mg/kg
ZENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
RICHLOROETHENE	BDL	0.001	mg/kg
-DICHLOROPROPANE	BDL	0.001	mg/kg
MODICHLOROMETHANE	BDL	0.001	mg/kg
IS-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
OLUENE	BDL	0.001	mg/kg
,2-TRICHLOROETHANE	BDL	0.001	mg/kg
IBROMOCHLOROMETHANE	BDL	0.001	mg/kg
HLOROBENZENE	BDL	0.001	mg/kg
HYLBENZENE	BDL	0.001	mg/kg
P-XYLENE	BDL	0.001	mg/kg
O-XYLENE	BDL	0.001	mg/kg
1,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
THYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
2-CHLOROETHYLVINYLETHER	BDL	0.001	mg/kg
2-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

*te: * - Also found in the blank at 0.006 ppm*

/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550

alyst: S. WILLIAMS Analysis Date: 16-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
ITIAL WEIGHT OR VOLUME	30.12		Grams
NAL VOLUME	1.0		mL

EMI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270

alyst: R. ROBERTS Analysis Date: 29-DEC-92 Instrument: GC/MS SVOA Test: 0505.3.0
rep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
ENAPHTHENE	BDL	0.33	mg/kg
THRACENE	BDL	0.33	mg/kg
BENZ(A)ANTHRACENE	0.73	0.33	mg/kg
NZO(A)PYRENE	0.68	0.33	mg/kg
(B)FLUORANTHENE	1.8	0.33	mg/kg
BENZO(K)FLUORANTHENE	BDL	0.33	mg/kg

ERITAGE LABORATORIES, INC. Lab Sample ID: B118675

Parameter	Result	Det. Limit	Units
(2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
RBAZOLE	BDL	0.33	mg/kg
RYSENE	0.92	0.33	mg/kg
A,H)ANTHRACENE	BDL	0.33	mg/kg
DRANTHENE	1.3	0.33	mg/kg
DENO(1,2,3-CD)PYRENE	0.68	0.33	mg/kg
HTHALENE	BDL	0.33	mg/kg
NANTHRENE	BDL	0.33	mg/kg
-CHLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
-CHLOROPHENOL	BDL	0.33	mg/kg
-DIMETHYLPHENOL	BDL	0.33	mg/kg
-DINITROPHENOL	BDL	1.6	mg/kg
ENTACHLOROPHENOL	BDL	1.6	mg/kg
NOL	BDL	0.33	mg/kg
RACHLOROPHENOL	BDL	0.33	mg/kg
,4,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
URROGATE RECOVERY			
LUOROPHENOL	66		% Rec
NOL-D5	78		% Rec
ITROBENZENE-D5	99		% Rec
LUOROBIPHENYL	102		% Rec
,6-TRIBROMOPHENOL	62		% Rec
ERPHENYL-D14	83		% Rec

Sample Comments

See Note for Parameter
BDL Below Detection Limit

mple chain of custody number 17170.

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ality Assurance Officer: Helmuth MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
HERITAGE LABORATORIES, INC. 4132 POMPANO ST. CHARLOTTE, NC 28216 (704) 393-1853	15-DEC-92	2024	B118676
	Complete	PO Number	
	30-DEC-92	530-06-506	
	Printed	Sampled	
	05-JAN-93	14-DEC-92 10:30	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-11
LOG #: 10792

FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	2.29		Grams
FINAL WEIGHT OR VOLUME	50		mL

CHROMIUM FAA SW846-7190

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
CHROMIUM	1.3	0.75	mg/kg

COPPER FAA SW846-7210

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M112.1.0

Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
COPPER	1.0	0.75	mg/kg

GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	2.00		Grams
FINAL WEIGHT OR VOLUME	50		mL

ARSENIC GFAA SW846-7060

Analyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0

Prep: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
ARSENIC	BDL	1.2	mg/kg

 (continued on next page)

ITAGE LABORATORIES, INC. Lab Sample ID: B118676

EAD GFAA SW846-7421
yst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M116.2.0
p: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
EAD	1.9	1.2	mg/kg

Analysis performed by 3 point MSA

OGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021
yst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: O461.1.0

Parameter	Result	Det. Limit	Units
HLORODIFLUOROMETHANE	BDL	0.005	mg/kg
OROMETHANE	BDL	0.005	mg/kg
INYL CHLORIDE	BDL	0.005	mg/kg
ROMOMETHANE	BDL	0.005	mg/kg
OROETHANE	BDL	0.005	mg/kg
ICHLOROFLUOROMETHANE	BDL	0.005	mg/kg
,1-DICHLOROETHENE	BDL	0.001	mg/kg
HLOROMETHANE (METHYLENE CHLORIDE)	* 0.007	0.001	mg/kg
NS-1,2-DICHLOROETHENE	BDL	0.001	mg/kg
,1-DICHLOROETHANE	BDL	0.001	mg/kg
OROFORM	BDL	0.001	mg/kg
,1-TRICHLOROETHANE	BDL	0.001	mg/kg
ARBON TETRACHLORIDE	BDL	0.001	mg/kg
ENZENE	BDL	0.001	mg/kg
-DICHLOROETHANE	BDL	0.001	mg/kg
ICHLOROETHENE	BDL	0.001	mg/kg
1,2-DICHLOROPROPANE	BDL	0.001	mg/kg
OMODICHLOROMETHANE	BDL	0.001	mg/kg
S-1,3-DICHLOROPROPENE	BDL	0.001	mg/kg
TOL E	BDL	0.001	mg/kg
1,1,2-TRICHLOROETHANE	BDL	0.001	mg/kg
BROMOCHLOROMETHANE	BDL	0.001	mg/kg
LOROBENZENE	BDL	0.001	mg/kg
ETHYLBENZENE	BDL	0.001	mg/kg
P-XYLENE	BDL	0.001	mg/kg
XYLENE	BDL	0.001	mg/kg
1,1,2,2-TETRACHLOROETHANE	BDL	0.001	mg/kg
THYL-T-BUTYL ETHER (MTBE)	BDL	0.005	mg/kg
CHLOROETHYLVINYLETHER	BDL	0.001	mg/kg
1,2-DIBROMOETHANE (EDB)	BDL	0.005	mg/kg

*Note: * - Also detected in the blank at 0.006 ppm.*

GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550
alyst: S. WILLIAMS Analysis Date: 16-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	30.13		Grams
NAL VOLUME	1.0		mL

SEMI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270
Analyst: R. ROBERTS Analysis Date: 29-DEC-92 Instrument: GC/MS SVOA Test: O505.3.0
rep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
ACENAPHTHENE	BDL	0.33	mg/kg
THRACENE	BDL	0.33	mg/kg
A)ANTHRACENE	BDL	0.33	mg/kg
BENZO(A)PYRENE	BDL	0.33	mg/kg

 (continued on next page)

ERITAGE LABORATORIES, INC. Lab Sample ID: B118676

Parameter	Result	Det. Limit	Units
ZO(B)FLUORANTHENE	BDL	0.33	mg/kg
NZO(K)FLUORANTHENE	BDL	0.33	mg/kg
IS(2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
OLE	BDL	0.33	mg/kg
YSENE	BDL	0.33	mg/kg
IBENZ(A,H)ANTHRACENE	BDL	0.33	mg/kg
ORANTHENE	BDL	0.33	mg/kg
ENO(1,2,3-CD)PYRENE	BDL	0.33	mg/kg
APHTHALENE	BDL	0.33	mg/kg
HENANTHRENE	BDL	0.33	mg/kg
HLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
CHLOROPHENOL	BDL	0.33	mg/kg
,4-DIMETHYLPHENOL	BDL	0.33	mg/kg
-DINITROPHENOL	BDL	1.6	mg/kg
NTACHLOROPHENOL	BDL	1.6	mg/kg
HENOL	BDL	0.33	mg/kg
ETRACHLOROPHENOL	BDL	0.33	mg/kg
4,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
2,4,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
RROGATE RECOVERY			
2-FLUOROPHENOL	65		% Rec
ENOL-D5	77		% Rec
TROBENZENE-D5	104		% Rec
2-FLUOROBIPHENYL	103		% Rec
2,4,6-TRIBROMOPHENOL	63		% Rec
RPHENYL-D14	91		% Rec

Sample reanalyzed with no improvement in internal standard areas.

Sample Comments

* *See Note for Parameter*
L *Below Detection Limit*

Sample chain of custody number 17170.

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Quality Assurance Officer: Helmuth MB Jansen

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
RITAGE LABORATORIES, INC. 4132 POMPANO ST. CHARLOTTE, NC 28216 (93-1853	11-DEC-92	2024	B118589
	Complete	PO Number	
	04-JAN-93	530-06-501	
	Printed	Sampled	
	05-JAN-93	09-DEC-92 16:30	

Report To

SANDRA WATSON
SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Bill To

SOUTHERN WOOD PIEDMONT
P.O. BOX 5447
SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-7
LOG #: 10788

OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.05		Grams
INAL WEIGHT OR VOLUME	50		mL

OMIUM FAA SW846-7190

lyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0

Pre AA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
OMIUM	9.2	0.75	mg/kg

OPPER FAA SW846-7210

lyst: L. SURRATT Analysis Date: 16-DEC-92 Instrument: FAA Test: M112.1.0

ep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
PER	5.1	0.75	mg/kg

EAD FAA SW846-7420

lyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M116.1.0

ep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
EAD	6.3	5.0	mg/kg

AA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
TIAL WEIGHT OR VOLUME	2.00		Grams
INAL WEIGHT OR VOLUME	50		mL

ITAGE LABORATORIES, INC. Lab Sample ID: B118589

RSENIC GFAA SW846-7060
lyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
p: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
RSENIC	2.3	1.2	mg/kg

Analysis performed by 3 point MSA

OGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021
lyst: P. WINTERS Analysis Date: 15-DEC-92 Instrument: GC/PID ELCD Test: 0461.1.0

Parameter	Result	Det. Limit	Units
HLORODIFLUOROMETHANE	BDL	0.05	mg/kg
OROMETHANE	BDL	0.05	mg/kg
INYL CHLORIDE	BDL	0.05	mg/kg
ROMOMETHANE	BDL	0.05	mg/kg
OROETHANE	BDL	0.05	mg/kg
CHLOROFLUOROMETHANE	BDL	0.05	mg/kg
,1-DICHLOROETHENE	BDL	0.01	mg/kg
HLOROMETHANE (METHYLENE CHLORIDE)	0.06	0.01	mg/kg
NS-1,2-DICHLOROETHENE	BDL	0.01	mg/kg
,1-DICHLOROETHANE	BDL	0.01	mg/kg
OROFORM	BDL	0.01	mg/kg
,1-TRICHLOROETHANE	BDL	0.01	mg/kg
ARBON TETRACHLORIDE	BDL	0.01	mg/kg
ENZENE	BDL	0.01	mg/kg
-DICHLOROETHANE	BDL	0.01	mg/kg
CHLOROETHENE	BDL	0.01	mg/kg
1,2-DICHLOROPROPANE	BDL	0.01	mg/kg
MODICHLOROMETHANE	BDL	0.01	mg/kg
S-1,3-DICHLOROPROPENE	BDL	0.01	mg/kg
TOLUENE	0.02	0.01	mg/kg
1,1,2-TRICHLOROETHANE	BDL	0.01	mg/kg
BROMOCHLOROMETHANE	BDL	0.01	mg/kg
LOROBENZENE	BDL	0.01	mg/kg
THYLBENZENE	0.15	0.01	mg/kg
P-XYLENE	0.08	0.01	mg/kg
XYLENE	0.07	0.01	mg/kg
1,1,2,2-TETRACHLOROETHANE	BDL	0.01	mg/kg
THYL-T-BUTYL ETHER (MTBE)	BDL	0.05	mg/kg
2 CHLOROETHYLVINYLETHER	BDL	0.01	mg/kg
1,2-DIBROMOETHANE (EDB)	BDL	0.05	mg/kg

Note: Sample was diluted 1:10

GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550
alyst: S. WILLIAMS Analysis Date: 11-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	30.00		Grams
FINAL VOLUME	1.0		mL

SEMI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270
Analyst: R. ROBERTS Analysis Date: 16-DEC-92 Instrument: GC/MS SVOA Test: 0505.3.0
rep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
ACENAPHTHENE	** 44	3.3	mg/kg
ACENE	** 10	3.3	mg/kg
(A)ANTHRACENE	3.2	0.33	mg/kg
BENZO(A)PYRENE	0.64	0.33	mg/kg

 (continued on next page)

Parameter	Result	Det. Limit	Units
ZO(B)FLUORANTHENE	BDL	0.33	mg/kg
O(K)FLUORANTHENE	1.2	0.33	mg/kg
IS(2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
RBAZOLE	** 17	3.3	mg/kg
E	1.9	0.33	mg/kg
BENZ(A,H)ANTHRACENE	BDL	0.33	mg/kg
LUORANTHENE	** 26	3.3	mg/kg
ENO(1,2,3-CD)PYRENE	BDL	0.33	mg/kg
HTHALENE	** 44	3.3	mg/kg
HENANTHRENE	** 55	3.3	mg/kg
-CHLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
HLOROPHENOL	BDL	0.33	mg/kg
,4-DIMETHYLPHENOL	BDL	0.33	mg/kg
,4-DINITROPHENOL	BDL	1.6	mg/kg
TACHLOROPHENOL	BDL	1.6	mg/kg
NOL	BDL	0.33	mg/kg
ETRACHLOROPHENOL	BDL	0.33	mg/kg
,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
UROGATE RECOVERY			

-FLUOROPHENOL	50		% Rec
HENOL-D5	61		% Rec
ROBENZENE-D5	* 142		% Rec
LUOROBIPHENYL	104		% Rec
,4,6-TRIBROMOPHENOL	99		% Rec
RPHENYL-D14	103		% Rec

*Note: * - Sample reanalyzed with no improvement in surrogate recovery. Results should be regarded as estimates.*
*** - Results taken from 1:10 dilution (GB3445.c) Run on 12/29/92*

Sample Comments

See Note for Parameter
See Note for Parameter
BDL Below Detection Limit

Sample chain of custody number 16791.

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Quality Assurance Officer: Chelmsith MB Tanner

CERTIFICATE OF ANALYSIS

Service Location	Received	Project	Lab ID
HERITAGE LABORATORIES, INC. 4132 POMPANO ST. CHARLOTTE, NC 28216 704/393-1853	15-DEC-92	2024	B118674
	Complete: 04-JAN-93	PO Number: 530-06-506	
	Printed: 05-JAN-93	Sampled: 14-DEC-92 09:00	

Report To	Bill To
SANDRA WATSON SOUTHERN WOOD PIEDMONT P.O. BOX 5447 SPARTANBURG, SC 29304	SOUTHERN WOOD PIEDMONT P.O. BOX 5447 SPARTANBURG, SC 29304

Sample Description

PROJECT: SWP WILMINGTON
SAMPLE ID: SS-9
LOG #: 10790

FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P129.7.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	2.04		Grams
FINAL WEIGHT OR VOLUME	50		mL

CHROMIUM FAA SW846-7190

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M110.1.0
Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
CHROMIUM	4.1	0.75	mg/kg

COPPER FAA SW846-7210

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M112.1.0
Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
COPPER	4.4	0.75	mg/kg

LEAD FAA SW846-7420

Analyst: L. SURRATT Analysis Date: 17-DEC-92 Instrument: FAA Test: M116.1.0
Prep: FAA OR ICP ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P129.7.0

Parameter	Result	Det. Limit	Units
LEAD	6.9	5.0	mg/kg

GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050

Analyst: M. KRASKA Analysis Date: 15-DEC-92 Test: P130.7.0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	2.09		Grams
FINAL WEIGHT OR VOLUME	50		mL

 (continued on next page)

ITAGE LABORATORIES, INC. Lab Sample ID: B118674

RSENIC GFAA SW846-7060
lyst: M. KRASKA Analysis Date: 18-DEC-92 Instrument: GFAA Test: M103.2.0
ep: GFAA ACID DIGESTION OF S/S/S SAMPLES SW846-3050 P130.7.0

Parameter	Result	Det. Limit	Units
C	BDL	1.2	mg/kg

ALOGENATED AND AROMATIC VOLATILE ORGANICS BY GC/PID ELCD SW846-8021
Analyst: P. WINTERS Analysis Date: 16-DEC-92 Instrument: GC/PID ELCD Test: O461.1.0

Parameter	Result	Det. Limit	Units
ICHLORODIFLUOROMETHANE	BDL	0.025	mg/kg
HLOROMETHANE	BDL	0.025	mg/kg
YL CHLORIDE	BDL	0.025	mg/kg
OMOMETHANE	BDL	0.025	mg/kg
HLOROETHANE	BDL	0.025	mg/kg
ICHLOROFLUOROMETHANE	BDL	0.025	mg/kg
1-DICHLOROETHENE	BDL	0.005	mg/kg
ICHLOROMETHANE (METHYLENE CHLORIDE)	0.020	0.005	mg/kg
RANS-1,2-DICHLOROETHENE	BDL	0.005	mg/kg
1-DICHLOROETHANE	BDL	0.005	mg/kg
LOROFORM	BDL	0.005	mg/kg
1,1,1-TRICHLOROETHANE	BDL	0.005	mg/kg
RBON TETRACHLORIDE	BDL	0.005	mg/kg
NZENE	BDL	0.005	mg/kg
1,2-DICHLOROETHANE	BDL	0.005	mg/kg
ICHLOROETHENE	BDL	0.005	mg/kg
2-DICHLOROPROPANE	BDL	0.005	mg/kg
ROMODICHLOROMETHANE	BDL	0.005	mg/kg
CIS-1,3-DICHLOROPROPENE	BDL	0.005	mg/kg
LUENE	BDL	0.005	mg/kg
1,2-TRICHLOROETHANE	BDL	0.005	mg/kg
DI MOCHLOROMETHANE	BDL	0.005	mg/kg
LOROBENZENE	BDL	0.005	mg/kg
HYLBENZENE	BDL	0.005	mg/kg
M/P-XYLENE	0.007	0.005	mg/kg
O-XYLENE	0.008	0.005	mg/kg
1,2,2-TETRACHLOROETHANE	BDL	0.005	mg/kg
ETHYL-T-BUTYL ETHER (MTBE)	BDL	0.025	mg/kg
2-CHLOROETHYLVINYLETHER	BDL	0.005	mg/kg
2-DIBROMOETHANE (EDB)	BDL	0.025	mg/kg

te: Sample diluted 1:5

/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550
Analyst: S. WILLIAMS Analysis Date: 16-DEC-92 Test: P236.4.0

Parameter	Result	Det. Limit	Units
NITIAL WEIGHT OR VOLUME	30.28		Grams
INAL VOLUME	1.0		mL

EMI-VOLATILE ORGANICS (BASE/NEUTRAL/ACID FRACTIONS) SW846-8270
Analyst: R. ROBERTS Analysis Date: 21-DEC-92 Instrument: GC/MS SVOA Test: O505.3.0
Prep: GC/MS SONICATION EXTRACTION FOR ORGANICS SW846-3550 P236.4.0

Parameter	Result	Det. Limit	Units
CENAPHTHENE	*** 32	6.6	mg/kg
ANTHRACENE	*** 49	6.6	mg/kg
BENZ(A)ANTHRACENE	*** 26	6.6	mg/kg
O(A)PYRENE	** 9.0	1.7	mg/kg
BENZO(B)FLUORANTHENE	*** 15	6.6	mg/kg
BENZO(K)FLUORANTHENE	BDL	0.33	mg/kg

 (continued on next page)

ERITAGE LABORATORIES, INC. Lab Sample ID: B118674

Parameter	Result	Det. Limit	Units
I (2-CHLOROETHYL)ETHER	BDL	0.33	mg/kg
ARBAZOLE	BDL	0.33	mg/kg
HRYSENE	*** 22	6.6	mg/kg
I A,H)ANTHRACENE	0.94	0.33	mg/kg
LUORANTHENE	*** 130	6.6	mg/kg
NDENO(1,2,3-CD)PYRENE	3.4	0.33	mg/kg
A HTHALENE	BDL	0.33	mg/kg
H NANTHRENE	*** 70	6.6	mg/kg
-CHLORO-3-METHYLPHENOL	BDL	0.33	mg/kg
-CHLOROPHENOL	BDL	0.33	mg/kg
, -DIMETHYLPHENOL	BDL	0.33	mg/kg
,4-DINITROPHENOL	BDL	1.6	mg/kg
ENTACHLOROPHENOL	BDL	1.6	mg/kg
H NOL	BDL	0.33	mg/kg
RACHLOROPHENOL	BDL	0.33	mg/kg
,4,5-TRICHLOROPHENOL	BDL	0.33	mg/kg
,6-TRICHLOROPHENOL	BDL	0.33	mg/kg
URROGATE RECOVERY			

LUOROPHENOL	47		% Rec
NOL-D5	51		% Rec
ITROBENZENE-D5	66		% Rec
LUOROBIPHENYL	* 116		% Rec
,6-TRIBROMOPHENOL	100		% Rec
ERPHENYL-D14	107		% Rec

*Ote: * - Sample reanalyzed with no improvement in surrogate recovery. Results should be regarded as estimates.*
*** - Result taken from 1:5 dilution (GB3429.c) Run on 12/28/92*
** - Result taken from 1:20 dilution (GB446.c) Run on 12/29/92*

Sample Comments

* *See Note for Parameter*
* *See Note for Parameter*
*** *See Note for Parameter*
BDL *Below Detection Limit*

Sample chain of custody number 17170.

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ality Assurance Officer: Chelsmith MB Janssen

HERITAGE LABORATORIES, INC.

4132 [illegible]MPANO ROAD
CHARLOTTE, N.C. 28216 (704) 393-1853

Co. Name: ETE, Inc
Project Name: SWP-Wil
Quote No.:
PO No.: 530-06-506

ENVIRONMENTAL PROGRAM:
CWA NPDES_____ IWP_____ SLUDGE_____
RCRA MW_____ SW_____ DISPOSAL_____
SDWA_____ CERCLA/SUPERFUND_____ OTHER_____

Sampled by:

Analyses Requested (Note special detection limits or methods): Wilmington Site-Specific List

Report To:
Co: ETE, Inc
Add: 1445 Ryanchurch Rd
Lexington SC 29072
Attn: Greg Kurtz
Phone: 803-957-6270

Accelerated Turnaround Requested _____ (Subject to Additional Charge)

Result Request by: ___/___/___ (Mo Day Yr) (Date must be Accepted and Approved by Lab.)

Sample ID:	Date:	Time:	Comp	Grab	Sample Description:	Sample Type (Matrix): DW, GW, WW, SOIL, SLUDGE, OTHER	No. of Containers	SV & Metals	VOC	Remarks:	EMS Sample No.
SS-1	12/9/92	14:00		X	SWP Lot #10782	Soil	3	1	2		8118583
SS-2		14:45			10783					Due to rain, SS-8	8118584
SS-3		15:15			10784					SS-9, SS-10, & SS-11	8118585
SS-4		16:00			10785					will be collected	8118586
SS-5		17:30			10786					on 12-14-92.	8118587
SS-6		18:15			10787					They will be fed Ex	8118588
SS-7		16:30			10788					to arrive the morning	8118589
~~SS-8~~										of 12-15-92.	
~~SS-9~~										SS-10 and SS-11 are	
~~SS-10~~										additional samples that	
~~SS-11~~										don't duplicate the previous	
										sample event. GBK	

Relinquished by: (Signature)	Date /Time	Received by: (Signature)	Relinquished by: (Signature)	Date /Time	Received by: (Signature)
Gregory B. Kurtz	12/10/92 / 14:30			/	
Relinquished by: (Signature)	Date /Time	Received by: (Signature)	Relinquished by: (Signature)	Date /Time	Received by: (Signature)
	/			/	
Relinquished by: (Signature)	Date /Time	Received for Lab by: (Signature)	Remarks:		
	12/11/92 / 1000	[signature]			

Distribution: Original and yellow copies accompany sample to laboratory; Pink copy retained by client; Yellow copy returned to client.

TO ENSURE PROPER HANDLING OF SAMPLES PLEASE COMPLETE THIS ENTIRE FORM

HERITAGE LABORATORIES, INC.

4132 POMPANO ROAD
CHARLOTTE, N.C. 28216 (704) 393-1853

Co. Name: ETE, Inc
Project Name: SWP-Wil
Quote No.: Z113586 PO No.: 530-06-506

ENVIRONMENTAL PROGRAM:
CWA NPDES_____ IWP_____ SLUDGE_____
RCRA MW_____ SW_____ DISPOSAL_____
SDWA_____ CERCLA/SUPERFUND_____ OTHER_____

Sampled by:

Analyses Requested (Note special detection limits or methods): Wilmington Site-Specific List

Report To:
Co: ETE, Inc
Add: 1445 Pisgah Church Rd
Lexington, SC 29072
Attn: Greg Kurtz
Phone: 803-957-6270

Accelerated Turnaround Requested _____ (Subject to Additional Charge)

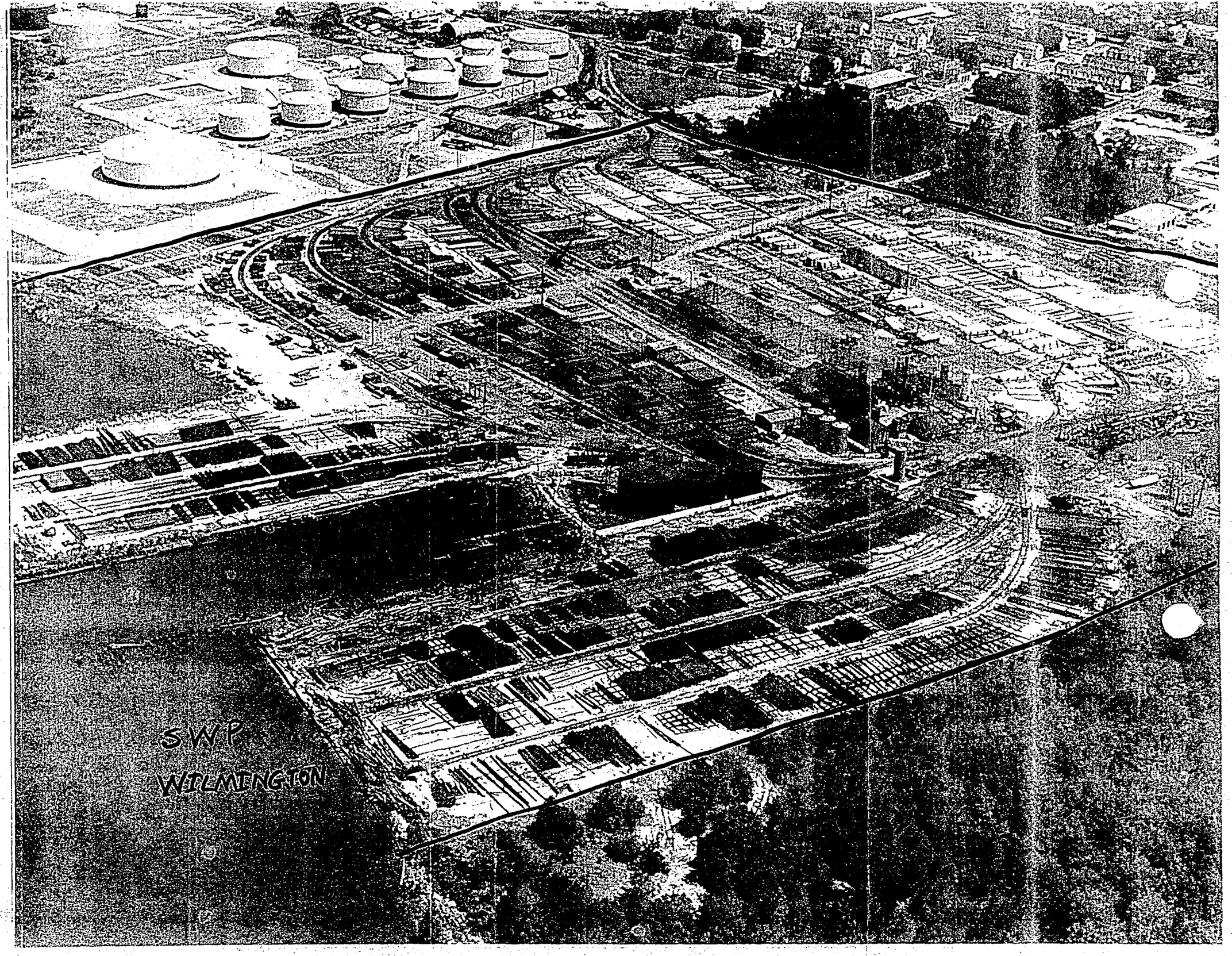
Result Request by: ___/___/___ (Mo Day Yr) (Date must be Accepted and Approved by Lab.)

Sample ID:	Date:	Time:	Comp	Grab	Sample Description:	Sample Type (Matrix): DW, GW, WW, SOIL, SLUDGE, OTHER	No. of Containers	SV & Metals	VOC	Remarks:	EMS Sample No.
SS-8	12/14/92	7:30		X	SWP Log# 10789	Soil	3	1	2	Final samples to	8118673
SS-9	↓	9:00		↓	10790	↓	↓	↓	↓	Sample set collected	8118674
SS-10	↓	9:45		↓	10791	↓	↓	↓	↓	on 12/9/92.	8118675
SS-11	↓	10:30		↓	10792	↓	↓	↓	↓		8118676

Relinquished by: (Signature)	Date /Time	Received by: (Signature)	Relinquished by: (Signature)	Date /Time	Received by: (Signature)
Gregory R. Kurtz	12/14/92 12:15			/	
Relinquished by: (Signature) Federal Express	Date /Time 12/15/92 1200	Received by: (Signature) Chris Diggs	Relinquished by: (Signature)	Date /Time /	Received by: (Signature)
Relinquished by: (Signature)	Date /Time /	Received for Lab by: (Signature)	Remarks:		

Distribution: Original and yellow copies accompany sample to laboratory; Pink copy retained by client; Yellow copy returned to client.

M-3241 1" = 1:500 1-22-94 RC-20
NCDOT HWYS PHTGM UNIT 9-174
SOUTHERN WOOD PIEDMONT CO.
WILMINGTON, NC
NCD 058 517 467
FR2 0 RC-3/3* SD- w/h-006000 006000
25.6 d=0000 1 d=0000 26.6V -64mb ER000 CAM5113


SWP
WILMINGTON

SOUTHERN WOOD PIEDMONT CO.
WILMINGTON, NC
NCD 058 517 467

Cemeteries

Bellevue Cemetery ..... H 20
Greenlawn Memorial Cemetery ..... H 14
Oakdale Cemetery ..... H 19
Pine Forest Cemetery ..... H 20

Fire Stations

Castle Hayne Fire Station ..... I 11
Myrtle Grove Fire Station ..... J 28
Federal Point Fire Dept ..... I 36
Ogden Fire Dept ..... O 17
Seagate Fire Station ..... N 22
South Wilmington Fire Station ..... G 26
Winter Park Fire Station ..... K 22
Wrightsboro Fire Station ..... H 16

Golf Courses

Beau Rivage Plantation ..... I 29
Cape Fear Country Club ..... H 22
Duck Haven Country Club ..... M 26
Echo Farms Golf Course ..... H 26
Inland Greens Par 3 Golf Course ..... H 19
Pine Valley Country Club ..... H 24
The Cape Golf Course ..... I 33
Wilmington Golf Course ..... K 22

Hospitals

Cape Fear Memorial Hospital ..... L 22
New Hanover Regional Medical Center ..... H 23

Parks

Annie Snipes Park ..... H 20
Arrowhead Park ..... I 28
Beaumont Park ..... I 20
Blair Noble Park ..... N 18
Bobby Benson Park ..... J 27
Bullock Park ..... H 25
Cameron Park ..... O 23
Carolina Lake Park ..... J 38
Castle Hayne Site ..... I 13
Castle Hayne Site ..... L 18
Church Nun Park ..... H 21
Empire Park ..... I 21
Fawn Creek Site Park ..... L 25
Fort Fisher County Park ..... H 42
Goldsen Field System ..... F 24
Greenfield Gardens ..... O 22
Greenfield Park ..... O 22
Greensboro Mini Park ..... O 22
Hanover Heights Park ..... H 24
Hilton Park ..... G 19
Hines Park ..... I 36
Hugh McRae Athletic Facility ..... J 23
Hugh McRae County Park ..... K 23
Island Drive Mini Park ..... P 22
Kennedy Park ..... H 20
Love Grove Park ..... H 19
Malden Park ..... H 19
Mary Bridge Park ..... H 20
Masonboro Island Park ..... L 31
Masonboro Island Park ..... N 27
Mike Chappell Park ..... I 36
Monterey Heights Site Park ..... I 30
Mothers Park ..... G 21
Mulnea Park ..... I 21
Myrtle Grove Park ..... K 28
Northside Park ..... G 19
Nuttalee Park ..... H 21
Ogden Site ..... H 17
Parkwood Park ..... L 17
River Road Site Park ..... H 29
Riverside Park ..... F 21
Riverside Park ..... I 10
Robert Strange Park ..... G 21
S Channel Mini Park ..... P 22
Snow Cut County Park ..... I 35
Sunset Park ..... O 23
Thomas Lilley Park ..... I 20
Trask Park ..... K 15
Triangle Park ..... I 21
Wallace Park ..... H 20
Wrightsville Beach Town Park ..... P 22

Points of Interest

Airlie Gardens Marina ..... N 22
Center Fishing Pier ..... J 37
City Hall ..... P 22
Coast Guard Dock ..... O 24
Coast Line Center ..... P 20
Coast Line Convention Center ..... P 20
Convention Visitors Bureau Information Center ..... G 20
Corning Inc ..... L 19
Crystal Pier ..... P 23
Fishermans Pier ..... J 36
Fort Fisher State Historic Site ..... I 41
Legion Stadium ..... G 23
Library ..... G 20
Marina ..... M 26
Marina ..... P 22
Mercers Pier ..... O 22
Monkey Junction ..... J 26
NARC ..... I 20
New Hanover International Airport ..... I 18
North Carolina Aquarium ..... I 41
Post Office & Federal Building ..... G 20
Pier ..... I 39
Riverfront Visitors Information Booth ..... F 21
Rock Hill Community Center ..... H 14
Sewage Treatment Plant ..... H 18
University Center ..... K 20
University Commons ..... L 20
University Landing ..... K 20
USS NC Battleship Memorial ..... F 20

Schools

A.H. Snipes Elementary School ..... H 20
Bradley Creek Elementary School ..... M 23
Carolina Beach Elementary School ..... I 36
College Park Elementary School ..... L 20
D.C. Virgo Middle School ..... G 19
Dorothy B. Johnson Elementary School ..... G 19
E.A. Alderman Elementary School ..... I 23
E.A. Laney High School ..... K 15
E.B. Trask Middle School ..... K 15
Forest Hills Elementary School ..... I 21
Gregory Elementary School ..... H 21
Haywood G Bellamy Elementary School ..... I 29
JC Roe Elementary School ..... G 24
JJ Blair Elementary School ..... N 19
John T. Hoggard High School ..... I 23
M.W. Howe Elementary School ..... H 21
Mary C. Williams Elementary School ..... I 28
MCS Noble Middle School ..... N 19
Myrtle Grove Elementary School ..... K 28
New Hanover High School ..... H 20
New Learning Center ..... H 22
Ogden Elementary School ..... O 18
Pine Valley Elementary School ..... J 25
Roland-Grise Middle School ..... J 23
Sunset Park Elementary School ..... G 23
University of North Carolina at Wilmington ..... L 21
W.H. Blount Elementary School ..... J 20
Williston Middle School ..... G 21
Winter Park Elementary School ..... K 22
Wrightsville Beach Elementary School ..... P 22

Shopping Centers

Hanover Shopping Center ..... I 22
Independence Mall ..... I 22
Landfall Shopping Center ..... N 21
Long Leaf Mall ..... J 23
Market Place ..... L 20
Myrtle Grove Shopping Center ..... J 28
Rotane Outlet Mall ..... J 21

Wilmington Downtown Inset

1. Wilmington Railroad Foundation Inc.
1. Coast Line Center
1. Coast Line Convention Center
2. Cotton Exchange
3. New Hanover County Public Library, North Carolina Room
4. Federal Building
5. George R. French & Sons Building
6. City Hall
7. County Courthouse & Vis. Info. Ctr.
8. John A. Taylor House
9. Bellamy House
10. Riverfront Visitor Information Booth
11. Burgwin-Wright House
12. Donald Mac Rae House
13. New Hanover County Museum
14. St. John's Museum of Art
15. Zebulon Latimer House
16. Smith-Anderson House
17. Chandlers Wharf
18. Governor Dockery House
19. Post Office

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Racine, Wisconsin 53403
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Cartography by: Bryan Pukowniia
Matt Anderson

LEGEND

ROADS & BOUNDARIES

- DIVIDED HIGHWAY, CONTROLLED ACCESS
- DIVIDED HIGHWAY, UNCONTROLLED ACCESS
- UNDIVIDED HIGHWAY
- DIVIDED ARTERIAL
- ARTERIAL
- STREET, MINOR ROAD
- RAILROAD
- CITY BOUNDARY
- COUNTY BOUNDARY
- STATE BOUNDARY
- ZIP CODE BOUNDARY
- 37228 ZIP CODE NUMBER

SYMBOLS & PATTERNS

- PARK
- GOLF COURSE
- FOREST
- CEMETERY
- AIRPORT
- POINT OF INTEREST
- SHOPPING CENTER
- SCHOOL
- COLLEGE/UNIVERSITY
- HOSPITAL

HIGHWAYS

90 INTERSTATE — 17 U. S. — 50 STATE

MILES 0 0.5 1

CONTINUED ON MAP 3
CONTINUED ON MAP 1
CONTINUED ON MAP 1
CONTINUED ON MAP 2
CONTINUED ON MAP 2

MAP 1

MAP 2

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CHILD DAY CARE SECTION

OUNTY: 65 NEW HANOVER MONTHLY ALPHABETIC LISTING AS OF 1992-09-30

FACILITIES

ID/ ABBREV	OPERATION NAME/ OPERATOR NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	RENEW POCI
555116 IC A C	A LITTLE CLASS A LITTLE CLASS, INC.	106 PINE GROVE DRIVE	WILMINGTON	NC	28405 919/452-3433	07/9
555100 IC A C	ADVENTURE WORLD DAY CARE CENTER ADVENTURE WORLD INCORPORATED	4604 LONGLEAF HILLS DR.	WILMINGTON	NC	28409 919/392-0868	07/9
555112 IC A C	BUILDING BLOCKS CHILD CARE CENTER RHONDA GORE AND KAY LAIRD	P. O. BOX 26 HWY. 17, 5908 CASTLE HAYNE RD.	CASTLE HAYNE CASTLE HAYNE	NC	28429 919/675-3249	04/9
555074 IC A C	CAROLINA PRESCHOOL FARMER, SUE	6501 CAROLINA BEACH ROAD HIGHWAY 421 S	WILMINGTON WILMINGTON	NC	28409 919/392-1560	07/9 0654003
5000010 EMP C	CAROLINA PRESCHOOL ON MARKET FARMER CYNTHIS A	7409 MARKET STREET	WILMINGTON	NC	28405 919/686-1010	07/9 0654006
555103 IC A C	CARRAWAY FAMILY DAY CARE CARRAWAY, ANNIE	1930 CHURCH STREET	WILMINGTON	NC	28403 919/763-9022	08/9 0654004
555119 IC A C	CHILD DEVELOPMENT CENTER CHILD DEVELOPMENT CENTER, INC.	608 S. COLLEGE ROAD	WILMINGTON	NC	28403 919/392-6417	04/9 0652000
5000012 EMP C	CHILD DEVELOPMENT CENTER CHILD DEVELOPMENT CENTER, INC.	608 S. COLLEGE ROAD 4702 S. COLLEGE ROAD	WILMINGTON WILMINGTON	NC	28403 919/392-6417	08/9 0654006
555117 IC A L	CHILD'S PLAY DAY CARE TOZOUR, JACQUELINE J.	619 ALBEMARLE ROAD 619 ALBEMARLE ROAD	WIMINGTON WILMINGTON	NC	28405 919/791-8143	08/9 0654005
5000007 IC A L	CHILD'S PLAY DAY CARE SOUTH TOZOUR JACQUELINE	902 SHIPYARD DRIVE 902 SHIPYARD DRIVE	WILMINGTON WILMINGTON	NC	28403 919/350-1272	06/9 0654005
555113 IC A C	CLASSY BEARS DAY CARE & PRESCHOOL CLASSY BEARS PRESCHOOL DAY CARE, INC.	6620 WINDMILL WAY	WILMINGTON	NC	28405 919/791-7872	06/9
553972 IC A C	CREATIVE WORLD II CREATIVE WORLD, INC.	2411 FLINT DRIVE	WILMINGTON	NC	28401 919/799-5195	10/9 0654004
555084 IC A C	CREATIVE WORLD II PRIMARY DAY SCHOOL CREATIVE WORLD, INC.	2411 FLINT DRIVE	WILMINGTON	NC	28401 919/799-5195	10/9 0654004
552015 IC A C	CREATIVE WORLD PRESCHOOL CREATIVE WORLD, INC.	4202 WILSHIRE BLVD.	WILMINGTON	NC	28403 919/791-2080	03/9 0654004
555012 IC AA C	CREEKWOOD NORTH DAY CARE CENTER CREEKWOOD NORTH HOMEBUYER ASSOCIATION	1210 KORNEGAY AVENUE 1210 KORNGAY AVENUE	WILMINGTON WILMINGTON	NC	28405 919/762-4546	05/9 0652000
555081 IC A C	DISCOVERY PLACE OF WILMINGTON CIRCLE B CORPORATION	3806 CHERRY AVENUE	WILMINGTON	NC	28403 919/799-0560	04/9
555082 IC A C	EARLY CHILDHOOD LEARNING CENTER EDUCO, INC.	4102 PEACHTREE AVENUE	WILMINGTON	NC	28403 919/392-4637	06/9

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CHILD DAY CARE SECTION

OUNTY: 65 NEW HANOVER MONTHLY ALPHABETIC LISTING AS OF 1992-09-30

FACILITIES

ID/ ABBREV	OPERATION NAME/ OPERATOR NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	RENEW POCN
552994 IC A C	EPHESUS DAY CARE CENTER EPHESUS SEVENTH DAY ADVENTIST CHURCH	1002 CASTLE STREET	WILMINGTON			05/9 06540036
555110 IC A C	GORDON ROAD DAY CARE WATSON, MARILYN	6768 GORDON ROAD	WILMINGTON	NC	28405 919/350-0629	06/9
555075 IC A C	GRANNY'S DAY CARE CENTER GRANNY'S DAY CARE CENTER, INC.	7010 MARKET STREET	WILMINGTON	NC	28405 919/686-4405	12/9
559005 S110 C	GREATER LOVE CHAPEL CHURC H OF GOD IN CHRIST GREATER LOVE CHAPEL CHURCH OF GOD IN CHRIST	1105 N. 8TH STREET	WILMINGTON	NC	99999 919/763-4797	11/9 0654005
555111 IC A L	HAPPY KIDS DAY CARE HUMPHREY, NORMA	521 KELLY ROAD	WILMINGTON	NC	28409 919/395-5286	03/9
555080 IC A C	HEAD START OF NEW HANOVER COUNTY HEAD START OF NEW HANOVER COUNTY	P. O. BOX 3434 507 N. 6TH STREET	WILMINGTON WILMINGTON	NC	28401 919/762-1177	01/9
5000025 ROV C	HELEN A HIGGINS MONTESSORI SCHOOL HIGGINS PEGGY	4915 ORIOLE DRIVE	WILMINGTON	NC	28403 919/392-7007	06/9
555042 IC A C	HOOD'S DAY CARE HOOD, ELLEN	419 RUTLEDGE DRIVE	WILMINGTON	NC	28412 919/799-6266	06/9
555104 IC A C	ISLANDER CHILD CARE ISLANDER CHILD CARE, INC.	204 ATLANTA AVENUE	CAROLINA BEACH	NC	28428 919/458-6258	04/9 0654004
555062 IC A C	KINDER CARE KINDER CARE, INC.	2619 NEWKIRK AVENUE	WILMINGTON	NC	28403 919/799-7195	12/9 0654003
555056 IC A C	LITTLE FRIENDS LEARNING CENTER I FINLEY, GALE P. AND JAMES L.	1551 41ST ST.	WILMINGTON	NC	28403 919/395-5400	06/9 0654008
555120 IC A C	LITTLE FRIENDS LEARNING CENTER III LITTLE FRIENDS PRESCHOOL, INC.	1553 41ST STREET 4808 NEW CENTRE DRIVE	WILMINGTON WILMINGTON	NC	28403 919/452-4444	10/9 0654005
555091 IC A C	LITTLE FRIENDS LEARNING CENTER III FINLEY, JAMES L. AND GALE P.	1553 41ST ST. 1553 41ST STREET	WILMINGTON WILMINGTON	NC	28403 919/395-5400	06/9 0654003
555025 IC A C	LITTLE RED SCHOOLHOUSE LITTLE RED SCHOOLHOUSE DAY CARE, INC.	ROUTE 3, BOX 279-A 2931 BLUE CLAY ROAD, SR 1318	CASTLE HAYNE CASTLE HAYNE	NC	28429 919/762-5724	02/9 0654004
5000009 IC A C	MCCLURE PRESBYTERIAN PRESCHOOL CENTER MCCLURE MEMORIAL PRESBYTERIAN CHURCH, INC.	P. O. BOX 26 HWY. 17, 5908 CASTLE HAYNE RD.	CASTLE HAYNE CASTLE HAYNE	NC	28429 919/675-3249	06/9 0654006
555118 IC A C	MCLEAN'S EARLY LEARNING CENTER MCLEAN, MAGNOLIA H.	617 S. 4TH STREET 625 S. 4TH STREET	WILMNGTON WILMINGTON	NC	28401 919/762-4066	07/9 0654005
555121 ROV C	MOTHER GOOSE CHILD CARE AND LEARNING CENTER, INC. MOTHER GOOSE CHILD CARE & LRNG. CTR., INC.	7409 MARKET STREET	WILMINGTON	NC	28405 919/686-1010	05/9 0654005

ID/ ABBREV	OPERATION NAME/ OPERATOR NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	RENEW/ POCNO
55079 C A C	MS. PAT'S INFANT CARE AND PRESCHOOL MCCOY, PATRICIA W.	1212 S. EIGHTH STREET	WILMINGTON	NC	28401 919/251-9811	10/93 06540035
59004 110 C	MYRTLE GROVE CHRISTIAN SCHOOL MYRTLE GROVE CHRISTIAN SCHOOL, INC.	800 PINER ROAD	WILMINGTON	NC	28409 919/392-2067	02/93
55124 C A C	NANCY'S LITTLE JEWELS CHILD DEVELOPMENT CENTER INMAN, NANCY	3504 N. KERR AVENUE	WILMINGTON	NC	28405 919/251-1108	05/93
55115 C A C	NOAH'S ARK DAY CARE CENTER MASONBORO BAPTIST CHURCH	1501 BEASELY RD.	WILMINGTON	NC	28409 919/395-0059	08/93
55072 C A C	PARK AVENUE SCHOOL YOPP INVESTMENTS, INC.	1306 FLORAL PARKWAY	WILMINGTON	NC	28406 919/791-6217	12/92 06540050
52919 C A L	PEARSON'S KINDERGARTEN PEARSON, MARY FRANCES	710 SOUTH ELEVENTH STREET	WILMINGTON	NC	28401 919/762-0050	05/93 06540011
55021 C AA C	PRESCHOOL ENRICHMENT PROGRAM SOUTHEASTERN MENTAL HEALTH CENTER	2023 S. 17TH STREET	WILMINGTON	NC	28401 919/251-6497	07/93
55126 C A L	PRIDE & JOY PLAYWORLD PRIDE & JOY PLAYWORLD, INC.	227 DIXIE AVENUE	WILMINGTON	NC	28403 919/395-1055	09/93
55077 C A C	SHAW SPEAKS DAY CARE CAPE FEAR AME ZION CHURCH CONFERENCE	718 S. THIRD STREET 718 SOUTH THIRD STREET	WILMINGTON WILMINGTON	NC	28401 919/343-1441	08/93 06540034
55057 C A C	SOUTHEASTERN PRESCHOOL EDUCATION CENTER SOUTHEASTERN PRESCHOOL EDUCATIONAL CTR., INC.	207 PINE GROVE DRIVE	WILMINGTON	NC	28403 919/799-4140	01/93 06540022
55066 C A C	SOUTHEASTERN PRESCHOOL EDUCATION CENTER SOUTHEASTERN PRESCHOOL ED. CTR., INC.	207 PINE GROVE DRIVE 3625 S. COLLEGE RD.	WILMINGTON WILMINGTON	NC	28403 919/799-4160	06/93 06540027
52992 C A C	ST. THOMAS PRESCHOOL ST. MARY CATHOLIC CHURCH - PARISH COUNCIL	109 S. 2ND STREET	WILMINGTON	NC	28401 919/762-7764	05/93
59008 110 C	THE KING'S MEMORIAL CHRISTIAN ACADEMY THE KING'S MEMORIAL CHRISTIAN ACAD. BOARD OF DIREC	1380 N. COLLEGE ROAD	WILMINGTON	NC	28405 919/799-8157	04/93
55045 C A C	TINY TOT NURSERY BASS, PEGGY	3910 MARKET STREET	WILMINGTON	NC	28403 919/762-4829	08/93
55125 C A C	TOTAL CHILD CARE CENTER, INC. TOTAL CHILD CARE CENTER, INC.	4304 HENSON DRIVE HENSON DRIVE NORTHCHASE	WILMINGTON WILMINGTON	NC	28405 919/799-3556	08/93 06540057
53479 C AA C	UCP DEVELOPMENTAL CENTER UCP OF NORTH CAROLINA, INC.	P. O. BOX 5003 2035 OLEANDER DRIVE	WILMINGTON WILMINGTON	NC	28403 919/762-7222	05/93 06520003
59001 110 C	UNITED ADVENT CHRISTIAN CHURCH PRE. & CH. DEV. PR UNITED ADVENT CHRISTIAN CHURCH PRE. COMM.	4912 SOUTH COLLEGE ROAD	WILMINGTON	NC	28412 919/791-9564	04/93

DATE 10/08/92 GHA043 DIVISION OF FACILITY SERVICES
CHILD CARE SECTION
COUNTY: 65 NEW HANOVER MONTHLY ALPHABETIC LISTING AS OF 1992-09-30
FACILITIES

ID/ ABBREV	OPERATION NAME/ OPERATOR NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	RE P
6559002 GS110 C	WESLEY MEMORIAL PRESCHOOL DEV. CENTER WESLEY MEMORIAL METHODIST CHURCH	1401 S. COLLEGE ROAD	WILMINGTON	NC	28403 919/791-4002	1
6559006 GS110 C	WILMINGTON CHRISTIAN ACADEMY PRESCHOOL WILMINGTON CHRISTIAN ACADEMY	1401 N. COLLEGE ROAD	WILMINGTON	NC	28405 919/791-4248	1
6555069 LIC A C	WINTER PARK BAPTIST PRESCHOOL WINTER PARK BAPTIST CHURCH WEEKDAY ED. COMM.	4700 WRIGHTSVILLE AVENUE 4700 WRIGHTSVILLE AVENUE	WIMINGTON WILMINGTON	NC	28403 919/799-2029	0
6554359 LIC A C	WINTER PARK PRESCHOOL I WINTER PARK PRESCHOOL, INC.	4306 LAKE AVENUE	WILMINGTON	NC	28403 919/799-4276	0 0651
6555037 LIC A C	WINTER PARK PRESCHOOL II WINTER PARK PRESCHOOL II, INC.	19 LENNON DRIVE	WILMINGTON	NC	28405 919/392-3430	0 0651
6555071 LIC A C	WINTER PARK PRIMARY SCHOOL WINTER PARK PRESCHOOL, INC.	4306 LAKE AVENUE	WILMINGTON	NC	28403 919/395-5818	0 0654
6555101 LIC A C	YOUNG PARENTS INFANT CARE & PRESCHOOL MCCOY, PATRICIA W.	~~1912 NUN STREET~~ 1020 MEARES STREET	WILMINGTON WILMINGTON	NC	28403 919/251-6197	1 0654
6555127 LIC A C	YWCA CENTER AT HOUSTON MOORE YWCA OF WILMINGTON, NC, INC.	1601 S. 13TH STREET	WILMINGTON	NC	28401 919/251-9159	0 0654

CHILD DAY CARE SECTION

COUNTY: 65 NEW HANOVER MONTHLY ALPHABETIC LISTING AS OF 1992-09-30

HOMES

ID/ ABBREV	OPERATOR NAME/ OPERATION NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	REN PO
6505392 REG S	BARNHILL, MARY MARY BARNHILL DAY CARE HOME	4818 W. LORD BYRON RD.	WILMINGTON	NC	28405 919/395-4261	02
65000002 REG S	BLACKWELL, DOTTIE DOTTIE BLACKWELL'S DAY CARE HOME	600 CARVER COURT	CASTLE HAYNE	NC	28429 919/675-9339	05
6505400 REG S	BLANTON, PAULA S. THE LITTLE PLAYROOM	6704 RUSHWOOD CT.	WILMINGTON	NC	28405 919/395-4891	02
6505409 REG S	BOYD, ELIZABETH ELIZABETH BOYD DAY CARE HOME	1910 NUN ST	WILMINGTON	NC	28403 919/251-8223	06 06570
65000013 TEMP S	BOYD, ELIZABETH ELIZABETH BOYD DAY CARE HOME	1306 QUEEN STREET	WILMINGTON	NC	28401 919/251-8223	07 06570
6505436 REG S	BROWN, KAREN KAREN BROWN DAY CARE HOME	6416 SPICEWOOD ST.	WILMINGTON	NC	28405 919/799-7392	04
6505417 REG S	BUNTING, KATHERINE KATHERINE BUNTING'S CHID DAY CARE HOME	818 SOUTH 10TH ST. 818 SOUTH 10TH STREET	WILMINGTON WILMINGTON	NC	28401 919/762-3516	06 06570
6505408 REG S	BURNS, KAY G. KAY G. BURNS DAY CARE HOME	383 SHORE POINT DR.	WILMINGTON	NC	28405 919/686-9679	05
6505407 REG S	CANTERBURY, JOAN CANTERBURY, JOAN	105 BUCCANEER RD	WILMINGTON	NC	28409 919/392-2302	04
65000016 REG S	CLARK, THERESA A. THERESA CLARK DAY CARE HOME	801 JENNINGS DR.	WILMINGTON	NC	28403 919/791-0449	07
6505432 REG S	COSLEY, ELMA ELMA COSLEY'S DAY CARE HOME	1009 KENNINGSTON STREET	WILMINGTON	NC	27405 919/791-1570	11 06570
65000019 REG S	DAVID, RUBY J. HOUSE OF LOVE DAY CARE	1617 N. 26TH ST.	WILMINGTON	NC	28405 919/763-3758	09 06570
6505333 REG S	DEVANE, ANNIE MAE ANNIE MAE DEVANE'S DAY CARE HOME	1904 CHURCH STREET	WILMINGTON	NC	28403 919/343-8955	02 06570
6505356 REG S	DUKES, MYRA LITTLE MISS MUFFIN'S	4623 D GREENTREE RD. 4623 D GREENTREE ROAD	WILMINGTON WILMINGTON	NC	28405 919/799-3646	10 06570
6505081 REG S	ELDER, FRANCES FRANCES ELDER'S DAY CARE HOME	4110 LYNBROOK DRIVE	WILMINGTON	NC	28405 919/799-9443	08 06570
6505339 REG S	EVERETT, CLARA CLARA EVERETT DAY CARE HOME	2009 CREECY AVE.	WILMINGTON	NC	28403 919/762-0137	03 06570
65000008 REG S	EVERETT, ELIZABETH ELIZABETH EVERETT DAY CARE HOME	322 SOUTH 17TH STREET	WILMINGTON	NC	28403	02 06570

ID/ ABBREV	OPERATOR NAME/ OPERATION NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	RENEW POCN
505368 EG S	FIELDS, KIMBELY KIMBELY FIELDS' CHILD DAY CARE HOME	14 NEIL COURT	WILMINGTON	NC	28405 919/392-3809	02/9 0657004
503589 EG S	FLOWERS, AMANDA AMANDA FLOWERS' CHILD DAY CARE HOME	2324 WRIGHTSVILLE AVE.	WILMINGTON	NC	28403 919/763-0075	01/9
505425 EG S	FRAMILLA, ROBIN LOVING ARMS CHILD CARE	1436 A HARBOUR DRIVE	WILMINGTON	NC	28401 919/350-0992	06/9
505422 EG S	FREEMAN, CAROL R. CAROL FREEMAN'S CHILD DAY CARE HOME	117 RAY DR. 117 RAY DRIVE	WILMINGTON WILMINGTON	NC	28405 919/111-1111	03/9
505387 EG S	GARD, SHELIA F. SHELIA F. GARD'S DAY CARE HOME	918 PARKWAY BOULEVARD	WILMINGTON	NC	28412 919/799-9870	10/9 0657006
505388 EG S	GARDNER, KOKETHA MAE KOKETHA MAE GARDNER'S DAY CARE HOME	11 W. GARDEN LAKE ESTATE	WILMINGTON	NC	28401 919/762-8995	11/9 0657005
505307 REG S	GORE, SHIRLEY SHIRLEY GORE'S CHILD DAY CARE HOME	213 NORMANDY DRIVE	WILMINGTON	NC	28412 919/791-0324	03/9
5000020 REG S	GRAY, JUANITA JUANITA GRAY DAY CARE HOME	137 SOUTHWOLD DRIVE	WILMINGTON	NC	28409 919/392-5854	08/9 0657007
65000001 REG S	GREEN, FELICIA FELICIA GREEN DAY CARE HOME	4457 HOLLY TREE ROAD	WILMINGTON	NC	28412 919/392-3054	05/ 0657007
6505291 REG S	HAM, ROSE ROSE HAM'S CHILD DAY CARE HOME	722 PORTORS NECK ROAD	WILMINGTON	NC	28405 919/686-4364	12/9
6505391 REG S	HAMMONDS, DEBI DEBI HAMMONDS' DAY CARE HOME	238 YULAN DRIVE	WILMINGTON	NC	28412 919/392-1812	01/
6505418 REG S	HARVEY, LINDA LINDA HARVEY'S CHILD DAY CARE HOME	201 TANBRIDGE RD. 201 TANBRIDGE ROAD	WILMINGTON WILMINGTON	NC	28405 919/799-7079	11/
65000022 REG S	HARVEY, LINDA LINDA HARVEY'S CHILD DAY CARE HOME	6263 TURTLE HALL DRIVE 6263 TURTLE HALL DRIVE	WILMINGTON WILMINGTON	NC	28409 919/799-7079	09/
6505223 REG S	HASAN, AQUEELAH HABEEBAH HASAN FAMILY DAY CARE HOME	1619 NORTH 26TH ST.	WILMINGTON	NC	28405 919/763-0709	09/
6505405 REG S	HATCHELL, BRENDA F. BRENDA F. HATCHELL'S DAY CARE HOME	114 DISNEY DRIVE	WILMINGTON	NC	28409 919/395-4297	05/
65000017 REG S	HENSON, LINDA J. STEPING STONES DAY CARE HOME	1014 BROWNING DR.	WILMINGTON	NC	28405 919/791-3021	09/
6505165 REG S	HOPKINS, IRENE IRENE HOPKINS DAY CARE HOME	206 ROGERSVILLE RD.	WILMINGTON	NC	28403 919/799-0378	04/ 065700

ID/ ABBREV	OPERATOR NAME/ OPERATION NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	RENEW/ POCNO
05308 G S	HUNT, JONNIE JONNIE HUNT'S DAY CARE HOME	635 SPRINGTIME ROAD	WILMINGTON	NC	28405 919/791-0827	05/93
05403 G S	JOHNSON, DEBBIE JOE JOHNSON, DEBBIE JOE	706 DOCK ST	WILMINGTON	NC	28401 919/762-9540	04/94 06570058
05216 G S	JUNIOUS, EARTHA M. EARTHA M. JUNIOUS' DAY CARE HOME	918 S. 14TH STREET	WILMINGTON	NC	28401 919/763-1585	05/93
05293 G S	KEELS, PATRICIA M. KEEL'S FAMILY DAY CARE HOME	1007 S. 5TH STREET 1007 SOUTH 5TH STREET	WILMINGTON WILMINGTON	NC	28401 919/763-6605	10/94 06570020
05402 G S	KELLY, CRYSTAL WINNER TENDER LOVING CARE CHRISTIAN HOME PRESCHOOL	4825 STILLWELL RD.	WILMINGTON	NC	28412 919/111-1111	04/94
05429 G S	KENNEDY, TAMMY E. TAMMY E. KENNEDY'S DAY CARE HOME	2706 DARE STREET	WILMINGTON	NC	28412 919/791-5374	11/93
05369 G S	KING, CYNTHIA LYNN CYNTHIA LYNN KING'S DAY CARE HOME	921 SPRING VALLEY ROAD	WILMINGTON	NC	28405 919/392-1341	02/93
05383 G S	KIRBY, ANN ANN KIRBY'S DAY CARE HOME	117 KENNETH COURT	WILMINGTON	NC	28405 919/395-0394	09/93 06570066
05431 G S	LIVENGOOD, DEBBIE DEBBIE LIVENGOOD'S DAY CARE HOME	214 ROCKWELL ROAD	WILMINGTON	NC	28405 919/452-7296	10/93
05419 G S	MELVIN, SHIRLEY SHIRLEY MELVIN'S CHILD DAY CARE HOME	1207 KORNEGAY AVE. 1207 KORNEGAY AVENUE	WILMINGTON WILMINGTON	NC	28405 919/762-4716	12/92 06570063
000003 G S	MORGAN, SUSAN D. SUSAN MORGAN DAY CARE HOME	3601 BETHEL ROAD	WILMINGTON	NC	28409 919/799-5392	05/94 06570073
000023 G S	MUSE, CARRIE MUSE FAMILY DAY CARE HOME	4625 NORWICH ROAD	WILMINGTON	NC	28405 919/452-5517	09/94 06570079
05424 G S	PARRETT, PATRICIA PATRICIA PARRETT'S DAY CARE HOME	205 LOVE GRASS COURT	WILMINGTON	NC	28405 919/395-0661	05/93
05426 G S	PATTERSON, HAZEL HAZEL PATTERSON'S DAY CARE HOME	506 GOVERNORS ROAD	WILMINGTON	NC	28405 919/395-1352	11/93 06570069
000021 G S	REASON, EDITH WEE CARE	2323 OAKLEY ROAD	CASTLE HAYNE	NC	28429 919/763-6169	08/94
05281 G S	RHODES, KUANGKUM RHODES, KUANGKUM	4817 CALDER CT	WILMINGTON	NC	28405 919/791-5102	03/93
05220 G S	RILEY, BERNICE BERNICE RILEY'S CHILD DAY CARE HOME	1121 ORANGE ST. 1121 ORANGE STREET	WILMINGTON WILMINGTON	NC	28401 919/762-0035	09/92

CHILD DAY CARE SECTION

NTY: 65 NEW HANOVER MONTHLY ALPHABETIC LISTING AS OF 1992-09-30

HOMES

ID/ BBREV	OPERATOR NAME/ OPERATION NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	RENEW/ POCNO
5398 S	SANDERS, MARY MARY SANDERS DAY CARE HOME	5325 DANDELION DR.	WILMINGTON	NC	28405 919/395-5098	03/94
5430 S	SHINGLETON, RACHEL RACHEL SHINGLETON'S DAY CARE HOME	26 STATION ROAD	WILMINGTON	NC	28405 919/791-5898	11/93
5175 S	SKIPPER, SHARON SHARON SKIPPER DAY CARE HOME	654 WINDEMERE RD	WILMINGTON	NC	28405 919/395-1561	07/94
00005 S	SMITH, KIM R. KIM SMITH DAY CARE HOME	4620 BARNARDS LANDING ROAD	WILMINGTON	NC	28412 919/452-2945	06/94
5203 S	SMITH, SHARRON SMITH, SHARON	510 CLEARBROOK DR	WILMINGTON	NC	28409 919/395-2961	06/94
00015 S	SMITH, TRUDY H. TRUDY SMITH'S DAY CARE HOME	5407 WRIGHTSVILLE AVE.	WILMINGTON	NC	28403 919/392-3361	07/94
5394 S	TAYLOR, MARY J. MARY J. TAYLOR'S DAY CARE HOME	6727 OLD BRICK ROAD	WILMINGTON	NC	28412 919/395-0654	02/94 06570056
4376 S	THOMAS, DOROTHY THOMAS FAMILY DAY CARE HOME	308 NUN STREET	WILMINGTON	NC	28401 919/762-8355	08/93 06570001
5415 S	TYNER, KAREN TYNER, KAREN	142 EL OGDEN DRIVE	WILMINGTON	NC	28405 919/686-9755	10/92
5421 S	TYNER, SUSAN SUSAN TYNER'S CHILD DAY CARE HOME	112 RAINTREE COURT 7708 SIDBURY ROAD	WILMINGTON WILMINGTON	NC	28405 919/686-0016	03/93
5265 S	WALKER, SARAH J. SARAH J. WALKER DAY CARE HOME	1611 NORTH 26TH ST.	WILMINGTON	NC	28405 919/763-2556	04/94
00018 S	WILLIAMS, PAMELA P. PAMELA WILLIAMS DAY CARE HOME	5827 RENEE COURT	WILMINGTON	NC	28403 919/799-2409	08/94
5390 S	WILSON, KATHRYN F. KATHRYN F. WILSON'S DAY CARE HOME	4946 WILDERNESS ROAD	WILMINGTON	NC	28412 919/799-2306	11/93 06570054
5248 S	WILSON, LINDA LINDA WILSON DAY CARE HOME	419 S 18TH ST	WILMINGTON	NC	28403 919/763-4466	08/94 06570060
5359 S	WRIGHT, LINDA R WRIGHT, LINDA R	1803 ANN ST	WILMINGTON	NC	28403 919/762-6124	10/92
5434 S	YATTIE, MEALING MEALING, YATTIE	1017 PRINCESS ST	WILLINGTON	NC	28401 919/762-8090	02/94 06570071
5413 S	YOUNG, CYNTHIA YOUNG, CYNTHIA	605 ROSE AVE	WILMINGTON	NC	28403 919/799-9514	08/92

NTY: 65 NEW HANOVER

ID/ BBREV	OPERATOR NAME/ OPERATION NAME	MAILING ADDRESS/ LOCATION ADDRESS	CITY	ST	ZIP/ PHONE	RENEW/ POCNO
5406 S	YOUNG, LYNITA P. LYNITA P. YOUNG DAY CARE HOME	225 GEORGIA AVE.	CAROLINA BEACH	NC	28428 919/458-4627	05/94 06570061
5107 S	ZYGMUNT, CATHY CATHY ZYGMUNT'S DAY CARE HOME	1214 SIDNEY DRIVE	WILMINGTON	NC	28405 919/799-8084	06/93 06570080

Holyfield

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Epidemiology

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary

DEHNR

Ref. 54

February 17, 1994

MEMORANDUM

TO: Doug Holyfield, Head
Waste Management Branch

FROM: Luanne K. Williams, Pharm.D., Toxicologist
Environmental Epidemiology Section

SUBJECT: Risk Assessment Review Southern Wood Piedmont
Wilmington, North Carolina

I have reviewed the soil sample results (only) as requested and offer the following comments:

1. The estimated excess lifetime cancer risk for the future construction worker (shown on Table 7-1) of 6×10^{-6} is not acceptable. The generally accepted incremental lifetime cancer risk is 1×10^{-6}. I disagree with the third finding and conclusion on page 9-1 which reads as follows:

   "The total ELCR calculated for a future site construction worker was 6×10^{-6} and is within the target risk range of 10^{-4} to 10^{-6}."

   ELCR of 6×10^{-6} is not within the range of 10^{-4} to 10^{-6}. The ELCR of 6×10^{-6} is greater than 1×10^{-6}.

2. It is stated on page 1-1 that "the future use proposed by the City of Wilmington and the North Carolina Ports Authority is for low intensity industrial use." The exposure pathways considered in this report included "incidental soil ingestion, dermal (skin) contact with soil, and inhalation of dust on-site during future construction activities." (Page 6-1) According to the report, it was <u>assumed</u> that future land use will remain industrial/commercial.

We cannot assume that future land use will remain industrial. When evaluating the risk from exposure to contaminants on a particular site, <u>ALL</u> future uses of the property (which includes residential) must be considered in order to protect public health.

3. The exposure point concentrations (shown on Table 3-1) for the following contaminants are above what is considered acceptable for industrial and residential use. I have listed the recommended remediation levels. (USEPA, Region III, October 15, 1993 Risk-Based Concentration Table).

Contaminants	Remediation Levels (mg/kg)
Benzo(a)anthracene	.87
Benzo(a)pyrene	.088
Benzo(b)fluoranthene	.87
Benzo(k)fluoranthene	8.8
Dibenzo(a,h)anthracene	.088
Indeno(1,2,3-cd)pyrene	.87
Pentachlorophenol	5.3
TCDD equivalents	.0043 ug/kg*

* In a national dioxin study, EPA sampled soils from 138 rural and 221 urban sites not associated with sources of 2,3,7,8-TCDD. Only 17 of the rural and urban soils had detectable levels of 2,3,7,8-TCDD at a concentration range of .0002 ug/kg - .0112 ug/kg. (Toxic Materials News, 1987 Survey finds little dioxin at control sites. Industry finds trace amounts in paper products and highest levels at pesticide plants. September 30, p. 301). The TCDD equivalents detected of 2.27 - 3.14 ug/kg suggests contamination introduced on the site.

All of these contaminants have been reported to cause cancer in animals. The long-term exposure to the current contaminant levels could significantly increase a resident or worker's risk of developing cancer.

If you have any questions, please contact me at (919) 733-3410.

LKW:tm

Enclosures

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Solid Waste Management

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary
William L. Meyer, Director

DEHNR

RECEIVED
MAR 18 1994
SUPERFUND SECTION

March 17, 1994

Mr. T.M. Davis, Manager
Environmental Affairs
Southern Wood Piedmont
P.O. Box 5447
Spartanburg, South Carolina 29304

RE: Southern Wood Piedmont - Wilmington, North Carolina
Administrative Order on Consent - NCD058517467

Dear Mr. Davis:

This office has reviewed the Risk Assessment Report for the Landfarm areas at the noted facility. The purpose of this report was to summarize remedial activities at the site within the requirements stipulated to in the 1985 Consent Agreement. This consent agreement was designed to close out the surficial, operational part of the site as well as remediating part of the Superfund areas by land applying contaminated soils in an on-site landfarm. Southern Wood Piedmont was to continue landfarming activities until residual concentrations are determined not to have a significant impact on the public health and the environment as determined by the State. Consequently, this office transmitted a copy of this Risk Assessment Report to the Environmental Epidemiology Section for their review to determine if these residual levels are "Protective of Human Health and the Environment".

A copy of Dr. Luanne Williams' report, dated February 17, 1994 is attached. In review of her report, she has considered that all future uses of the property, including residential must be considered when evaluating the risk from exposure. Therefore, her acceptable remediation levels are considerably lower than the residual levels reported by SWP.

In recent discussions with Dr. Williams, she indicated that if Southern Wood Piedmont in coordination with the City of Wilmington and the N.C. Ports Authority can provide detailed information on the exact future use of the property, such as low intensity industrial (assumed in the report), then alternate residual concentrations may be considered. The following concentrations

have been provided by Dr. Williams as being acceptable in Industrial Soils without cover:

Benzo(a)anthracene	3.9	mg/kg
Benzo(a)pyrene	.39	mg/kg
Benzo(b)fluoranthene	3.9	mg/kg
Benzo(k)fluoranthene	39.0	mg/kg
Dibenzo(a,h)anthracene	.39	mg/kg
Indeno(1,2,3-cd)pyrene	3.9	mg/kg
Pentachlorophenol	24.0	mg/kg
TCDD equivalents	.019	ug/kg

With cover, such as that provided by soils or concrete, whereby no exposures are possible, existing levels in the landfarm may be acceptable. Otherwise, the Industrial or Residential levels apply. These residual levels not only apply to the landfarm area, but the wood storage areas as well (data for contaminated soils in the treated and non-treated wood storage areas indicate significant levels of contamination, and in fact much greater than the levels in the landfarm, i.e. TWS-10B). In addition, risk for construction workers would have to be reduced to minimize exposure by additional personal protective equipment.

In conclusion, please contact me at (919-733-2178) or Dr. Williams (919-733-3410) if you have any questions or comments regarding this review or if you would like to arrange a meeting.

Sincerely,

R. Douglas Holyfield

R. Douglas Holyfield, Head
Waste Management Branch
Hazardous Waste Section

attachment:

cc: Jerry Rhodes
Flint Worrell
✓Pat DeRosa
Glenn Dunn
Dr. Luanne Williams

DEPARTMENT OF COMMERCE
G. Hodges, Secretary

WEATHER BUREAU
F. W. Reichelderfer, Chief

TECHNICAL PAPER NO. 40

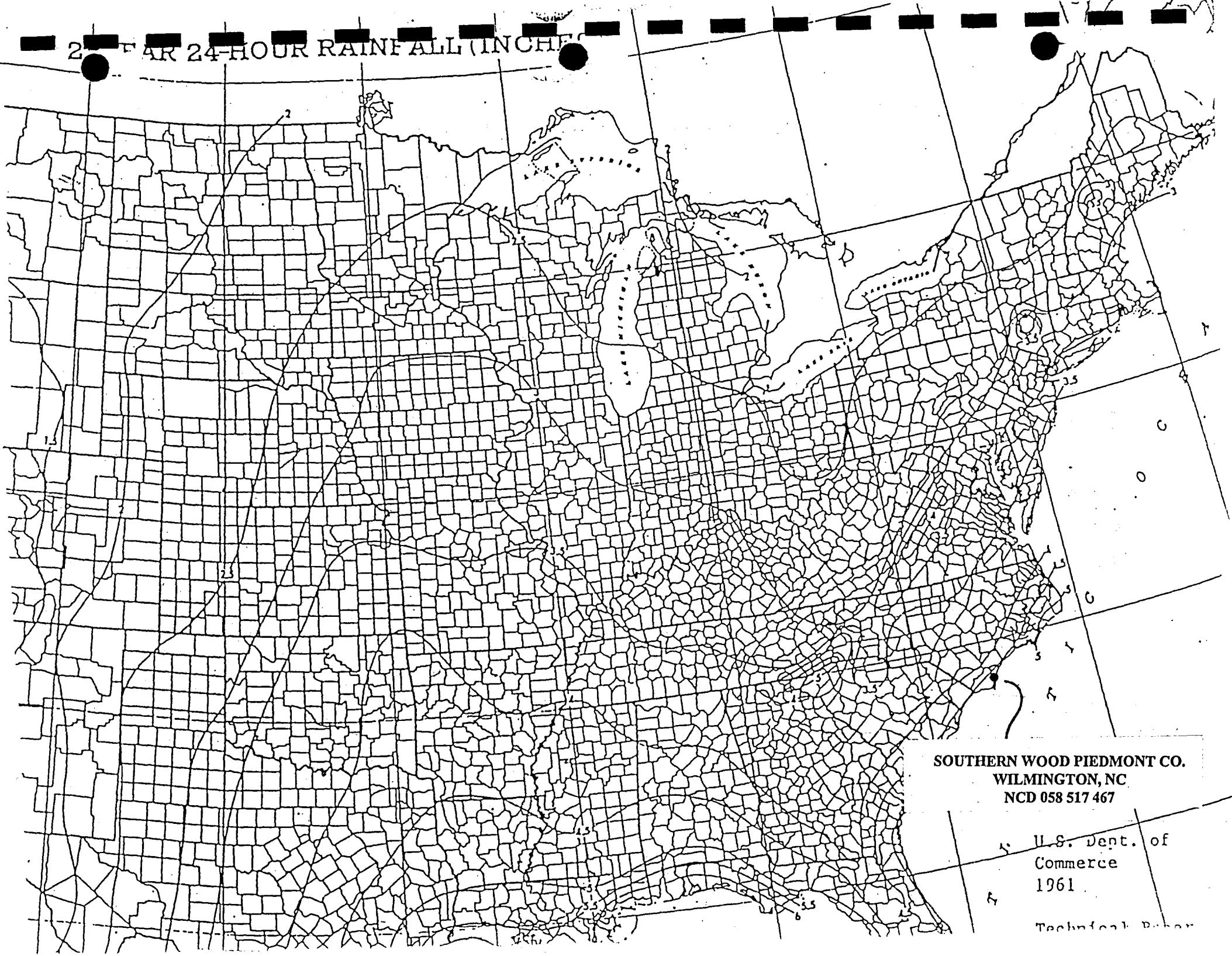
RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

Prepared by
DAVID M. HERSHFIELD
Cooperative Studies Section, Hydrologic Services Division
for
Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

PROPERTY OF EPA
FIT IV

Ref. 55


2-YEAR 24-HOUR RAINFALL (INCHES)
SOUTHERN WOOD PIEDMONT CO.
WILMINGTON, NC
NCD 058 517 467
U.S. Dept. of
Commerce
1961

Site Name: Southern Wood Piedmont Wilmington
Site Number: NCD 058 517 46

Site Location: Wilmington, New Hanover County, N.C.

Site Coordinates:

34 13 01.0	77 57 08.5
34 13 01.0	77 56 54.5
34 12 48.0	77 56 52.0
34 12 47.0	77 57 13.0

Date: October 05, 1994

Calculation Results

Distance from Site Location	Population		Number of Households	
	Per Ring	Cumulative	Per Ring	Cumulative
0 to 1/4 mile	527	527	260	260
>1/4 to 1/2 mile	828	1,355	447	707
>1/2 to 1 mile	7,206	8,561	3,445	4,152
>1 to 2 miles	16,147	24,708	7,857	12,009
>2 to 3 miles	12,212	36,920	5,545	17,554
>3 to 4 miles	14,994	51,914	6,592	24,146

Note: The populations and number of households within specified target distance rings were calculated for the NC Superfund Section by the NC State Center for Geographic Information and Analysis using the 1990 US Census data. These values were calculated by summing the population and the number of households data for each census block located within each target ring. For census blocks lying only partially within the ring, the per cent area of the block within the ring was multiplied by the population and household densities of the block.

MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist
Date: September 30, 1994
Re: Southern Wood Piedmont Co., Wilmington
NCD 058 517 467
Telecommunication with Chuck Davis, Southern Wood Piedmont Co.

SFP telephoned Chuck Davis, Manager, Environmental Affairs, SWP (803-599-1075) on 9/30/94 with questions to follow up the SIP site reconnaissance.

SFP inquired as to the areas and depths of excavation and filling at the site. According to Chuck Davis, excavated areas (and depths) included the drip track and wood treating areas (3-5 feet deep), the adjacent treating cylinders (12-15 feet), the CCA area (as indicated by the arsenic testing results), the aboveground tank farm by the river (5-8 feet), the aboveground diesel tanks (3 feet, around their concrete slabs) and the former creosote ditch (10-12 feet). The creosote ditch area was 50-75 feet wide, narrowing to 15-20 feet by the plant, and this area contributed the most soil for treatment. The excavations were backfilled with sandy clay brought from a borrow pit 10-15 miles from the site, apparently supplied by a "Billy White". The NTA, NTB, and TWS areas were not excavated.

SFP inquired as to the fate of the CCA area soils that were not stabilized with cement at the site. CD replied that soils exceeding 5 ppm arsenic EP Tox concentration were transported to the GSX (now Laidlaw) hazardous waste landfill in Pinewood, South Carolina.

Ref. 58

RECEIVED
FEB 14 1994
SUPERFUND SECTION

W P
RECEIVED
SEP 7 1992
EPA - REGION IV
ATLANTA, GA

FINAL
EXPANDED SITE INSPECTION

DATE REPORT ACCEPTED 2/10/94
DISPOSITION High priority
SAM SIGNATURE [illegible]

Old ATC Refinery
Wilmington, New Hanover County, North Carolina

EPA ID № NCD986186518
WasteLAN № 05591

EPA Work Assignment № 14
EPA Contract № 68-W9-0055

Prepared for the
U. S. Environmental Protection Agency
Region IV

Prepared by

B&V Waste Science and Technology Corp
BVWST Project № 52014.100

September 2, 1993

Prepared by
Jancie S. Hatcher for
Scotti Thomas
Site Manager

Reviewed by
Jancie S. Hatcher
Jancie S. Hatcher
Technical Reviewer

Approved by
Hubert Wieland
Project Manager

Ref. 59

STATE OF NORTH CAROLINA

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

WILMINGTON COAL GAS
NCD 986 188 910
Preliminary Assessment

Mary Ganley
Hydrogeologist
December 1991

MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist
Date: December 20, 1994
Re: Southern Wood Piedmont Co, Wilmington
NCD 058 517 467
Source Area Dimensions

SFP utilized various methods and sources to estimate the volumes and/or surface areas of the various contaminant source areas designated during the SIP investigation. Methods are summarized below:

1) Track & Treating Areas: The Treating Area dimensions were estimated to be 250 x 200 ft. = 50,000 sq.ft., using Fig. 4 of ETE/Virogroup's Phase III Report (Ref. 7). The Track Area was assumed to be about 1 acre = 43,560 sq. ft. The depth of excavation in each area was reported by Chuck Davis to be about 4 ft (Ref. 57). Volume therefore = 93,560 sq. ft. x 4 ft.= 374,240 cu. ft. = 13,861 cu. yd.

2) Buried Creosote Ditch: The ditch was reported in the PA Letter Report (Ref. 10) to be 5 ft. x 25 ft. x 500 ft. = 125000 sq. ft.area = 62,500 cu. ft. volume (3215 cu. yd.).

3) Landfarm Areas: The landfarming areas were reported by Geraghty & Miller (Refs. 12-13) to be 5 acres in area.

4) Non-treated wood storage (NTA, NTB): Based on Geraghty & Miller's descriptions and illustrations (Ref. 14), the two areas measure approximately 750 ft. x 750 ft., and approximately 525 x 750 ft., or 956,250 sq. ft. (21.95 acres) total. The sampled depth interval is approximately 6 in. Therefore the combined volume of the areas is 478,125 cu. ft. or 17,208 cu. yd.

5) Treated wood storage(TWS): Based on Geraghty & Miller's descriptions and illustrations (Ref. 14), the area measures approximately 300 x 900 ft. and was sampled to a depth of 1.5 ft.
The area is therefore approximately 270,000 sq. ft. (6.2 acres), the volume is 270,000 ft. x 1.5 ft. = 405,000 cu. ft. = 15,000 cu yd.

6) Creosote Tank Storage Area: This area, based on the Geraghty & Miller report, measures approximately 120 ft. x 80 ft., and was contaminated to about 1 ft. deep (Refs. 7, 9). The volume is therefore 21,600 cu. ft. or 800 cu. yd.

7) Chromated Copper Arsenate (CCA)area: 93 cu.yd.of soils were treated at the area and another 98 cu. yd. were removed (Ref. 19).