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SITE INSPECTION REPORT
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BELLMAWR, NEW JERSEY
VOLUME 2 OF 2

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FOR THE

ENVIRONMENTAL SERVICES DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY

SEPTEMBER 6, 1991

HALLIBURTON NUS CORPORATION
SUPERFUND DIVISION

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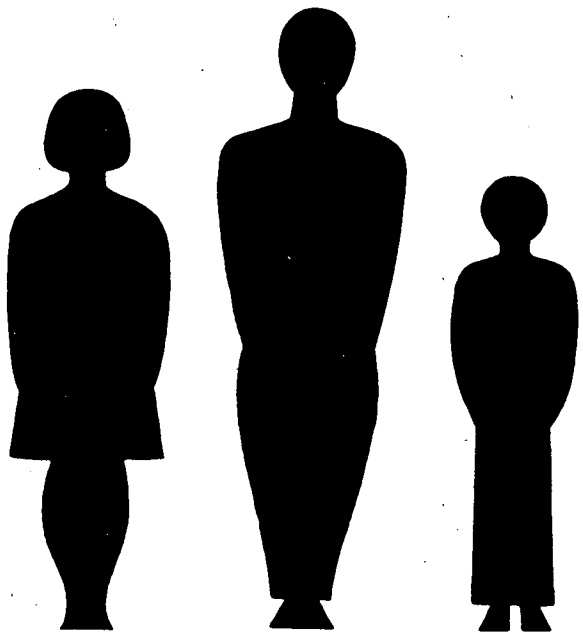
REFERENCE NO. 19

Official State Estimates

Population Estimates for New Jersey

JULY 1, 1982



OFFICE OF DEMOGRAPHIC AND ECONOMIC ANALYSIS
DIVISION OF PLANNING AND RESEARCH
DEPARTMENT OF LABOR
C N 388
TRENTON, NEW JERSEY 08625 - 0388

THOMAS H. KEAN
Governor

ROGER A. BODMAN
Commissioner

SEPTEMBER 1983

POPULATION ESTIMATES FOR NEW JERSEY:

REVISED ESTIMATES, JULY 1, 1981

AND

PROVISIONAL ESTIMATES, JULY 1, 1982

OFFICIAL STATE ESTIMATES

STATE OF NEW JERSEY

THOMAS H. KEAN, GOVERNOR

Department of Labor

Roger A. Bodman, Commissioner

Office of Demographic and Economic Analysis

Division of Planning and Research

CN 388

Trenton, New Jersey 08625-0388

September 1983

RESIDENT POPULATION

CAMDEN COUNTY	CENSUS COUNTS, APRIL 1, 1980	REVISED ESTIMATES, JULY 1, 1981	PROVISIONAL ESTIMATES, JULY 1, 1982
Audubon borough	9,533	9,530	9,556
Audubon Park borough	1,274	1,272	1,275
Barrington borough	7,418	7,413	7,428
Bellmawr borough	13,721	13,730	13,768
Berlin borough	5,786	5,796	5,818
Berlin township	5,348	5,464	5,495
Brooklawn borough	2,133	2,135	2,140
Camden city	84,910	84,608	84,238
Cherry Hill township	68,785	69,437	69,855
Chesilhurst borough	1,590	1,618	1,638
Clementon borough	5,764	5,767	5,771
Collingswood borough	15,838	15,817	15,848
Gibbsboro borough	2,510	2,517	2,525
Gloucester township	45,156	46,589	47,248
Gloucester City city	13,121	13,100	12,918
Haddon township	15,875	16,117	16,155
Haddonfield borough	12,337	12,351	12,383
Haddon Heights borough	8,361	8,355	8,380
Hi-Nella borough	1,250	1,249	1,251
Laurel Springs borough	2,249	2,254	2,259
Lawnside borough	3,042	3,031	3,041
Lindenwold borough	18,196	18,271	18,353
Magnolia borough	4,881	4,900	4,911
Merchantville borough	3,972	3,964	3,973
Mount Ephraim borough	4,863	4,862	4,875
Oaklyn borough	4,223	4,217	4,231
Pennsauken township	33,775	33,972	34,115
Pine Hill borough	8,684	8,753	8,916
Pine Valley borough	23	24	24
Runnemede borough	9,461	9,462	9,482
Somerdale borough	5,900	5,901	5,922
Stratford borough	8,005	7,996	8,013
Tavistock borough	9	9	9
Voorhees township	12,919	15,249	15,867
Waterford township	8,126	8,501	8,665
Winslow township	20,034	20,952	21,435
Woodlynne borough	2,578	2,583	2,586
TOTAL	471,650	477,766	480,367

RESIDENT POPULATION

GLOUCESTER COUNTY	CENSUS COUNTS, APRIL 1, 1980	REVISED ESTIMATES, JULY 1, 1981	PROVISIONAL ESTIMATES, JULY 1, 1982
Clayton borough	6,013	6,013	6,033
Deptford township	23,473	23,553	23,713
East Greenwich township	4,142	4,176	4,202
Elk township	3,187	3,245	3,305
Franklin township	12,396	12,708	13,158
Glassboro borough	14,574	14,644	14,677
Greenwich township	5,406	5,396	5,409
Harrison township	3,585	3,622	3,655
Logan township	3,078	3,196	3,311
Mantua township	9,193	9,168	9,174
Monroe township	21,639	22,038	22,376
National Park borough	3,552	3,529	3,540
Newfield borough	1,563	1,553	1,548
Paulsboro borough	6,944	6,927	6,903
Pitman borough	9,744	9,691	9,696
South Harrison township	1,486	1,525	1,564
Swedesboro borough	2,031	2,025	2,033
Washington township	27,878	29,100	29,507
Wenonah borough	2,303	2,304	2,305
West Deptford township	18,002	18,000	18,084
Westville borough	4,786	4,748	4,755
Woodbury city	10,353	10,757	10,772
Woodbury Heights borough	3,460	3,452	3,469
Woolwich township	1,129	1,138	1,144
TOTAL	199,917	202,508	204,333

REFERENCE NO. 20

Series 1961, No. 42

Issued April 1966

SOIL SURVEY

Camden County New Jersey

OUR SOIL * OUR STRENGTH

This is the last report of the 1961 series.

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
NEW JERSERY AGRICULTURAL EXPERIMENT STATION

Contents

	Page
How this soil survey was made	1
General soil map	3
1. Aura-Downer association	3
2. Downer-Woodstown-Dragston association	3
3. Freehold-Holmdel-Collington association	4
4. Howell-Urban land association	4
5. Lakewood-Lakehurst-Lakeland association	4
6. Muck-Alluvial land association	5
7. Marlton-Kresson association	5
8. Westphalia-Nixonton-Barclay association	5
Descriptions of the soils	5
Aura series	6
Barclay series	8
Clay pits	8
Colemantown series	8
Collington series	9
Downer series	9
Dragston series	10
Fallsington series	11
Freehold series	11
Holmdel series	13
Howell series	14
Klej series	15
Kresson series	15
Lakehurst series	16
Lakeland series	17
Lakewood series	17
Leon series	18
Loamy alluvial land	19
Made land	19
Marlton series	19
Matawan series	20
Moderately wet land	21
Muck	21
Nixonton series	21
Pasquotank series	22
Pocomoke series	23
St. Johns series	23
Sand and gravel pits	24
Sandy alluvial land	24
Shrewsbury series	24
Descriptions of the soils—Continued	
Tidal marsh-Made land complex	25
Urban-Moderately wet land complex	25
Weeksville series	25
Westphalia series	25
Woodstown series	26
Use and management of the soils	27
Capability groups of soils	27
Management by capability units	29
Estimated yields	35
Use of soils for woodland	37
Woodland suitability grouping	38
Descriptions of woodland suitability groups	40
Use of soils for wildlife	42
Suitability of soils for wildlife habitats	42
Suitability of soils for different kinds of wildlife	44
Engineering applications	44
Engineering classification systems	45
Engineering test data	45
Soil properties significant to engineering	45
Engineering interpretations of soils	60
Soils in urban development	60
Formation and classification of soils	73
Formation of the soils	73
Parent material	73
Climate and relief	75
Biological activity	75
Time	76
Genesis and classification	76
Soil genesis	76
Classification	77
Descriptions of the soil series	78
General information about the county	90
Climate	90
Water supply	91
History	92
Literature cited	93
Glossary	93
Guide to mapping units, capability units, and woodland groups	facing 94

Series 1961, No. 42

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be organized in a way that it is readily useful to different groups of readers, among them farmers, managers of woodland, engineers, urban developers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. The soil scientists set up trial groups based on the yield and practice tables and other data and test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

While a survey is in progress, and after some areas have been mapped, however, many changes occur. In this county, highway construction has left borrow pits in fields and woodlands and made fills in low, wet areas. Also, some areas that were fields when the aerial photographs at the back of the report were made are now covered by houses.

In some townships urban development has extended beyond the public sewage lines. These townships require that percolation tests be made of the soils at all homesites. The soil survey report can be used to assist in the planning of sewage systems. For example, the soil map shows areas of soils that have rapid permeability of the substratum where septic fields function well and where few percolation tests are needed. Also, this soil survey indicates areas that have slow permeability, those areas where percolation tests are needed to determine whether the soil is suitable for septic fields and how the fields should be designed. In addition, the report shows areas where drainage is so poor and permeability is so slow that the soils are generally not suitable for septic systems.

General Soil Map

The general soil map at the back of this report shows, in color, the soil associations in Camden County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The eight soil associations in Camden County are shown on the general soil map at the back of this report and are described in the following pages.

1. Aura-Downer association: Gently sloping gravelly and sandy soils

This soil association occurs in irregularly shaped areas at elevations between 120 and 180 feet. It occupies the divide between the water flowing west into the Delaware River and the water flowing east into the Atlantic Ocean. The association includes Sicklerville, West Berlin, Williamstown Junction, the eastern part of Berlin, and the western part of Chesilhurst.

Most soils in the association are well drained. The soil material formed from geologic formations locally called Bridgeton and Cohansey.

The dominant soils in this association are the Aura and the Downer. The Aura soils are in slightly higher positions in the landscape than Downer soils. The Aura soils have a sandy loam or loamy sand surface layer and a reddish, coarse sandy loam subsoil containing some quartz gravel. The subsoil is so firm that root growth is restricted. Downer soils also have a sandy loam or loamy sand surface layer, but their subsoil is not so red nor so firm as that in the Aura soils.

Minor soils in this association are the Woodstown, Dragston, Fallsington, Pocomoke, Sandy alluvial land, Loamy alluvial land, and Muck. These soils are in moderately low to low positions where a high water table and flooding are problems. Deep drainage is needed if these soils are to be used for urban areas.

Sweetpotatoes and peaches are the most extensively grown crops in this association. In some places sweetpotatoes are grown between rows of trees in young orchards (fig. 3). The Aura soils are a source of much gravel and subbase material for building roads.

Figure 3.—**Sweetpotatoes interplanted in young peach orchard.**

2. Downer-Woodstown-Dragston association: Gently sloping, grayish-brown sandy soils

This association consists mostly of sand and gravel deposited by streams or rivers. It occurs in several widely separated areas. One strip, 1 to 2 miles wide, lies immediately east of the Delaware River at elevations ranging from 5 to 100 feet above sea level. This strip includes the western part of Gloucester City, most of the city of Camden, all of East Camden, and the northern part of Pennsauken Township around Industrial Park.

Other areas of this association are east of and just below the divide, which is a section of high ground across the county. Elevations range from 60 to 120 feet. These areas include the communities of Berlin, Atco, and Waterford.

The soils in this association formed from materials of the Cape May, Pennsauken, Cohansey, and Bridgeton geologic formations.

The dominant soils in this association are the Downer, Woodstown, and Dragston, all of which are sandy. Downer soils are well drained, but they are droughty because they are sandy and shallow. Woodstown and Dragston soils have a high water table.

Minor soils in this association are the Fallsington, Pocomoke, and Klej.

In the strip of this association that lies within 5 miles of the Delaware River, nearly all the land is used for industry, commerce, residences, or recreation. In this part farmland occupies less than 5 percent of the acreage and is in isolated parcels. This land is rapidly being converted to urban use.

In areas of this association east of the divide, about 50 percent of the acreage has been cleared. Included in the cleared acreage are some commercial and residential areas, which are mostly small. The farms are generally of small or medium size, and they produce mainly vegetables, fruits, or poultry. Sweetpotatoes, tomatoes, peaches, and apples are the most important crops. Wood products of this association include pine for pulpwood from the uplands and white-cedar from the swamps. The soils in this association are not highly fertile. Areas could be cleared, however, if needed, and made to produce more than the soils now farmed. Irrigation and well-planned application of lime and fertilizer would be needed.

This association is well suited to most urban uses. Deep drainage, however, is needed in the Woodstown and Dragston soils to keep basements dry.

3. Freehold-Holmdel-Collington association: Gently to strongly sloping soils from greensand

This soil association is a band 4 to 6 miles wide and is roughly parallel to the Delaware River. It is adjacent to the Howell-Urban land association. It includes Runnemede, Barrington, Haddon Heights, and Haddonfield and many subdivisions, such as the Barclay Farms and Kingston Estates.

Generally, slopes in this association are gentle, but immediately adjacent to streams they are strong to steep. The soils are at elevations ranging from 40 to 120 feet. The slope generally is toward the Delaware River. The parent materials of soils in this association are mostly fine sand but include some silt and clay. All of the materials contain glauconite. The soil materials formed from geologic formations locally called the Englishtown, Marshalltown, and Mt. Laurel-Wenonah.

The dominant soils in the association are the Freehold, Holmdel, and Collington. Freehold and Collington soils are well drained. Holmdel soils are moderately well drained to somewhat poorly drained and have a high water table late in winter and during prolonged wet periods.

Shrewsbury soils are the minor soils in the association.

The soils in this association are fertile, and nearly all the gentle slopes have been cleared for farming. Now more than half of the acreage is in urban uses, and the rest is rapidly being converted from farmland and woodland to urban uses. Deep drainage is needed on Holmdel soils to prevent flooding and to allow septic fields to operate. If Shrewsbury soils are used in urban development, deep drainage is needed to lower the high water table.

Septic fields are generally satisfactory in this association, except where the soils are underlain by a clayey layer. The steep slopes adjacent to streams are suitable for use as parks, such as the Pennypacker Park along the Cooper River in Haddonfield.

4. Howell-Urban land association: Gently sloping, brown silty and clayey soils

This soil association is a band 1 to 3 miles wide and is roughly parallel to the Delaware River. It includes parts of Bellmawr, Northmont, Audubon Park, Oaklyn, Collingswood, and Merchantville. The soils are gently sloping and occupy elevations that range from 20 to nearly 100 feet. The parent materials are silty and clayey marine deposits as much as 110 feet thick. Locally these deposits are called the Merchantville and Woodbury clays. Runoff is high because water soaks into these materials very slowly.

Dominant in this association are the Howell soils and Urban-Moderately wet land complex. The Howell soils occupy the higher elevations and are well drained or moderately well drained. Urban-Moderately wet land complex occupies the lower positions in the landscape.

Minor soils in this association are the Freehold, Holmdel, and Downer.

Nearly all of this association is used as sites for industry, commerce, residences, recreation, and other urban projects. Because the soils are slowly permeable, they are generally not suitable as disposal fields for septic systems. Urban-Moderately wet land complex is low and subject to flooding. If basements are constructed on this land, deep drainage is needed.

5. Lakewood-Lakehurst-Lakeland association: Level to steep, gray sandy soils

The strongly sloping to steep areas of this association occur in a wavy strip at relatively high elevations; the nearly level areas occur adjacent to the major east flowing streams just above the border of swamps. The association consists of deep sandy soils, most of which have a bleached, gray surface layer.

The parent material of soils in this association is sand. Part of the western area is from the Kirkwood geologic formation and is dominantly fine sand; the rest of the association is from the Cohansey formation and is dominantly medium and coarse sand. Soils on higher elevations are well drained, but those on the lower sites have a high water table.

The dominant soils in this association are the Lakewood, Lakehurst, and Lakeland, named in order of extent. Because they are so droughty and so infertile, less than 10 percent of their acreage has been cleared for farming. The Lakewood and the Lakeland soils are excessively drained, but the Lakehurst soils have a fluctuating water table. Septic fields work well in Lakewood and Lakeland soils but are hampered by a high water table in the Lakehurst soils. The soils are suitable for building sites but droughtiness and low natural fertility are problems in establishing and maintaining plants for landscaping and lawn grasses. Some of the areas are too steep for residences of the customary design and construction.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent
	Acres	*Percent*
Aura loamy sand, 0 to 2 percent slopes	400	0.3
Aura loamy sand, 2 to 5 percent slopes	3,000	2.1
Aura sandy loam, 0 to 2 percent slopes	1,100	.8
Aura sandy loam, 2 to 5 percent slopes	3,000	2.1
Aura-Downer loamy sands, 0 to 5 percent slopes	1,700	1.2
Aura-Downer sandy loams, 0 to 5 percent slopes	1,200	.8
Aura-Urban land complex	250	.2
Clay pits	100	(1)
Colemantown loam	200	.1
Collington fine sandy loam, 0 to 2 percent slopes	800	.6
Collington fine sandy loam, 2 to 5 percent slopes	600	.4
Downer loamy sand, 0 to 5 percent slopes	18,000	12.8
Downer loamy sand, clayey substratum, 0 to 5 percent slopes	300	.2
Downer sandy loam, 0 to 2 percent slopes	800	.6
Downer sandy loam, 2 to 5 percent slopes	900	.6
Downer soils, 5 to 10 percent slopes	1,000	.7
Downer-Aura complex, 5 to 10 percent slopes	400	.3
Fallsington sandy loam	1,300	.9
Freehold fine sandy loam, 0 to 2 percent slopes	1,000	.7
Freehold fine sandy loam, 2 to 5 percent slopes	2,500	1.8
Freehold fine sandy loam, 5 to 10 percent slopes	700	.5
Freehold loamy fine sand, 0 to 5 percent slopes	2,000	1.4
Freehold loamy fine sand, 5 to 10 percent slopes	300	.2
Freehold sand, thick surface variant, 0 to 5 percent slopes	500	.4
Freehold soils, 15 to 30 percent slopes	400	.3
Freehold and Collington soils, 10 to 15 percent slopes	400	.3
Freehold and Downer-Urban land complex, gently sloping	13,000	9.2
Freehold and Downer-Urban land complex, sloping	300	.2
Freehold and Downer, clayey substrata, -Urban land complex	1,300	.9
Holmdel fine sandy loam, 0 to 3 percent slopes	3,000	2.1
Holmdel loamy fine sand, 0 to 3 percent slopes	300	.2
Holmdel, clayey substratum, -Urban land complex	400	.3
Holmdel-Urban land complex	1,000	.7
Howell-Urban land complex, gently sloping	1,300	.9
Howell-Urban land complex, sloping	100	(1)
Klej loamy sand, 0 to 2 percent slopes	300	.2
Kresson sandy loam, 0 to 3 percent slopes	250	.2
Lakehurst sand, 0 to 3 percent slopes	2,350	1.6
Lakehurst-Lakewood association, 0 to 5 percent slopes	3,400	2.4
Lakeland fine sand, firm substratum, 0 to 5 percent slopes	2,300	1.6
Lakeland sand, 0 to 5 percent slopes	1,500	1.1
Lakeland sand, water table, 0 to 2 percent slopes	500	.4
Lakewood fine sand, 0 to 5 percent slopes	1,000	.7
Lakewood fine sand, 5 to 10 percent slopes	500	.4
Lakewood fine sand, 10 to 25 percent slopes	200	.1
Lakewood sand, 0 to 5 percent slopes	8,000	5.7
Lakewood sand, 5 to 10 percent slopes	700	.5
Lakewood and Lakeland sands, 10 to 30 percent slopes	2,000	1.4
Leon sand	3,000	2.1
Leon-St. Johns sands	3,500	2.5
Loamy alluvial land	2,300	1.6
Made land	1,500	1.0
Marlton sandy loam, 0 to 2 percent slopes	300	.2
Marlton sandy loam, 2 to 5 percent slopes	300	.2
Marlton soils, 5 to 10 percent slopes, severely eroded	100	(1)
Marlton and Kresson-Urban land complex	800	.6
Matawan loamy sand, 0 to 5 percent slopes	250	.2
Matawan sandy loam, 0 to 2 percent slopes	300	.2
Matawan sandy loam, 2 to 5 percent slopes	150	.1
Moderately wet land	400	.3
Muck	6,700	4.8
Nixonton and Barclay fine sandy loams, 0 to 3 percent slopes	450	.3
Nixonton and Barclay loamy fine sands, 0 to 5 percent slopes	350	.3
Pasquotank fine sandy loam	2,000	1.4
Pasquotank and Weeksville-Urban land complex	700	.5
Pocomoke sandy loam	800	.6
St. Johns sand	1,000	.7
St. Johns sand, clayey substratum	500	.4
Sand and gravel pits	1,500	1.0
Sandy alluvial land	2,000	1.4
Shrewsbury fine sandy loam	1,000	.7
Shrewsbury-Urban land complex	250	.2
Tidal marsh-Made land complex	300	.2
Urban-Moderately wet land complex	1,000	.7
Weeksville fine sandy loam	300	.2
Westphalia fine sandy loam, 0 to 5 percent slopes	700	.5
Westphalia loamy fine sand, 0 to 5 percent slopes	800	.6
Westphalia loamy fine sand, 5 to 10 percent slopes	300	.2
Westphalia soils, 10 to 20 percent slopes	350	.3
Westphalia soils, 10 to 20 percent slopes, severely eroded	150	.1
Westphalia and Nixonton-Urban land complex	4,000	2.9
Woodstown and Dragston sandy loams, 0 to 3 percent slopes	800	.6
Woodstown and Klej loamy sands, 0 to 3 percent slopes	2,300	1.6
Woodstown and Klej loamy sands, clayey substrata, 0 to 3 percent slopes	300	.2
Unmapped city of Camden	13,400	9.5
Total	141,400	100.0

[1] Less than 0.1 percent.

Listed at the end of the description of a mapping unit are the capability unit, the woodland suitability group, and the urban group in which that kind of soil has been placed. Some mapping units have been placed only in urban groups. The pages on which the capability unit, and woodland suitability group are described can be found readily by referring to the "Guide to Mapping Units, Capability Units, and Woodland Groups," at the back of the report.

Soil scientists, teachers, engineers, foresters, and others who want more detailed information about the soils should turn to the section "Formation and Classification of Soils." Many terms used in the soil descriptions and in other sections of the report are defined in the Glossary.

Aura Series

The Aura series consists of dark grayish-brown, well-drained, sandy soils in high positions. The soils are nearly level to gently sloping. In the upper 2 feet, they contain variable amounts of quartzose gravel (fig. 4). The lower part of the subsoil is firm, reddish coarse sandy clay loam that restricts root growth.

vegetables and to general farm crops. Most areas have been cleared for farming.

In Camden County, Dragston soils are mapped only in an undifferentiated group, Woodstown and Dragston sandy loams, 0 to 3 percent slopes. The Woodstown soils are described under the Woodstown series.

Fallsington Series

The Fallsington series consists of grayish-colored, poorly drained, moderately coarse textured soils that are generally prominently mottled. They are in the southeastern part of the county in low positions and have slopes of less than 1 percent. Runoff is slow, and some areas are ponded.

The natural vegetation consists of pin, willow, and swamp white oaks and red maple. If seed trees are nearby, idle fields are rapidly seeded to pitch pine. There is generally a dense undergrowth of highbush blueberry, sheep laurel, gallberry, sweet pepperbush, and other shrubs.

A representative profile of Fallsington sandy loam has a dark-gray plow layer about 10 inches thick. The subsoil is grayish-brown sandy loam that is mottled with dark yellowish brown and has slightly more clay than the plow layer. It extends to a depth of about 24 inches. The underlying material is loose, light brownish-gray coarse loamy sand.

The subsoil ranges from sandy loam to sandy clay loam in texture. In places it extends to a depth of 30 to 36 inches. It ranges from gray to yellowish brown in color. In places the substratum has brighter colors. Rounded quartzose pebbles are common in the underlying material. The content ranges from 0 to 5 percent, by volume. Also in some areas the underlying material contains discontinuous lenses of clay, but it was not feasible to map these areas separately.

In their natural state, the Fallsington soils are extremely acid, but some farmed fields have been limed and are now less acid. Also, these soils are almost constantly wet. In winter the water table is near the surface; in summer it is about 2 feet below the surface. The soils are moderately permeable. Generally, tile drains or open ditches can be used to lower the water table. Because of the loose material in the substratum, deep ditches, especially in shallow soils, require careful management to prevent ditchbanks from caving in.

The Fallsington soils occur beside the Pocomoke, Woodstown, and Dragston soils. They are grayer than the Woodstown and Dragston soils. They are not so dark in the surface layer as the Pocomoke soils.

Without drainage, the Fallsington soils are not suitable for any kind of farming. If drained, they are suitable for blueberries and for annual vegetables that can withstand short periods of subsoil saturation. They are also suitable for general crops and pasture. The soils generally cannot be drained well enough to produce high-value perennial crops, such as asparagus, fruit, or alfalfa. They are generally suitable as sites for ponds that are supplied by groundwater.

(Fd) **Fallsington sandy loam.**—A profile of this soil is described for the Fallsington series. Small areas of Pocomoke sandy loam, Dragston sandy loam, and small areas of Fallsington loam are included with this soil in mapping.

In some circular depressions, clay layers occur between a depth of 30 and 60 inches from the surface. In these areas groundwater recharge may be slow if groundwater ponds are constructed. (Capability unit IIIw–21; woodland suitability group 4; urban group 9)

Freehold Series

The Freehold series consists of dark grayish-brown, well-drained, sandy soils that are low in glauconite. They occur in high positions in the western part of the county. Their subsoil is dark yellowish brown or brown. The substratum is stratified material that is mostly loamy sand but that also contains thin layers of sandy loam and clayey material. The finer material generally has a reddish color derived from iron coatings. Generally, the soils contain little quartzose gravel.

The natural vegetation consists mostly of red oak, beech, and yellow-poplar.

A typical profile of Freehold soil has a dark grayish-brown fine sandy loam plow layer 9 inches thick; a yellowish-brown fine sandy loam subsurface layer 6 inches thick; a dark yellowish-brown sandy clay loam subsoil 20 inches thick; and underlying layers of mostly stratified loamy sand and sandy loam. The underlying layers range in color from light olive brown to strong brown in places where the sand grains are coated with iron. There are thin ironstone sheets in some lower layers.

The subsoil ranges from fine sandy loam to sandy clay loam in texture. In high positions where oxidation takes place readily, the colors of the subsoil are somewhat redder than those in the typical Freehold soil. The thickness of the solum ranges from 30 to 42 inches. As a rule, Freehold soils contain little gravel (fig. 5).

The Freehold soils naturally are extremely acid, but some farmed fields have been limed and are now less acid. The soils are moderately fertile, moderately permeable, and have a moderate to good water-holding capacity.

Freehold soils occur beside the Holmdel, Shrewsbury, and Collington soils. They lack the mottling common in Holmdel and Shrewsbury soils. They contain less glauconite than Collington soils.

Nearly all the Freehold soils that have favorable slopes have been cleared for farming. They are highly prized for growing fruit, high-value vegetables, and nursery crops, as well as general crops of corn, small grain, hay, and soybeans.

(FfA) **Freehold fine sandy loam, 0 to 2 percent slopes.**—A profile of this soil is described as typical of the Freehold series. Included with this soil in mapping are small areas of Holmdel soils in depressions. These areas may need drainage if crops of high value are to be grown. Also included are areas that contain remnants of more recently deposited material. This material is redder and contains more gravel and less glauconite than normal for Freehold soils, and the sand is generally coarser. The same crops can be grown on this material, but the soil is less fertile and more droughty.

This soil is highly favorable to farming, as there is little erosion hazard and only minor problems of drainage in small areas. The use of cover crops or sod crops is needed

to maintain a large amount of organic matter and a porous plow layer.

In places this soil is underlain by clay between a depth of 30 and 60 inches. The clay may cause the layer above to be saturated for brief periods. If this soil is used for a homesite, the clayey layer could cause basement seepage and restrict the use of the soil as a septic field. (Capability unit I–5; woodland suitability group 1; urban group 1)

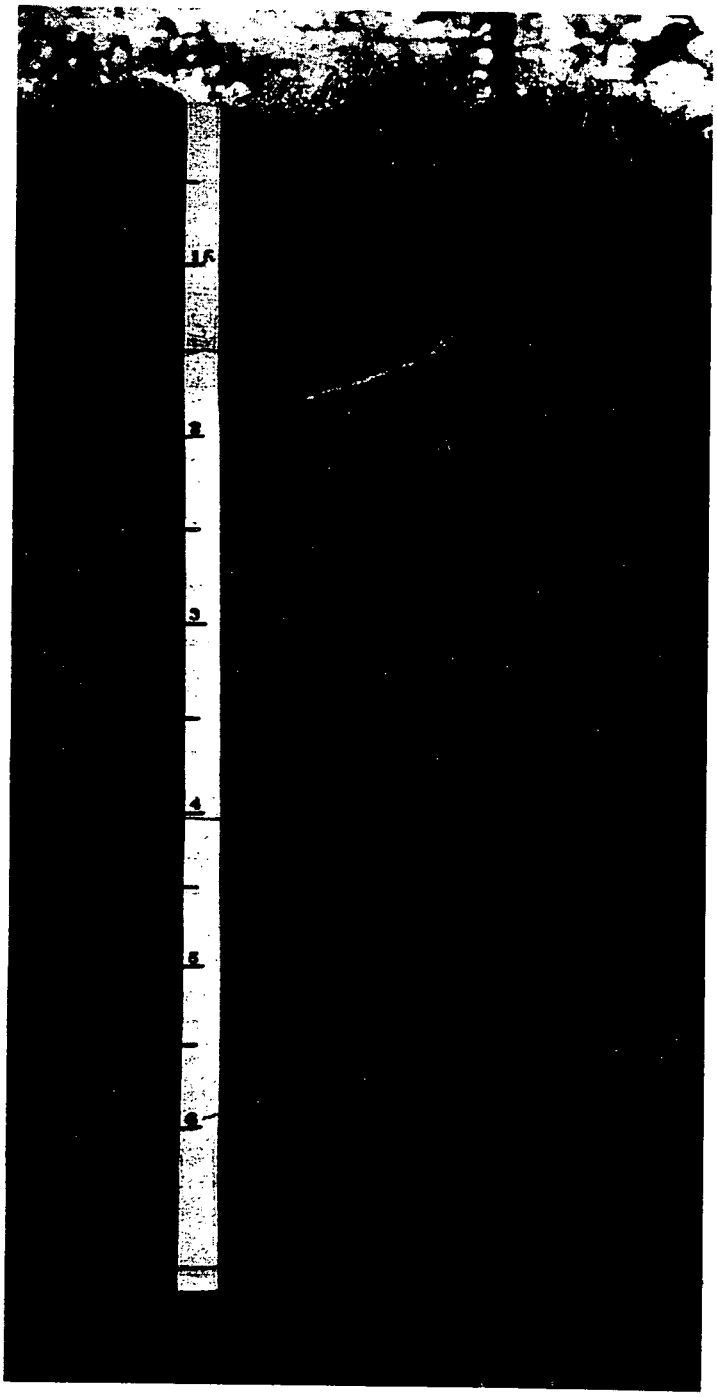


Figure 5.—**A profile of Freehold loamy fine sand showing the loose surface layer.**

(FfB) **Freehold fine sandy loam, 2 to 5 percent slopes.**—Because this soil is more sloping than Freehold fine sandy loam, 0 to 2 percent slopes, runoff is more rapid and organic-matter content is more difficult to maintain. Unless erosion is controlled, it limits crop production. Contour planting, cover crops, and sod crops can be used to reduce the erosion hazard.

This soil is well suited to most urban uses. If underlying clay layers are present, however, they may cause basement seepage and slight problems in septic fields. (Capability unit IIe–5; woodland suitability group 1; urban group 1)

(FfC) **Freehold fine sandy loam, 5 to 10 percent slopes.**—Runoff is rapid on this sloping and strongly sloping soil. If not controlled, erosion is a serious hazard in plowed fields. In some fields erosion has removed part of the surface layer and has cut gullies. Yields of these fields are low, and soil management is more difficult. Contour planting, cover crops, and diversion terraces are practices that help to reduce the erosion hazard in cropped areas. In pasture land and in woodland, however, erosion is not a problem.

If this soil is used for homesites, erosion is a problem in establishing lawns. In some areas sodding may be required. The slope of this soil should be considered in the design of septic fields. (Capability unit IIIe–6; woodland suitability group 1; urban group 4)

(FhB) **Freehold loamy fine sand, 0 to 5 percent slopes.**—The total thickness of the surface and subsurface layers of this soil is about 18 inches. The surface layer is loose and therefore is subject to wind erosion. The subsoil contains considerably more clay than the surface soil. Because of the clay content, the subsoil is moderately permeable and has moderate available moisture holding capacity. This soil generally contains little or no gravel. Some areas that have a surface layer of sand are included with this soil in mapping.

This soil warms readily in spring and is well suited to early crops. Most crops of high value grown on this soil are irrigated. Because most slopes are short, there is little hazard of water erosion. Some erosion control practices may be needed on long slopes. Cover crops, wind strip-crops, and privet windbreaks can be used to reduce wind erosion

If this soil is used for homesites, drought-resistant grasses should be grown in lawns, and water and fertilizer should be regularly applied. (Capability unit IIs–6; woodland suitability group 1; urban group 2)

(FhC) **Freehold loamy fine sand, 5 to 10 percent slopes.**—This soil is like Freehold loamy fine sand, 0 to 5 percent slopes. It has stronger slopes than that soil, runoff is more rapid, and cultivated areas are more likely to have gullies and a thinner surface layer. This soil is more droughty than the less sloping Freehold loamy fine sand. Water erosion is more of a problem on this soil than wind erosion. Contour farming can be used to reduce water erosion.

If this soil is used for homesites, erosion is a problem in establishing a lawn. In some places sodding may be needed. Drought-resistant grasses should be grown, and water and fertilizer should be applied regularly to lawns and landscape plants. The slope should be considered in designing a septic field on this soil. (Capability unit IIIe–6; woodland suitability group 1; urban group 4)

(FnB) **Freehold sand, thick surface variant, 0 to 5 percent slopes.**—The total thickness of the surface and subsurface layers of this soil exceeds 30 inches. These layers are made up of loose sand. Because of the extreme thickness of the sand, this soil has little in common with the other Freehold soils. The sand makes it less fertile and and more droughty than the other Freehold soils. It is also more likely to be eroded by wind. The subsoil, however, contains enough clay to prevent rapid percolation of water and the leaching of added fertilizer. This clayey layer is about 1 foot thick and is underlain by loamy sand.

This soil is best suited to peach trees, apple trees, and grapevines, and other deep-rooted perennial plants. It is too sandy and droughty for pasture.

If this soil is used for homesites, the establishment of lawn grasses and landscape plants is severely limited, as the soil is droughty and infertile. Drought-resistant grasses or warm-climate grasses can be established by using plugs. Deep-rooted landscape plants are needed. Water and fertilizers should be applied frequently. (Capability unit IIIs–7; woodland suitability group 3; urban group 2)

(FsE) **Freehold soils, 15 to 30 percent slopes.**—These soils are chiefly in narrow bands on steep banks adjacent to streams. Nearly all the acreage is forested. Because of steepness and erosion, alternate layers of geologic deposits that have not been greatly altered by the soil-forming processes are exposed at the surface. The deposits are mainly sandy, though in places they are finer textured. Seeps occur if the sand lies over finer material. Runoff is rapid. Because of the erosion hazard, it would be better if these soils were not cleared for farming.

These soils generally occur near streams and have been developed in places as part of a park. (Capability unit VIe–5; woodland suitability group 1; urban group 11)

(FtD) **Freehold and Collington soils, 10 to 15 percent slopes.**—This group is composed mostly of Freehold fine sandy loam and Freehold loamy fine sand, but it also contains Collington soils of the same textures. In places, however, the soils are underlain by clayey deposits that cause seeps. Because the slopes are steep, runoff is rapid.

Small areas have been cleared for farming. The erosion hazard is very high in cultivated fields, and contour planting, hay strips, or diversion terraces are needed. In a few fields gullies have formed. In areas used for pasture and woodland, however, the erosion hazard is only slight. (Capability unit IVe–6; woodland suitability group 1; urban group 11)

(FxB) **Freehold and Downer-Urban land complex, gently sloping**—This mapping unit consists of Freehold and Downer soils in urban areas where it was impractical to map each soil separately. The Freehold soils are more extensive than the Downer soils. The slope ranges from 0 to 5 percent.

The soils in this complex are in urban or suburban use. Most areas are residential, but some are commercial, and some are idle. In the older developed areas where construction was mainly of single units, disturbance of the soil was restricted to the immediate location of the unit. In the newer areas, the disturbance has affected the entire area through stockpiling of surface soil, grading or leveling the area, excavating for foundations, and then replacing the surface soil after construction was finished. (Urban group 1, Freehold and Urban land parts; urban group 2, Downer part)

(FxC) **Freehold and Downer-Urban land complex, sloping.**—Except for stronger slopes, this complex is similar to Freehold and Downer-Urban land complex, gently sloping. The slope ranges from 5 to 15 percent.

Erosion of the soils in this complex is a problem. Also, the septic fields are more difficult to install on these soils than on the less sloping soils, and they do not function so well. (Urban group 4)

(Fy) **Freehold and Downer, clayey substrata,-Urban land complex.**—This unit contains either Freehold or Downer soils; the two seldom occur together in one area. Generally these soils are gently sloping (0 to 5 percent), but some steeper areas are included in mapping.

The Freehold and Downer soils in this unit are similar to the ones described as typical of their respective series, except that they have underlying layers of clay or sandy clay between a depth of 30 and 60 inches. The clayey layers range from 3 to 24 inches in thickness. They reduce the permeability of the substratum and thereby trap water in wet seasons. Thus basement seepage may be a problem for buildings on this unit. Drainage to a depth below 4 feet is needed on land in this unit that is used for a septic field. (Urban group 1, Freehold and Urban land parts; urban group 2, Downer part)

Holmdel Series

The Holmdel series consists of dark grayish-brown, moderately well drained to somewhat poorly drained soils that have a mottled yellowish-brown or light olive-brown subsoil and a stratified substratum. The soils contain a small amount of glauconite. They are on slopes where the water table rises into the subsoil in winter but drops to a depth of 3 feet or more in summer. These soils are in the western part of the county.

The natural vegetation consists mostly of red, scarlet, and white oaks, yellow-poplar, beech, and hickory. In the somewhat poorly drained areas, however, pin oak, willow oak, and sweetgum predominate. The natural shrubs are viburnum and spicebush.

A typical profile of Holmdel soil has a dark grayish-brown, fine sandy loam plow layer 10 inches thick, and a yellowish-brown or light olive-brown, prominently mottled, fine sandy loam subsoil about 24 inches thick. The subsoil is slightly more clayey than the surface layer. Below the subsoil is mostly stratified, olive-colored loamy sand and sandy loam extending to a depth of 60 inches.

In moderately well drained areas, mottling is in the lower part of the subsoil only, but in the somewhat poorly drained areas, it is in the upper part. The subsoil ranges from sandy loam to sandy clay loam in texture, though the sandy loam is more common. In places the subsoil is not so thick as that in the typical profile described. The texture and color of the stratified material varies widely from place to place. Normally, rounded quartzose gravel is not common in Holmdel soils. In places the soils have a pale subsurface layer between the plow layer and the subsoil.

The Holmdel soils naturally are extremely acid, but some farmed fields have been heavily limed and are now less acid. The soils are generally permeable enough to be drained efficiently by tile.

The Holmdel soils occur beside the Freehold, Collington, and Shrewsbury soils. Mottling in the subsoil dis-

adequate natural regeneration ordinarily will take place if the seedbed and seed sources are adequate. On old field sites losses resulting from the effect of the soil are ordinarily less than 25 percent. Normally, satisfactory restocking by initial planting can be expected. The rating *moderate* means that there is a regeneration problem. On old field sites losses resulting from the effect of the soil are ordinarily between 25 and 50 percent. Normally, some replanting to fill openings will be necessary. Natural regeneration cannot be relied on for adequate and immediate restocking, even if seedbeds, seed sources, and weather are reasonably favorable. The rating *severe* means that losses resulting from the effect of the soil are ordinarily more than 50 percent. Natural regeneration can be relied on only if seedbeds, seed sources, and the weather are favorable.

Plant competition refers to the rate that undesirable plants invade the site when openings are made in the canopy. The rating *slight* means that there are no special problems of plant competition. The rating *moderate* means that plant competition develops but can be controlled by site preparation, weeding, or other simple management. The rating *severe* means that plant competition prevents adequate restocking of designated species, unless controlled burning, disking, use of chemical sprays, girdling, or other special management practices are used.

The ratings for windthrow hazard are based on soil characteristics or qualities that enable trees to resist the force of the wind. Windthrow damage is most severe on soils that remain wet for long periods, particularly the muck soils and soils in very low positions that receive much surface water. The ratings are *slight*, *moderate*, and *severe*, depending on the expected hazard of windthrow. Several woodland suitability groups have a range in ratings. This range is explained in the discussion of these groups.

The trees that are most suitable for favoring in the stand or for planting on each woodland suitability group are also given in table 4. These trees will provide the most valuable timber crop. In general, conifers are better suited to the sandy soils. Yellow-poplar, sweetgum, and oaks, however, are better suited to the finer textured, relatively moist soils. Only the species of pine that are available locally are listed in the table as suitable for planting. Other species of pine, spruce, fir, and other trees for special products are given in the text for each woodland suitability group. In some groups, however, no planting is suggested because of severe competition from other plants or because of successive failures caused by animals.

For specific information on what trees to plant or how to manage woodlands, landowners should consult their district forester of the New Jersey Department of Conservation and Economic Development. For general information concerning forestry, they should consult the extension forester of the Agricultural Extension Service.

Descriptions of woodland suitability groups

In this section the seven woodland suitability groups of Camden County are discussed, and the soils in each group are listed.

Because they are not suitable for, or generally are not used for woodland, the land types, Clay pits, Made land, Sand and gravel pits, and Tidal marsh-Made land complex, and soils in urban land complexes were not placed in woodland suitability groups.

WOODLAND SUITABILITY GROUP 1

This group consists of nearly level to steep soils that have moderate to high available moisture capacity, a loamy subsoil, and moderate natural fertility. The texture of the subsoil ranges from moderately coarse to moderately fine (sandy loam, loam, or sandy clay loam). The natural drainage of the soils in this group ranges from good to somewhat poor. The soils are—

CoA	Collington fine sandy loam, 0 to 2 percent slopes.
CoB	Collington fine sandy loam, 2 to 5 percent slopes.
DrA	Downer loamy sand, clayey substratum, 0 to 5 percent slopes.
FfA	Freehold fine sandy loam, 0 to 2 percent slopes.
FfB	Freehold fine sandy loam, 2 to 5 percent slopes.
FfC	Freehold fine sandy loam, 5 to 10 percent slopes.
FhB	Freehold loamy fine sand, 0 to 5 percent slopes.
FhC	Freehold loamy fine sand, 5 to 10 percent slopes.
FsE	Freehold soils, 15 to 30 percent slopes.
FtD	Freehold and Collington soils, 10 to 15 percent slopes.
HdA	Holmdel fine sandy loam, 0 to 3 percent slopes.
HfA	Holmdel loamy fine sand, 0 to 3 percent slopes.
MmB	Matawan loamy sand, 0 to 5 percent slopes.
MnA	Matawan sandy loam, 0 to 2 percent slopes.
MnB	Matawan sandy loam, 2 to 5 percent slopes.
NbA	Nixonton and Barclay fine sandy loams, 0 to 3 percent slopes.
NcA	Nixonton and Barclay loamy fine sands, 0 to 5 percent slopes.
WaB	Westphalia fine sandy loam, 0 to 5 percent slopes.
WfB	Westphalia loamy fine sand, 0 to 5 percent slopes.
WfC	Westphalia loamy fine sand, 5 to 10 percent slopes.
WhD	Westphalia soils, 10 to 20 percent slopes.
WhD3	Westphalia soils, 10 to 20 percent slopes, severely eroded.
WsA	Woodstown and Dragston sandy loams, 0 to 3 percent slopes.
WtA	Woodstown and Klej loamy sands, 0 to 3 percent slopes (Woodstown part).
WuA	Woodstown and Klej loamy sands, clayey substrata, 0 to 3 percent slopes.

The soils of this group are well suited to high-quality hardwoods, especially oaks and yellow-poplar. The site index for yellow-poplar is wide; it ranges from 80 to 108.

Plant competition is moderate to severe. It is moderate for most of the soils, but it is severe for the somewhat poorly drained areas occupied by Holmdel and Barclay soils. Plant competition is generally so severe that yellow-poplar seedlings will not grow unless special regeneration practices are used.

The windthrow hazard is slight to moderate. It is slight for most soils but is moderate for the somewhat poorly drained areas of Holmdel and Barclay soils.

In some old fields, plantings of white pine or yellow-poplar are successful. Plantings may also be made of trees for special purposes; for example, coniferous trees for Christmas trees, black locust for posts, and holly for Christmas greens. In places laurel is common and can be cut for Christmas decorations.

Because the slopes are steep and short and support a cover of shrubs, there is slight hazard of erosion. In extremely wet periods, there is a slight equipment limitation on the Holmdel and Barclay soils.

WOODLAND SUITABILITY GROUP 2

This group consists of nearly level to strongly sloping soils that have a moderate to high available moisture capacity and a clayey subsoil. Their natural fertility ranges from low to moderate. Drainage ranges from good to somewhat poor. The soils are—

KrA	Kresson sandy loam, 0 to 3 percent slopes.
McC3	Marlton soils, 5 to 10 percent slopes, severely eroded.
MrA	Marlton sandy loam, 0 to 2 percent slopes.
MrB	Marlton sandy loam, 2 to 5 percent slopes.
Mo	Moderately wet land.

This group is well suited to high-quality hardwoods, especially yellow-poplar and oaks. Sweetgum grows in places on Kresson sandy loam and Moderately wet land but rarely on the other soils.

Seedling mortality is moderate to severe on the severely eroded Marlton soils. Plant competition is moderate on Kresson sandy loam and Moderately wet land and is slight on the other soils in the group.

In old fields, plantings of white pine and yellow-poplar are successful. Special plantings for this group include Christmas trees, trees for fenceposts, holly, and laurel. Black locust should not be planted on the Kresson soil and on Moderately wet land.

WOODLAND SUITABILITY GROUP 3

This group consists of nearly level to strongly sloping soils that are somewhat droughty and are low in natural fertility. The texture of their subsoil ranges from coarse to fine. The natural drainage of the soils in this group ranges from good to somewhat poor. The soils are—

AmA	Aura loamy sand, 0 to 2 percent slopes.
AmB	Aura loamy sand, 2 to 5 percent slopes.
ArA	Aura sandy loam, 0 to 2 percent slopes.
ArB	Aura sandy loam, 2 to 5 percent slopes.
AtB	Aura-Downer loamy sands, 0 to 5 percent slopes.
AvB	Aura-Downer sandy loams, 0 to 5 percent slopes.
DoA	Downer loamy sand, 0 to 5 percent slopes.
DsA	Downer sandy loam, 0 to 2 percent slopes.
DsB	Downer sandy loam, 2 to 5 percent slopes.
DtC	Downer soils, 5 to 10 percent slopes.
DxC	Downer-Aura complex, 5 to 10 percent slopes.
FnB	Freehold sand, thick surface variant, 0 to 5 percent slopes.
KmA	Klej loamy sand, 0 to 2 percent slopes.
WtA	Woodstown and Klej loamy sands, 0 to 3 percent slopes (Klej part).

Because this group does not produce hardwoods of good quality, pines should be favored. Native pines include pitch, shortleaf, and Virginia. All three species are good for pulpwood, but shortleaf pine is best for sawtimber. Prescribed burning can be used to reduce the hazard of wildfire and to prepare a more favorable seedbed for pines. The site index varies widely. It is affected by rooting depth, by the moisture in the soil, and by soil texture.

Plant competition is slight to moderate for pines. The windthrow hazard is slight on these soils.

Christmas trees and black locust for posts can be planted on the soils of this group.

WOODLAND SUITABILITY GROUP 4

This group consists of nearly level, poorly drained and very poorly drained, loamy mineral soils and Loamy alluvial land. Their natural fertility ranges from low to moderate. The soils are—

Cm	Colemantown loam.
Fd	Fallsington sandy loam.
Lv	Loamy alluvial land.
Pa	Pasquotank fine sandy loam.
Ps	Pocomoke sandy loam.
Sw	Shrewsbury fine sandy loam.
Wd	Weeksville fine sandy loam.

These soils are well suited to hardwoods, especially oaks and sweetgum. The site index for sweetgum on the Fallsington and Pocomoke soils is considerably lower than average in areas where the sand is predominantly medium and coarse. Where Loamy alluvial land contains much glauconite, it has a high site index for sweetgum (*6*).

Holly could be planted or developed from natural stands on all soils of the group except Loamy alluvial land. On this land type the competition from other plants is too great, and flooding is a constant hazard. Excessive wetness on the soils of this group frequently limits the use of some equipment.

WOODLAND SUITABILITY GROUP 5

(Mu) Muck, the one soil in this group, is a nearly level, very wet organic soil. Atlantic white-cedar is the principal commercial species suited to this soil. Poorly shaped red maple and sweetbay magnolia occupy the area after Atlantic white-cedar has been cut. White-cedar, however, could be reestablished through the use of chemicals and direct seeding, but the success would depend on the amount of animal damage. On this soil excessive browsing by deer frequently prevents the survival and growth of enough white-cedar seedlings. In areas where the muck is shallow, pitch pine may be abundant enough to favor in the stand.

The use of equipment is severely limited by a high water table and by the unstable, saturated muck. Corduroy roads are generally necessary. The windthrow hazard is severe.

WOODLAND SUITABILITY GROUP 6

This group consists of nearly level to steep, droughty, infertile, sandy soils. The soils are—

LaA	Lakehurst sand, 0 to 3 percent slopes.
LbA	Lakehurst-Lakewood association, 0 to 5 percent slopes.
LcB	Lakeland fine sand, firm substratum, 0 to 5 percent slopes.
LdA	Lakeland sand, 0 to 5 percent slopes.
LeA	Lakeland sand, water table, 0 to 2 percent slopes.
LfB	Lakewood fine sand, 0 to 5 percent slopes.
LfC	Lakewood fine sand, 5 to 10 percent slopes.
LfD	Lakewood fine sand, 10 to 25 percent slopes.
LgB	Lakewood sand, 0 to 5 percent slopes.
LgC	Lakewood sand, 5 to 10 percent slopes.
LhE	Lakewood and Lakeland sands, 10 to 30 percent slopes.

This group consists of the common upland soils in an area called the New Jersey pine region. These soils are best suited to pitch and shortleaf pines.

Plant competition is from scrub oak and other oaks, especially in areas where wildfires have been numerous. Productivity on these soils has been limited mostly by wildfires.

WOODLAND SUITABILITY GROUP 7

This group consists of nearly level, very wet, infertile, sandy soils. The soils are—

Lo	Leon sand.
Ls	Leon-St. Johns sands.
Sa	St. Johns sand.
Sc	St. Johns sand, clayey substratum.
Sv	Sandy alluvial land.

This group consists of the poorly drained and very poorly drained soils of the area called the pine region. These soils are best suited to pitch pine. Atlantic white-cedar is the species to favor in the stand on some areas of St. Johns soils and on some of Sandy alluvial land.

Windthrow hazard is moderate on all soils except Sandy alluvial land. It is severe on this land type.

In wet periods there are equipment limitations on the St. Johns soils and on Sandy alluvial land.

Use of Soils for Wildlife

In this section the suitability of the soils for specific wildlife habitats and for kinds of wildlife is discussed. Suitability ratings are given in table 5.

Suitability of soils for wildlife habitats

In this section the various wildlife habitats are discussed, and the soils of the county are rated according to their suitability for the establishment, improvement, or maintenance of each kind of habitat. The suitability ratings are given in table 5. These ratings are defined in the table.

Clay pits, Made land, Sand and gravel pits, Tidal marsh-Made land complex, and soils in mapping units that contain urban land complexes do not provide a suitable habitat for wildlife and therefore are not rated in table 5.

Soil ratings for the habitats listed in the table are explained as follows:

Grain and Seed Crop Habitat: The soils are rated according to their suitability for producing corn, sorghum, millet, soybeans, wheat, barley, oats, and other grain used as food by wildlife.

Grass and Legume Habitat: The soils are rated according to their suitability for producing introduced grasses, herbaceous legumes, and other forage crops commonly grown in the area. Cultivated grasses and legumes valuable for wildlife food and cover include alfalfa, clover, lespedeza, bluegrass, bromegrass, redtop, fescue, and orchardgrass.

TABLE 5.—*Suitability of the soils for wildlife habitats and kinds of wildlife*

[Soils rated 1 are well suited; 2, suited; 3, poorly suited; and 4, unsuited. Some soils that are not suitable for wildlife are not listed]

Soil series and map symbols	Kind of habitat										Kind of wildlife		
	Grain and seed crop	Grass and legume	Wild herbaceous upland plant	Hardwood woodland plant		Coniferous woodland plant		Wetland plant	Shallow water	Excavated pond	Openland wildlife	Woodland wildlife	Wetland wildlife
				Upland	Lowland	Upland	Lowland						
Aura:													
AmA, AmB	2	2	2	2	------	3	------	4	4	4	2	2	4
ArA, ArB, AtB, AvB	2	1	1	2	------	3	------	4	4	4	2	2	4
Colemantown:													
Cm	3	2	2	------	1	------	2	1	1	1	2	1	1
Collington:													
CoA	1	1	1	1	------	3	------	4	4	4	1	1	4
CoB	2	1	1	1	------	3	------	4	4	4	1	1	4
Downer:													
DoA, DrA	2	2	2	2	------	3	------	4	4	4	2	2	4
DsA, DsB, DtC, DxC	2	1	1	2	------	3	------	4	4	4	2	2	4
Fallsington:													
Fd	3	2	2	------	1	------	2	1	1	1	2	1	1
Freehold:													
FfA	1	1	1	1	------	3	------	4	4	4	1	1	4
FfB, FfC	2	1	1	1	------	3	------	4	4	4	1	1	4
FhB, FhC	2	2	2	2	------	3	------	4	4	4	2	2	4
FnB	3	3	3	3	------	1	------	4	4	4	3	3	4
FsE	4	3	1	1	------	3	------	4	4	4	3	1	4
FtD	3	2	1	1	------	3	------	4	4	4	2	1	4
Holmdel:													
HdA, HfA	2	1	1	1	1	3	3	[1] 2, 3	[1] 2, 3	[1] 2, 3	1	1	[1] 2, 3
Klej:													
KmA	3	2	2	3	------	1	------	3	3	3	2	3	3
Kresson:													
KrA	2	1	1	1	1	3	------	2	2	2	1	1	2

See footnotes at end of table.

TABLE 6.—*Engineering*

[Tests performed by the College of Engineering, Rutgers University, in accordance with

Soil type	Sampling site			Depth	Test results				
					Sieve analysis				
					Cumulative percentage passing—				
	Site number	Latitude	Longitude		¾ inch	No. 4 (4.7 mm.)	No. 10 (2 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)
		Degrees, minutes, seconds	*Degrees, minutes, seconds*	*Inches*					
Aura loamy sand.	10	39°43′11″	74°59′08″	0 to 14	93	80	73	55	11
				14 to 30	99	94	92	79	40
				30 to 52	100	99	99	89	33
				52 to 72	100	100	99	79	30
Aura loamy sand.	21	39°46′58″	74°55′12″	0 to 3					
				3 to 14	100	96	92	70	7
				14 to 18					
				18 to 40	100	100	100	97	25
				40 to 60	100	100	98	95	11
				60 to 84	100	100	100	95	3
Aura sandy loam.	16	39°55′43″	75°01′10″	0 to 6	95	88	83	55	36
				6 to 20	90	73	70	38	22
				20 to 84	82	59	54	27	10
				84 to 108	100	100	99	69	16
Collington fine sandy.	40	39°51′58″	75°00′30″	0 to 10	100	100	100	92	49
				10 to 34	100	100	99	87	45
				34 to 60	100	100	99	89	48
				60 to 84	100	100	98	90	29
Downer sandy loam.	3	39°49′47″	74°55′30″	0 to 2					
				2 to 20	98	89	86	65	20
				20 to 60	97	77	71	55	20
				60 to 90	100	100	99	84	6
Downer sandy loam.	4	39°45′40″	74°56′29″	0 to 20	86	68	63	48	22
				20 to 100	87	61	56	39	22
				100 to 220	100	99	92	48	7
				220 to 400	95	91	84	41	9
Downer sandy loam.	9	39°44′19″	75°00′19″	0 to 3					
				3 to 16	100	100	98	81	34
				16 to 36	100	98	96	83	39
				36 to 54	94	65	56	40	12
				54 to 66	96	72	68	32	2
Downer loamy sand.	11	39°43′08″	74°50′17″	0 to 3	100	97	93	59	16
				3 to 16	100	95	94	58	23
				16 to 26	90	74	67	52	16
				26 to 36					
				36 to 64	100	100	93	30	6
Freehold fine sandy loam.	14	39°52′06″	75°05′43″	0 to 6	100	100	99	83	35
				6 to 18	100	100	100	84	42
				18 to 42	100	100	100	89	28
				42 to 72	100	100	99	84	24
Freehold fine sandy loam.	18	39°54′15″	75°00′43″	0 to 8	100	100	100	92	37
				8 to 24	100	100	100	95	43
				24 to 40	100	100	100	92	27
				40 to 72	100	100	99	85	10
Freehold fine sandy loam.	19	39°54′45″	75°00′00″	0 to 8	100	100	98	93	27
				8 to 24	100	100	99	94	36
				24 to 48	100	100	98	93	27
				48 to 72	100	100	99	93	17

See footnotes at end of table.

test data

standard procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Test results—Continued						Classification		
Hydrometer analysis		Liquid limit [1]	Plasticity index [2]	Maximum density	Optimum moisture content	AASHO		Unified [3]
0.05–0.005 mm.	<0.005 mm.					Group	Group index	
Percent	*Percent*	*Percent*	*Percent*	*Lb. per cu. ft.*	*Percent*			
		NL	NP			A-2-4	0	SP-SM.
17	21	23	7			A-4	1	SM-SC.
7	27	28	10			A-2-4	0	SC.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-3	0	SP-SM.
1	24	27	9			A-2-4	0	SC.
		NL	NP			A-2-4	0	SP-SM.
		NL	NP			A-3	0	SP.
		NL	NP			A-4	0	SM.
4	18	37	14			A-2-6	0	SC.
		NL	NP			A-1-b	0	SP-SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-4	3	SM.
16	27	31	13	115	15	A-6	3	SC.
24	20	27	9	117	13	A-4	3	SC.
7	19	31	14			A-2-6	1	SC.
		NL	NP			A-2-4	0	SM.
		18	5			A-2-4	0	SM-SC.
		NL	NP			A-3	0	SP-SM.
		NL	NP			A-1-b	0	SM.
7	13	32	10	114	16	A-2-4	0	GC.
		NL	NP	111	12	A-1-b	0	SP-SM.
		NL	NP			A-1-b	0	SP-SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-4	1	SM.
		NL	NP			A-1-b	0	SM.
		NL	NP			A-1-b	0	SP.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-1-b	0	SP-SM.
		NL	NP			A-2-4	0	SM.
		21	6			A-4	1	SM-SC.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-4	0	SM.
15	24	28	9			A-4	2	SC.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-3	0	SP-SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-4	0	SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-2-4	0	SM.

TABLE 6.—*Engineering*

Soil type	Sampling site: Site number	Sampling site: Latitude	Sampling site: Longitude	Depth	Test results: Sieve analysis: Cumulative percentage passing— ¾ inch	No. 4 (4.7 mm.)	No. 10 (2 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)
		Degrees, minutes, seconds	*Degrees, minutes, seconds*	*Inches*					
Freehold loamy fine sand.	28	39°51′27″	75°03′47″	0 to 20	100	100	100	83	4
				20 to 42	100	100	100	86	12
				42 to 44					
				44 to 100	100	100	100	89	6
				100 to 130	100	100	100	96	17
				130 to 160	100	100	100	96	11
Freehold loamy fine sand.	29	39°51′55″	75°01′40″	0 to 6	100	100	99	68	4
				6 to 20	100	99	97	65	3
				20 to 42	99	99	98	76	22
				42 to 76	100	100	100	76	12
Freehold sand, thick surface variant.	32	39°53′17″	74°59′33″	0 to 24	100	100	100	98	5
				24 to 52	100	100	100	90	6
				52 to 72	100	100	100	92	15
				72 to 84	100	100	100	94	7
Freehold sand, thick surface variant.	33	39°54′02″	74°48′00″	0 to 10	100	100	100	95	14
				10 to 30	100	100	100	93	13
				30 to 44	100	100	99	95	29
				44 to 60	100	100	100	96	32
				60 to 84	100	100	98	93	10
Howell loam [4].	13	39°53′36″	75°05′18″	0 to 8	99	96	96	78	46
				8 to 26	99	98	98	87	58
				26 to 36	100	100	100	90	66
				36 to 70	100	99	98	72	25
				70 to 90	100	100	98	65	12
				90 to 100	100	100	99	89	66
Howell loam [4].	42	39°57′10″	75°02′11″	0 to 6	100	100	99	94	48
				6 to 24	100	100	100	97	65
				24 to 48	100	100	100	96	67
				48 to 64	100	98	97	83	28
Howell loam [4].	45	39°52′28″	75°06′20″	0 to 20	99	94	93	76	44
				20 to 36	100	100	100	93	84
				36 to 60	100	100	99	90	83
				60 to 96	100	100	100	93	78
Howell loam [4].	46	39°57′17″	75°01′36″	0 to 18	96	94	92	82	53
				18 to 48	99	97	96	91	68
				48 to 92	100	100	100	99	64
				92 to 120	100	100	96	94	36
Kresson sandy loam.	36	39°50′52″	75°00′59″	0 to 12	100	96	76	51	34
				12 to 30	100	100	100	97	75
				30 to 42	100	100	97	78	39
Kresson sandy loam.	38	39°52′27″	74°56′18″	0 to 12	100	100	100	94	74
				12 to 24	100	100	98	95	84
				24 to 60	100	100	100	81	45
Kresson sandy loam.	39	39°52′33″	74°58′05″	0 to 6	80	62	59	53	39
				6 to 24	100	100	99	98	95
				24 to 60	100	100	100	100	97
Lakewood fine sand.	23	39°46′18″	75°01′19″	0 to 6	100	100	95	75	9
				6 to 36	100	100	100	81	9
				36 to 48	100	100	99	80	5
				48 to 60	100	100	100	72	8
				60 to 84	98	88	78	59	6

See footnotes at end of table.

test data—Continued

Test results—Continued						Classification		
Hydrometer analysis		Liquid limit [1]	Plasticity index [2]	Maximum density	Optimum moisture content	AASHO		Unified [3]
0.05–0.005 mm.	<0.005 mm.					Group	Group index	
Percent	*Percent*	*Percent*	*Percent*	*Lb. per cu. ft.*	*Percent*			
		NL	NP			A-3	0	SP.
		NL	NP			A-2-4	0	SP-SM.
		NL	NP			A-3	0	SP-SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-2-4	0	SP-SM.
		NL	NP			A-3	0	SP.
		NL	NP	104	14	A-3	0	SP.
		NL	NP			A-2-4	0	SM.
		NL	NP	115	13	A-2-4	0	SP-SM.
		NL	NP			A-3	0	SP-SM.
		NL	NP			A-3	0	SP-SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-3	0	SP-SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-2-4	0	SM.
		NL	NP			A-3	0	SP-SM.
		21	6			A-4	2	SM-SC.
		NL	NP	112	13	A-4	5	ML.
15	23	27	6			A-4	6	CL-ML.
		NL	NP	125	10	A-2-4	0	SM.
		NL	NP			A-2-4	0	SP-SM.
33	27	32	8			A-4	6	ML-CL.
		NL	NP			A-4	3	SM.
		22	4			A-4	6	CL-ML.
		23	6			A-4	6	CL-ML.
		NL	NP			A-2-4	0	SM.
		32	12			A-6	2	SC.
51	26	57	24	89	28	A-7-5	17	MH.
39	43	60	24	89	28	A-7-5	18	MH.
42	33	55	24			A-7-5	17	MH-CH.
		23	8			A-4	4	CL.
24	40	48	20	90	30	A-7-6	12	ML-CL.
25	37	49	17	90	30	A-7-5	10	ML.
		NL	NP			A-4	0	SM.
		45	13			A-2-7	1	SM.
		61	26	86	33	A-7-5	18	MH.
		49	17	95	29	A-7-5	3	SM.
		31	9			A-4	8	CL-ML.
47	34	34	11			A-6	8	CL.
		30	12			A-6	2	CL.
		37	12			A-6	2	GC.
		53	20	90	31	A-7-5	14	MH.
		45	12	95	27	A-7-5	10	ML.
		NL	NP			A-3	0	SP-SM.
		NL	NP	109	11	A-3	0	SP-SM.
		NL	NP			A-3	0	SP-SM.
		NL	NP			A-3	0	SP-SM.
		NL	NP	111	13	A-3	0	SP-SM.

TABLE 7.—*Brief description of the soils and their*

Map symbol	Soil name [1]	Depth to seasonally high water table	Description of soil	Depth from surface
				Inches
DoA DsA DsB DtC DxC	Downer loamy sand, 0 to 5 percent slopes. Downer sandy loam, 0 to 2 percent slopes. Downer sandy loam, 2 to 5 percent slopes. Downer soils, 5 to 10 percent slopes. Downer-Aura complex, 5 to 10 percent slopes (Downer part).	5 to 10 feet.	About 1 to 1½ feet of loamy sand or sandy loam over 1 foot of sandy loam; underlain by stratified, loose loamy sand or sand; in places, contains rounded quartzose gravel up to 2 inches in diameter and 1 to 5 percent by volume; in intermediate positions. For data on the Aura part of Downer-Aura complex, see Aura loamy sand and Aura sandy loam.	0–18 18–30 30–60
DrA	Downer loamy sand, clayey substratum, 0 to 5 percent slopes.	5 to 10 feet.	About 1½ feet of loamy sand over 1 foot of sandy loam; underlain by stratified loamy sand and sandy loam that contain layers of sandy clay; in intermediate positions.	0–16 16–30 30–60
Fd	Fallsington sandy loam.	1 foot.	About 2 feet of sandy loam over stratified loamy sand and sandy loam; in places, contains small amount of rounded quartzose gravel up to 2 inches in diameter; soil is in low positions; slope ranges from 0 to 2 percent; soil originally ponded from late in fall until early in spring.	0–24 24–60
FfA FfB FfC FhB FhC FsE FtD	Freehold fine sandy loam, 0 to 2 percent slopes. Freehold fine sandy loam, 2 to 5 percent slopes. Freehold fine sandy loam, 5 to 10 percent slopes. Freehold loamy fine sand, 0 to 5 percent slopes. Freehold loamy fine sand, 5 to 10 percent slopes. Freehold soils, 15 to 30 percent slozes. Freehold and Collington soils, 10 to 15 percent slopes (Freehold part).	5 to 10 feet or more.	Freehold soils have about 1 or 1½ feet of fine sandy loam or loamy fine sand over loamy sand or sandy loam; underlain by stratified loamy fine sand and sandy loam, weakly cemented with iron in places; in high positions. For data on Collington soil in Freehold and Collington soils, see Collington fine sandy loam.	0–15 15–42 42–60
FnB	Freehold sand, thick surface variant, 0 to 5 percent slopes.	5 to 10 feet or more.	About 2½ feet of loose sand over 1 to 1½ feet of fine sandy loam; underlain by stratified loamy fine sand and fine sandy loam; in high positions.	0–30 30–40 40–60
FxB FxC	Freehold and Downer-Urban land complex, gently sloping (Urban land part). Freehold and Downer-Urban land complex, sloping (Urban land part).	5 feet or more.	About 5 feet of mixed loamy sand and sandy loam; in high positions; slope ranges from 0 to 5 percent. For data on Freehold part of this complex, see Freehold fine sandy loam and Freehold loamy fine sand. For data on Downer part, see Downer loamy sand and Downer sandy loam.	0–60
Fy	Freehold and Downer, clayey substrata, Urban land complex (Urban land part).	3 feet or more.	About 2 to 3 feet of mixed loamy sand or sandy loam underlain by layers of sandy clay; in high positions. For data on Freehold part of this complex, see Freehold fine sandy loam. For data on Downer part, see Downer loamy sand, clayey substratum.	0–30 30–60
HdA HfA	Holmdel fine sandy loam, 0 to 3 percent slopes. Holmdel loamy fine sand, 0 to 3 percent slopes.	2 to 3 feet.	About 10 inches to 1½ feet of fine sandy loam or loamy fine sand over 1½ to 2 feet of fine sandy loam or fine sandy clay loam; underlain by stratified fine sandy loam and loamy fine sand; in intermediate positions.	0–10 10–34 34–60

See footnotes at end of table.

estimated physical and chemical properties—Continued

Classification			Mechanical analysis				Permeability	Available water capacity	Reaction [2]	Shrink-swell potential
USDA texture	Unified	AASHO	Percentage passing sieve—							
			No. 4 [3]	No. 10	No. 40	No. 200				
							Inches per hour	*Inches per inch of soil*	*pH*	
Loamy sand or sandy loam.	SP-SM or SM.	A-2 or A-3	80-100	70-100	50-90	10-30	0. 63-2. 0	0. 10-0. 14	4. 0-4. 5	Low.
Sandy loam	SM	A-2	80-100	70-90	50-90	15-35	0. 63-2. 0	0. 12	4. 5-5. 0	Low.
Loamy sand or sand.	SP-SM	A-2 or A-3	70-100	60-100	40-70	10-20	2. 0-6. 3	0. 08	4. 5-5. 0	Low.
Loamy sand	SP-SM or SM.	A-2 or A-3	90-100	85-95	40-60	10-20	0. 63-2. 0	0. 10	4. 0-4. 5	Low.
Sandy loam	SM	A-2	90-100	85-95	40-60	15-25	0. 63-2. 0	0. 12	4. 5-5. 0	Low.
Loamy sand and sandy clay.	SP-SM or SM.	A-2 or A-4	70-90	60-80	40-60	10-50	0. 63-2. 0	0. 10	4. 5-5. 0	Low to moderate.
Sandy loam	SM	A-2 or A-4	95-100	95-100	60-80	30-40	0. 63-2. 0	[4] 0. 15	4. 0-4. 5	Low.
Loamy sand	SP-SM	A-2, A-3, or A-4.	95-100	90-100	50-80	10-40	2. 0-6. 3	[4] 0. 10	4. 5-5. 0	Low.
Loamy fine sand or fine sandy loam	SP-SM or SM.	A-2, A-3, or A-4.	100	95-100	75-95	5-40	0. 2-2. 0	0. 15-0. 20	4. 0-4. 5	Low.
Fine sandy clay loam.	SM-SC	A-2 or A-4	100	95-100	75-95	10-45	0. 63-2. 0	0. 18	4. 5-5. 0	Low to moderate.
Loamy sand and sandy loam.	SP-SM or SM.	A-2 or A-3	100	90-100	70-90	10-30	0. 63-6. 3	0. 15	4. 5-5. 0	Low.
Sand	SP or SP-SM.	A-2 or A-3	100	98-100	60-100	5-15	2. 0-6. 3	0. 10	4. 0-4. 5	Low.
Fine sandy loam.	SM	A-2	100	95-100	80-100	15-30	0. 63-2. 0	0. 15	4. 5-5. 0	Low.
Fine sand	SP-SM or SM.	A-2 or A-3	100	95-100	75-95	5-15	6. 3+	0. 12	4. 5-5. 0	Low.
Sandy loam or loamy sand.	SM or SP	A-2	90-100	85-100	60-90	10-30	0. 63-2. 0	0. 15	4. 5-5. 0	Low.
Sandy loam or loamy sand.	SM or SP-SM.	A-2	90-100	85-100	60-90	10-30	0. 63-2. 0	0. 15	4. 5-5. 0	Low.
Sandy clay	SC	A-2, A-4, or A-6.	95-100	85-100	60-90	20-50	0. 63-2. 0	0. 20	4. 5-5. 0	Low to moderate.
Fine sandy loam or loamy fine sand.	SM or SP-SM.	A-2, A-3, or A-4.	100	95-100	75-95	5-40	0. 63-2. 0	[4] 0. 15-0. 20	4. 0-4. 5	Low.
Fine sandy loam or fine sandy clay loam.	SM or SC	A-2 or A-4	100	95-100	75-95	15-50	0. 63-2. 0	[4] 0. 18	4. 5-5. 0	Low.
Loamy fine sand and fine sandy loam.	SM or SP-SM.	A-2 or A-3	100	90-100	70-95	5-25	0. 63-6. 3	[4] 0. 15	4. 5-5. 0	Low.

TABLE 8.—*Engineering*

Soil and map symbol [1]	Susceptibility to frost action	Suitability for—			Features affecting engineering practices	
		Gravel	Road subgrade	Road fill	Impoundments	
					Reservoir area	Dikes or embankments
Aura, (AmA, AmB, ArA, ArB).	Low to moderate.	Good for road gravel.	Good	Good	Permeable substratum.	Stable; good for core, fair for shell.
Aura-Downer (AtB, AvB).	Low	Fair for road gravel.	Fair	Good	Not suitable; permeable substratum.	Stable; good for core, fair for shell.
Colemantown (Cm)	High	Not suitable	Poor	Fair	Slowly permeable substratum; high water table.	Stable to fairly stable; impervious for core and shell; substratum sandy.
Collington (CoA, CoB).	Low to moderate.	Not suitable	Fair	Good	Permeable substratum.	Fairly stable; good for core, fair for shell; sandy substratum.
Downer (DoA, DrA, DsA, DsB, DtC, DxC).	Low	Not suitable	Good	Good	Rapidly permeable substratum.	Stable; good for core; sandy substratum.
Fallsington (Fd)	Low to moderate.	Not suitable	Fair	Good	Permeable substratum; high water table.	Fairly stable; good for core, fair for shell; sandy substratum.
Freehold (FfA, FfB, FfC, FhB, FhC, FsE, FtD).	Low	Not suitable	Fair	Good	Permeable substratum.	Fairly stable; impervious when compacted; sandy substratum.
Freehold sand, thick surface variant (FnB).	Low	Not suitable	Fair	Good	Permeable substratum.	Suitable in homogenous mixture.
Holmdel (HdA, HfA)	Low	Not suitable	Fair	Good	Permeable substratum.	Fairly stable; impervious when compacted; rapidly permeable substratum.
Klej (KmA)	Low	Not suitable	Fair	Good	Rapidly permeable.	Rapid permeability; low cohesion; fairly stable in flat areas.
Kresson (KrA)	Moderate	Not suitable	Fair to poor	Good	Seepage unlikely; slowly permeable substratum.	Stable; impervious; sandy substratum.
Lakehurst (LaA, LbA).	Low	Not suitable	Fair to good	Good	Rapid permeability.	Fairly stable; rapid permeability; low cohesion.
Lakeland fine sand, firm substratum (LcB).	Low	Fair for road gravel.	Fair to good	Good	Rapid permeability.	Fairly stable; rapid permeability; low cohesion.
Lakeland (LdA, LeA).	Low	Not suitable	Fair	Good	Rapid permeability.	Fairly stable; rapid permeability; low cohesion.
Lakewood (LfB, LfC, LfD, LgB, LgC, LhE).	Low	Not suitable	Fair	Good	Rapid permeability.	Fairly stable; rapid permeability; low cohesion.
Leon (Lo, Ls)	Low to moderate.	Not suitable	Fair	Good	Permeable substratum.	Fairly stable; rapid permeability; low cohesion.

See footnote at end of table.

terpretations of the soils

Features affecting engineering practices—Continued

Dugout ponds	Land smoothing	Agricultural drainage	Irrigation
Low water table; reservoir must be sealed.	Shallow surface soil and restricted root zone limit grading to shallow cuts.	Not needed	Low water-holding capacity; slow to moderate permeability.
Low water table; reservoir must be sealed.	Shallow surface soil and abrupt texture change limit grading to shallow cuts.	Not needed	Low water-holding capacity; slow to rapid permeability.
High water table; slow recharge.	Plastic nature of subsoil limits grading to shallow cuts.	Excess surface water and possibly ground water; slow permeability.	High water-holding capacity; slow permeability.
Low water table; reservoir must be sealed.	Suitable for deep cuts	Not needed	High water-holding capacity; moderate permeability.
Not suitable; rapidly permeable substratum.	Shallow surface soil and abrupt texture change limit grading to medium depth.	Not needed	Low water-holding capacity; moderate permeability.
Rapid recharge; high water table.	Shallow surface soil and abrupt texture change limit grading to shallow cuts.	Moderate permeability; seasonally high water table; subsurface drainage needed.	Moderate water-holding capacity; moderate permeability.
Low water table	Suitable for deep cuts	Not needed	Moderate water-holding capacity; moderate to slow permeability.
Low water table	Suitable for deep cuts	Not needed	Low water-holding capacity; rapid permeability to a depth of 30 inches.
Low water table in summer; rapidly permeable substratum.	Suitable for deep cuts	Moderate to moderately slow permeability; seasonally high water table; subsurface drainage satisfactory.	Moderate water-holding capacity; moderate to moderately slow permeability.
Low water table in summer; rapidly permeable substratum.	Suitable for deep cuts	Rapid permeability; seasonally high water table; subsurface drainage satisfactory.	Low water-holding capacity; rapid permeability.
Slow recharge; moderately high water table.	Sandy clay subsoil limits grading to shallow cuts.	Because of slow permeability, soil requires surface drainage and possibly subsurface drainage.	High water-holding capacity; slow permeability.
Low water table in summer; rapidly permeable substratum.	Soil too infertile to justify smoothing.	Soil too infertile to justify drainage.	Soil too infertile to justify irrigation.
Rapid permeability; low water table.	Suitable for deep cuts	Not needed	Very low water-holding capacity; rapid permeability to a depth of 30 inches.
Low water table	Suitable for deep cuts	Not needed	Very low water-holding capacity; rapid permeability.
Low water table; rapid permeability.	Soil too infertile for leveling	Not needed	Soil too infertile to justify irrigation.
Rapid recharge; high water table.	Suitable for moderate cuts; stockpiling and spreading surface soil may be needed.	Moderate permeability; suitable for controlled water table.	Not needed; permanently high water table.

776-501—66——5

TABLE 9.—*Limitations of soils for*

Urban group number and description	Map symbol and soil		Urban use: Building sites [1] — Light industrial	Urban use: Building sites [1] — Low residential	Urban use: Septic effluent disposal
Group 1: Nearly level to gently sloping, well-drained soils that have a moderate water-holding capacity.	CoA	Collington fine sandy loam, 0 to 2 percent slopes.	Slight	Slight	Slight
	CoB	Collington fine sandy loam, 2 to 5 percent slopes.			
	FfA	Freehold fine sandy loam, 0 to 2 percent slopes.			
	FfB	Freehold fine sandy loam, 2 to 5 percent slopes.			
	FxB	Freehold and Downer-Urban land complex, gently sloping (Freehold and Urban land parts).			
	Fy	Freehold and Downer, clayey substrata, -Urban land complex (Freehold and Urban land parts).			
	WaB	Westphalia fine sandy loam, 0 to 5 percent slopes.			
	Wr	Westphalia and Nixonton-Urban land complex (Westphalia and Urban land parts).			
Group 2: Nearly level to gently sloping, well-drained soils that have a moderate to low water-holding capacity.	AtB	Aurora-Downer loamy sands, 0 to 5 percent slopes (Downer part).	Slight	Slight	Slight; rapid permeability of substratum in Downer soils may permit pollution of ground water.
	AvB	Aura-Downer sandy loams, 0 to 5 percent slopes (Downer part).			
	DoA	Downer loamy sand, 0 to 5 percent slopes.			
	DrA	Downer loamy sand, clayey substratum, 0 to 5 percent slopes.			
	DsA	Downer sandy loam, 0 to 2 percent slopes.			
	DsB	Downer sandy loam, 2 to 5 percent slopes.			
	FhB	Freehold loamy fine sand, 0 to 5 percent slopes.			
	FnB	Freehold sand, thick surface variant, 0 to 5 percent slopes.			
	FxB	Freehold and Downer-Urban land complex, gently sloping (Downer part).			
	Fy	Freehold and Downer, clayey substrata, -Urban land complex (Downer part).			
	WfB	Westphalia loamy fine sand, 0 to 5 percent slopes.			
Group 3: Nearly level to gently sloping, well-drained soils that have a firm substratum.	AmA	Aura loamy sand, 0 to 2 percent slopes.	Slight	Slight	Moderate; slow permeability of substratum.
	AmB	Aura loamy sand, 2 to 5 percent slopes.			
	ArA	Aura sandy loam, 0 to 2 percent slopes.			
	ArB	Aura sandy loam, 2 to 5 percent slopes.			
	AtB	Aura-Downer loamy sands, 0 to 5 percent slopes. (Aura part).			
	AvB	Aura-Downer sandy loams, 0 to 5 percent slopes. (Aura part).			
	Ax	Aura-Urban land complex.			
	LcB	Lakeland fine sand, firm substratum, 0 to 5 percent slopes.			

See footnotes at end of table.

rban and recreational uses

Urban use—Continued			Recreation use		
Sanitary land fill	Landscaping		Athletic fields	Parks and playgrounds	Campsites [2]
	Lawns	Ornamental plants			
Slight	Slight	Slight	Slight for soils that have 0 to 2 percent slopes. Moderate for soils that have 2 to 5 percent slopes.	Slight	Slight.
Slight	Moderate; low available water capacity. Severe limitation for Freehold sand, thick surface variant, since it has very low available water capacity.	Moderate; low available water capacity.	Slight for sandy loams and soils that have 0 to 2 percent slopes. Moderate for loamy sands and soils that have 2 to 5 percent slopes. Severe for Freehold loamy sand because it is droughty and infertile.	Slight	Slight.
Moderate; firm substratum difficult to move.	Moderate; low available water capacity. Severe for Lakeland sand, firm substratum, because of very low available water capacity.	Slight	Slight for sandy loams and soils that have 0 to 2 percent slopes. Moderate for loamy sands and soils that have 2 to 5 percent slopes. Severe for Lakeland sand, firm substratum, which has very low available water capacity.	Slight for most soils. Severe for playgrounds on Lakeland sand, firm substratum, which is droughty and infertile.	Slight.

SOIL LEGEND

The first letter in each symbol is the initial of the soil name. A second capital letter, A, B, C, D, or E shows the slope. Most symbols without a slope letter are for nearly level soils, but some are for soils that have considerable range in slope. A final number, 3, in a symbol shows that the soil is severely eroded.

SYMBOL	NAME
AmA	Aura loamy sand, 0 to 2 percent slopes
AmB	Aura loamy sand, 2 to 5 percent slopes
ArA	Aura sandy loam, 0 to 2 percent slopes
ArB	Aura sandy loam, 2 to 5 percent slopes
AtB	Aura-Downer loamy sands, 0 to 5 percent slopes
AvB	Aura-Downer sandy loams, 0 to 5 percent slopes
Ax	Aura-Urban land complex
Ca	Clay pits
Cm	Colemantown loam
CoA	Collington fine sandy loam, 0 to 2 percent slopes
CoB	Collington fine sandy loam, 2 to 5 percent slopes
DaA	Downer loamy sand, 0 to 5 percent slopes
DrA	Downer loamy sand, clayey substratum, 0 to 5 percent slopes
DsA	Downer sandy loam, 0 to 2 percent slopes
DsB	Downer sandy loam, 2 to 5 percent slopes
DtC	Downer soils, 5 to 10 percent slopes
DxC	Downer-Aura complex, 5 to 10 percent slopes
Fd	Fallsington sandy loam
FfA	Freehold fine sandy loam, 0 to 2 percent slopes
FfB	Freehold fine sandy loam, 2 to 5 percent slopes
FfC	Freehold fine sandy loam, 5 to 10 percent slopes
FhB	Freehold loamy fine sand, 0 to 5 percent slopes
FhC	Freehold loamy fine sand, 5 to 10 percent slopes
FnB	Freehold sand, thick surface variant, 0 to 5 percent slopes
FsE	Freehold soils, 15 to 30 percent slopes
FtD	Freehold and Collington soils, 10 to 15 percent slopes
FxB	Freehold and Downer-Urban land complex, gently sloping
FxC	Freehold and Downer-Urban land complex, sloping
Fy	Freehold and Downer, clayey substrata, -Urban land complex
HdA	Holmdel fine sandy loam, 0 to 3 percent slopes
HfA	Holmdel loamy fine sand, 0 to 3 percent slopes
Hm	Holmdel, clayey substratum, -Urban land complex
Hn	Holmdel-Urban land complex
HoB	Howell-Urban land complex, gently sloping
HoC	Howell-Urban land complex, sloping
KmA	Klej loamy sand, 0 to 2 percent slopes
KrA	Kresson sandy loam, 0 to 3 percent slopes
LaA	Lakehurst sand, 0 to 3 percent slopes
LbA	Lakehurst-Lakewood association, 0 to 5 percent slopes
LcB	Lakeland fine sand, firm substratum, 0 to 5 percent slopes
LdA	Lakeland sand, 0 to 5 percent slopes
LeA	Lakeland sand, water table, 0 to 2 percent slopes
LfB	Lakewood fine sand, 0 to 5 percent slopes
LfC	Lakewood fine sand, 5 to 10 percent slopes
LfD	Lakewood fine sand, 10 to 25 percent slopes
LgB	Lakewood sand, 0 to 5 percent slopes
LgC	Lakewood sand, 5 to 10 percent slopes
LhE	Lakewood and Lakeland sands, 10 to 30 percent slopes
Lo	Leon sand
Ls	Leon-St. Johns sands
Lv	Loamy alluvial land
Mo	Made land
McC3	Marlton soils, 5 to 10 percent slopes, severely eroded
Mk	Marlton and Kresson-Urban land complex
MrA	Marlton sandy loam, 0 to 2 percent slopes
MrB	Marlton sandy loam, 2 to 5 percent slopes
MmB	Matawan loamy sand, 0 to 5 percent slopes
MnA	Matawan sandy loam, 0 to 2 percent slopes
MnB	Matawan sandy loam, 2 to 5 percent slopes
Mo	Moderately wet land
Mu	Muck
NbA	Nixonton and Barclay fine sandy loams, 0 to 3 percent slopes
NcA	Nixonton and Barclay loamy fine sands, 0 to 5 percent slopes
Pa	Pasquotank fine sandy loam
Pc	Pasquotank and Weeksville-Urban land complex
Ps	Pocomoke sandy loam
Sa	St. Johns sand
Sc	St. Johns sand, clayey substratum
Sg	Sand and gravel pits
Sv	Sandy alluvial land
Sw	Shrewsbury fine sandy loam
Sx	Shrewsbury-Urban land complex
Tm	Tidal marsh-Made land complex
Um	Urban-Moderately wet land complex
Wd	Weeksville fine sandy loam
WaB	Westphalia fine sandy loam, 0 to 5 percent slopes
WfB	Westphalia loamy fine sand, 0 to 5 percent slopes
WfC	Westphalia loamy fine sand, 5 to 10 percent slopes
WhD	Westphalia soils, 10 to 20 percent slopes
WhD3	Westphalia soils, 10 to 20 percent slopes, severely eroded
Wr	Westphalia and Nixonton-Urban land complex
WsA	Woodstown and Dragston sandy loams, 0 to 3 percent slopes
WtA	Woodstown and Klej loamy sands, 0 to 3 percent slopes
WuA	Woodstown and Klej loamy sands, clayey substrata, 0 to 3 percent slopes

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferries
- Ford
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries

Mine dump

Pits, gravel or other

Power lines

Pipe lines

Cemeteries

Dams

Levees

Tanks

Oil wells

BOUNDARIES

- National or state
- County
- Reservation
- Land grant
- Township, civil

DRAINAGE

Streams
- Perennial
- Intermittent, unclass.

Canals and ditches — CANAL, DITCH

Lakes and ponds
- Perennial
- Intermittent

Wells — flowing

Springs

Marsh

Wet spot

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peaks

Depressions — Large, Small
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

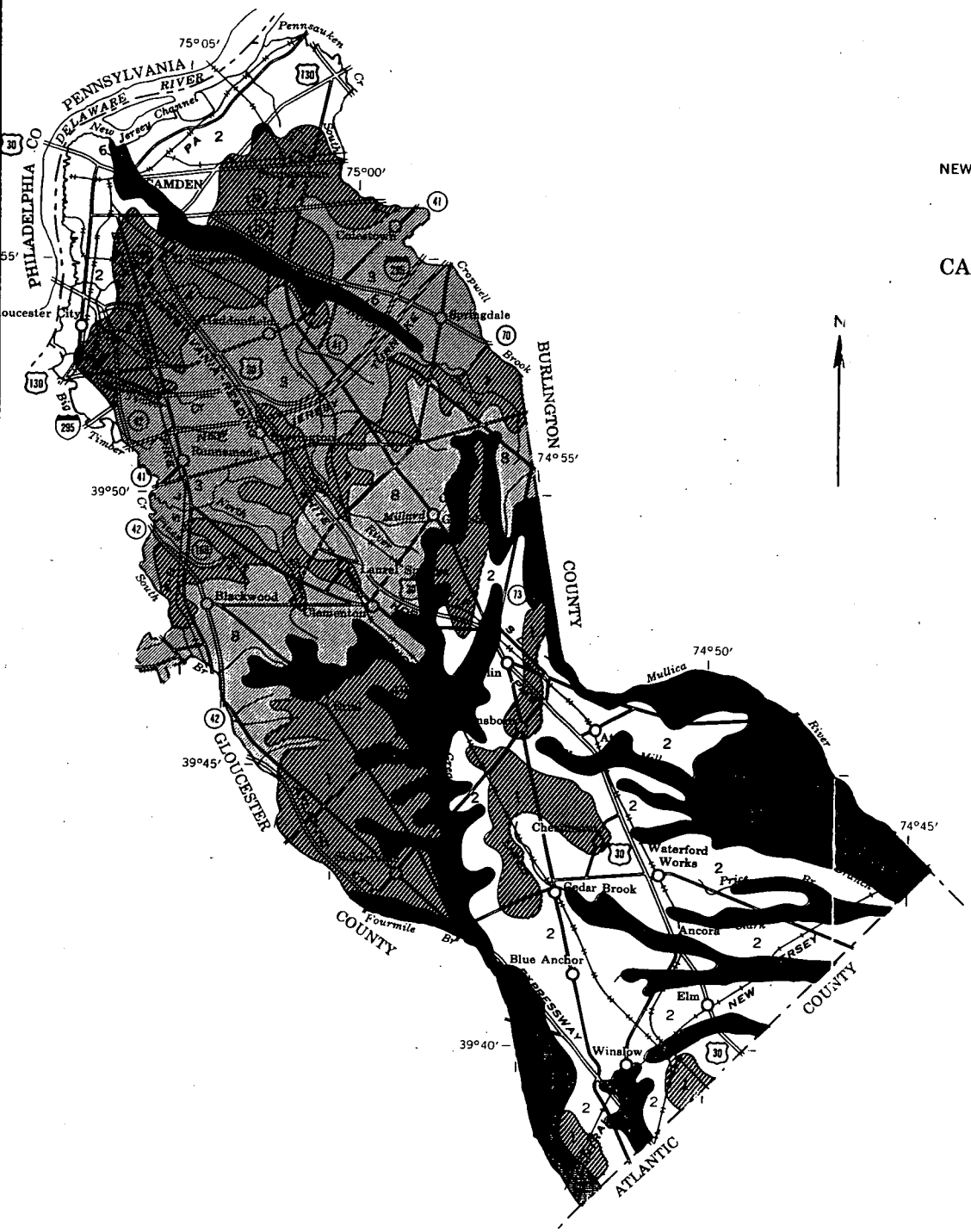
SOIL SURVEY DATA

- Soil boundary and symbol — Dx
- Gravel
- Stones
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gullies

Soil map constructed 1965 by Cartographic Division, Soil Conservation Service, USDA, from 1957 aerial photographs. Controlled mosaic based on New Jersey plane coordinate system, transverse Mercator projection, 1927 North American datum.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NEW JERSEY AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
CAMDEN COUNTY, NEW JERSEY



SOIL ASSOCIATIONS

1 Aura-Downer association: Gently sloping gravelly and sandy soils

2 Downer-Woodstown-Dragston association: Gently sloping, grayish-brown sandy soils

3 Freehold-Holmdel-Collington association: Gently to strongly sloping soils from greensand

4 Howell-Urban land association: Gently sloping, brown silty and clayey soils

5 Lakewood-Lakehurst-Lakeland association: Level to steep, gray sandy soils

6 Muck-Alluvial land association: Wet soils mainly along streams

7 Marlton-Kresson association: Gently sloping to steep, olive clay soils

8 Westphalia-Nixonton-Barclay association: Nearly level to steep, fine sandy soils

July 1965

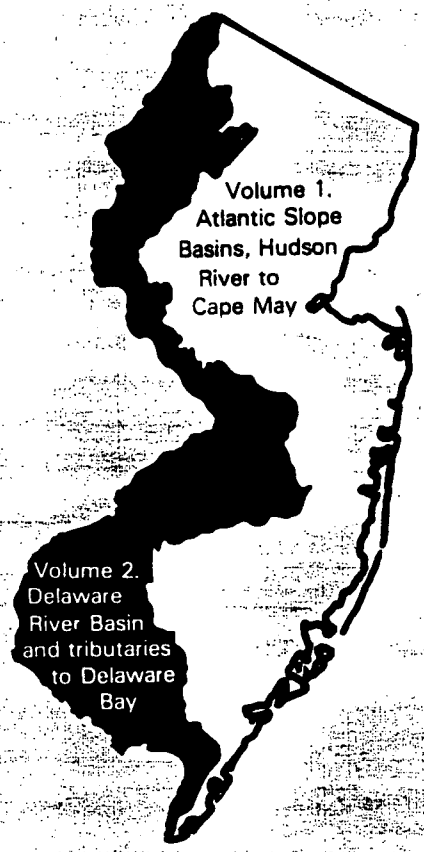
0 ½ 1 Mile Scale 1:15 840 0 5000 Feet

(Joins sheet 11)

REFERENCE NO. 21

Water Resources Data
New Jersey
Water Year 1987

Volume 2. Delaware River Basin and tributaries to Delaware Bay



U.S. GEOLOGICAL SURVEY WATER-DATA REPORT NJ-87-2
Prepared in cooperation with the New Jersey Department of Environmental Protection and with other agencies

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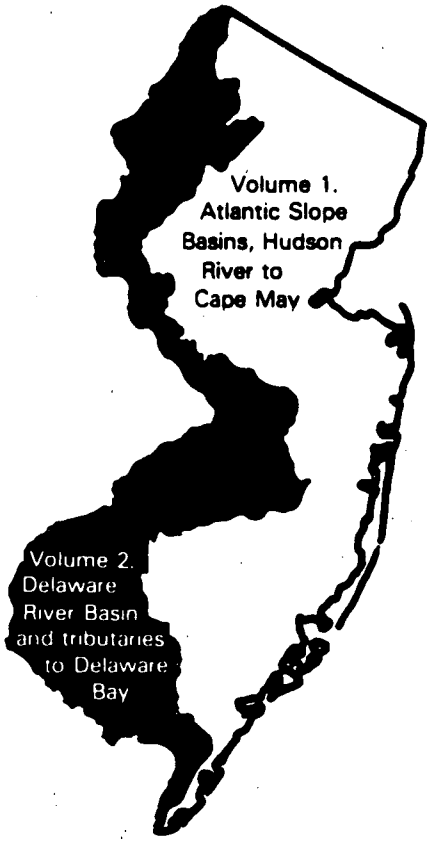
by W.R. Bauersfeld, E.W. Moshinsky, E.A. Pustay, and W.D. Jones



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Department of Environmental Protection
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UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For information on the water program in New Jersey write to

District Chief, Water Resources Division
U.S. Geological Survey
Mountain View Office Park
810 Bear Tavern Road, Suite 206
West Trenton, New Jersey 08628

1988

01467329 SOUTH BRANCH BIG TIMBER CREEK AT BLACKWOOD TERRACE, NJ

LOCATION.--Lat 39°48'05", long 75°04'27", Gloucester County, Hydrologic Unit 02040202, at bridge on Blackwood-Clementon Road at Blackwood Terrace, 1,000 ft upstream from Bull Run, and 2.0 mi northeast of Fairview.

DRAINAGE AREA.--19.1 mi^2.

PERIOD OF RECORD.--Water years 1976 to current year.

COOPERATION.--Analyses of fecal coliform and fecal streptococci by the MPN method, and water-phase nutrients were performed by the New Jersey Department of Health, Division of Laboratories and Epidemiology.

WATER QUALITY DATA, WATER YEAR OCTOBER 1986 TO SEPTEMBER 1987

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE WATER (DEG C)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	COLI-FORM, FECAL, EC BROTH (MPN)	STREP-TOCOCCI FECAL (MPN)
OCT 1986										
06...	0900	E18	170	6.6	16.5	7.7	79	1.5	490	2400
JAN 1987										
21...	0900	E41	146	7.0	1.0	13.4	94	1.5	140	270
MAR										
16...	0900	E24	165	7.1	2.5	12.9	94	2.1	170	270
MAY										
28...	0900	E26	148	6.8	14.5	9.3	90	2.4	220	2200
JUL										
13...	0900	E36	112	6.4	22.5	6.3	73	6.9	3500	1600
AUG										
04...	0900	E18	140	6.6	22.5	6.4	75	2.4	940	5400

DATE	HARD-NESS (MG/L AS CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)
OCT 1986									
06...	42	12	3.0	9.3	3.2	26	13	13	<0.1
JAN 1987									
21...	35	9.9	2.5	9.1	2.5	21	18	12	<0.1
MAR									
16...	41	12	2.8	9.8	2.7	24	19	15	0.1
MAY									
28...	39	11	2.8	9.1	2.6	24	9.0	15	<0.1
JUL									
13...	37	11	2.2	8.2	2.0	17	16	11	<0.1
AUG									
04...	39	11	2.9	9.2	2.8	26	10	12	0.1

DATE	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NITRITE TOTAL (MG/L AS N)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	CARBON, ORGANIC TOTAL (MG/L AS C)
OCT 1986									
06...	5.8	75	0.031	0.93	0.20	0.83	1.8	0.160	4.9
JAN 1987									
21...	5.4	72	0.021	0.86	0.45	0.99	1.8	0.140	6.8
MAR									
16...	5.4	81	0.020	1.39	0.42	1.1	2.5	0.062	3.4
MAY									
28...	5.0	69	0.049	1.17	0.35	1.4	2.6	1.06	5.9
JUL									
13...	3.7	64	0.047	0.64	0.27	0.97	1.6	0.200	11
AUG									
04...	4.2	68	0.031	1.10	0.21	0.92	2.0	0.170	5.2

01467329 SOUTH BRANCH BIG TIMBER CREEK AT BLACKWOOD TERRACE, NJ--Continued

WATER QUALITY DATA, WATER YEAR OCTOBER 1986 TO SEPTEMBER 1987

DATE	TIME	SULFIDE TOTAL (MG/L AS S)	ALUMINUM, DISSOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	BERYLLIUM, TOTAL RECOVERABLE (UG/L AS BE)	BORON, TOTAL RECOVERABLE (UG/L AS B)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	COPPER, TOTAL RECOVERABLE (UG/L AS CU)
OCT 1986									
06...	0900	<0.5	10	1	<10	70	<1	<10	5

DATE	IRON, TOTAL RECOVERABLE (UG/L AS FE)	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	NICKEL, TOTAL RECOVERABLE (UG/L AS NI)	SELENIUM, TOTAL (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	PHENOLS TOTAL (UG/L)
OCT 1986								
06...	3100	11	60	<0.10	4	<1	280	2

01467060 DELAWARE RIVER AT PALMYRA, NJ

LOCATION.--Lat 40°01'05", long 75°02'16", Philadelphia County, PA, Hydrologic Unit 02040202, on right bank opposite Palmyra, 0.5 mi upstream from Tacony-Palmyra Bridge, 3.5 mi downstream from Rancocas Creek, and at mile 107.55.

DRAINAGE AREA.--7,850 mi^2.

PERIOD OF RECORD.--December 1962 to current year. Tidal volumes published from December 1962 to September 1970.

GAGE.--Water-stage recorder. Datum of gage is -10.00 ft below National Geodetic Vertical Datum of 1929. Gage-height record converted to elevation above or below (-) National Geodetic Vertical Datum of 1929 for publication.

REMARKS.--No gage-height or doubtful record: Sept. 1-30. Some periods of low tide are affected by sluggish or plugged intake and the record is estimated with negligible loss in accuracy. Some periods cannot be estimated and are noted by dash (--) lines.

EXTREMES FOR PERIOD OF RECORD.--Maximum elevation, 8.23 ft, Oct. 25, 1980; minimum, -8.6 ft, Dec. 31, 1962.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum elevation known since 1899, 8.9 ft, Aug. 24, 1933, from profile furnished by Corps of Engineers, U.S. Army.

EXTREMES FOR CURRENT YEAR.--Maximum elevation recorded, 6.96 ft, Dec. 2, Jan. 2; minimum recorded, -4.05 ft; minimum estimated, 4.8 ft, Feb. 9 (bottom of stilling well at 4.0 ft).

Summaries of tide elevations during current year are as follows:

TIDE ELEVATIONS, IN FEET, WATER YEAR OCTOBER 1986 TO SEPTEMBER 1987

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	Elevation	5.35	5.69	6.96	6.96	5.07	6.10	6.58	5.53	5.77	6.06	6.23	--
high tide	Date	8	20	2	2	2	31	15	15	12	13	10	--
Minimum	Elevation	-3.48	-3.41	-3.36	e-4.4	e4.8	-2.70	-2.62	-3.27	-3.17	-2.67	-2.96	--
low tide	Date	6	13	13	24	9	7	1	16	10	1	23	--
Mean high tide		4.43	4.37	4.45	4.20	3.77	4.71	5.16	4.57	4.65	4.81	4.71	--
Mean water level		1.35	1.32	1.38	1.16	0.77	1.71	2.08	1.36	1.43	1.57	1.57	--
Mean low tide		-3.48	-2.02	-1.99	-2.22	-2.57	-1.64	-1.33	-2.23	-2.22	-2.07	-1.99	--

e - Estimated

RESERVOIRS IN DELAWARE RIVER BASIN

01416900 PEPACTON RESERVOIR.--Lat 42°04'38", long 74°58'04", Delaware County, NY, Hydrologic Unit 02040102, near release chamber at Downsville Dam on East Branch Delaware River, and 1.6 mi east of Downsville, NY. DRAINAGE AREA, 371 mi². PERIOD OF RECORD, September 1954 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Board of Water Supply, City of New York).

REMARKS.--Reservoir is formed by an earthfill rockfaced dam. Storage began Sept. 15, 1954. Usable capacity 140,190 mil gal between minimum operating level, elevation, 1,152.0 ft, and crest of spillway, elevation, 1,280.0 ft. Capacity, at crest of spillway 149,700 mil gal; at minimum operating level, 9,609 mil gal; at sill of diversion tunnel, elevation, 1,143.0 ft, 6,098 mil gal; in dead storage below release outlet, elevation, 1,126.50 ft, 1,898 mil gal. Figures given herein represent total contents. Reservoir impounds water for diversion through East Delaware Tunnel to Rondout Reservoir on Rondout Creek, in Hudson River basin (see Delaware River Basin, diversions), for water supply to City of New York; for release during periods of low flow in the lower Delaware River basin, as directed by the Delaware River Master; and for conservation release. No diversion prior to Jan. 6, 1955.

COOPERATION.--Records provided by Bureau of Water Resources Development and Department of Environmental Protection, City of New York.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents observed, 154,027 mil gal, Apr. 5, 1960, elevation, 1,282.27 ft; minimum observed (after first filling), 9,575 mil gal, Dec. 26, 1964, elevation, 1,151.92 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents observed, 151,652 mil gal, Apr. 9, 13, elevation, 1,281.00 ft; minimum, 109,022 mil gal, Sept. 8, elevation, 1,255.90 ft.

01424997 CANNONSVILLE RESERVOIR.--Lat 42°03'46", long 75°22'29", Delaware County, NY, Hydrologic Unit 02040101, in emergency gate tower at Cannonsville Dam on West Branch Delaware River, and 1.8 mi southeast of Stilesville, NY. DRAINAGE AREA, 454 mi². PERIOD OF RECORD, October 1963 to current year. REVISED RECORDS, WRD-NY 1972: 1966. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Board of Water Supply, City of New York).

REMARKS.--Reservoir is formed by an earthfill rockfaced dam; storage began Sept. 30, 1963, usable capacity 95,706 mil gal between minimum operating level, elevation, 1,040.0 ft and crest of spillway, elevation, 1,150.0 ft. Capacity, at crest of spillway, 98,618 mil gal; at minimum operating level, 2,912 mil gal; at mouth of inlet channel to diversion tunnel, elevation, 1,035.0 ft, 1,892 mil gal; in dead storage below release outlet elevation, 1,020.5 ft, 328 mil gal. Figures given herein represent total contents. Impounded water is diverted for New York City water supply via West Delaware Tunnel to Rondout Reservoir in Hudson River basin (see Delaware River Basin, diversion); is released in Delaware River for downstream low flow augmentation as directed by Delaware River Master; and is released for conservation flow in the Delaware River. No diversion prior to Jan. 29. 1964.

COOPERATION.--Records provided by Bureau of Water Resources Development, City of New York.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents observed, 108,116 mil gal, Mar. 15, 1977, elevation, 1,155.85 ft; minimum observed (after first filling), 11,901 mil gal, Nov. 7, 1968, elevation, 1,066.24 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 105,908 mil gal, Apr. 6, elevation, 1,154.53 ft; minimum, 57,550 mil gal, Sept. 8, elevation, 1,119.80 ft.

01428900 PROMPTON RESERVOIR.--Lat 41°35'18", long 75°19'39", Wayne County, PA, Hydrologic Unit 02040103, at dam on West Branch Lackawaxen River, 0.3 mi north of Prompton, PA, 0.4 mi upstream from highway bridge and 0.5 mi upstream from Van Auken Creek. DRAINAGE AREA, 59.6 mi². PERIOD OF RECORD, December 1960 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Corps of Engineers).

REMARKS.--Reservoir formed by an earth and rockfill dam with ungaged bedrock spillway at elevation 1,205.00 ft; storage began July 1960. Capacity at elevation 1,205.00 ft is 51,700 acre-ft. Ordinary minimum (conservation) pool elevation, 1,125.00 ft capacity, 3,420 acre-ft. Reservoir is used for flood control and recreation. Figures given herein represent total contents. Regulation is accomplished by discharge through an ungated tunnel.

COOPERATION.--Records provided by U.S. Army Corps of Engineers.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 8,170 acre-ft, June 29, 1973, elevation, 1,138.40 ft; minimum (after first filling), 2,920 acre-ft, Sept. 27, 1964, elevation, 1,123.20 ft.

EXTREMES FOR CURRENT YEAR.--Maximum content, 4,860 acre-ft, Sept. 9, elevation, 1,129.87 ft; minimum, 3,040 acre-ft, Aug. 26, elevation, 1,123.37 ft.

01429400 GENERAL EDGAR JADWIN RESERVOIR.--Lat 41°36'44", long 75°15,55", Wayne County, PA, Hydrologic Unit 02040103, at dam on Dyberry Creek, 0.45 mi upstream from unnamed tributary, 2.4 mi north of Honesdale, PA, and 2.9 mi upstream from mouth. DRAINAGE AREA, 64.5 mi². PERIOD OF RECORD, October 1959 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Corps of Engineers).

REMARKS.--Reservoir formed by an earth and rockfill dam with ungated, concrete spillway at elevation, 1,053.00 ft; storage began in October 1959. Capacity at elevation 1,053.00 ft is 24,500 acre-ft. Reservoir is used for flood control. Figures given herein represent total contents. Regulation is accomplished by discharge through an ungated tunnel.

COOPERATION.--Records provided by U.S. Army Corps of Engineers.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 6,520 acre-ft, June 19, 1973, elevation 1,017.40 ft; no storage many times.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 1,620 acre-ft, Apr. 5 elevation, 998.15 ft; no storage many times.

01431700 LAKE WALLENPAUPACK.--Lat 41°27'35", long 75°11'10", Wayne County, PA, Hydrologic Unit 02040103, at dam on Wallenpaupack Creek at Wilsonville, PA, 1.2 mi south of and 1.5 mi upstream from mouth. DRAINAGE AREA, 228 mi². PERIOD OF RECORD, January 1926 to current year. GAGE, vertical staff. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Pennsylvania Power and Light Co.).

REMARKS.--Reservoir formed by concrete gravity-type and earthfill dam with concrete spillway at elevation 1,176.00 ft in two sections. Spillway equipped with roller gate, 14 ft high on each section. Storage began Nov. 3, 1925; water in reservoir first reached minimum pool elevation in January 1926. Total capacity at elevation 1,190.00 ft, top of gates, is 209,300 acre-ft of which 157,800 acre-ft is controlled storage above elevation 1,160.00 ft, minimum pool. Reservoir is used for generation of hydroelectric power. Figures given herein represent usable contents.

COOPERATION.--Records provided by Pennsylvania Power and Light Co.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 178,200 acre-ft, Aug. 19-21, 1955, elevation, 1,193.45 ft; minimum (after first filling), 12,280 acre-ft, Mar. 28, 1958, elevation, 1,162.60 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 92,170 acre-ft, May 28, 31, elevation, 1,187.1 ft; minimum, 26,960 acre-ft, Feb. 20, elevation, 1,175.2 ft.

RESERVOIRS IN DELAWARE RIVER BASIN--Continued

01433000 SWINGING BRIDGE RESERVOIR.--Lat 41°34'25", long 74°47'00", Sullivan County, NY, Hydrologic Unit 02040104, at dam on Mongaup River, and 1.8 mi northwest of Fowlersville, NY. DRAINAGE AREA, 118 mi^2 excluding Cliff Lake, Lebanon Lake, and Toronto Reservoir. PERIOD OF RECORD, January 1930 to current year. REVISED RECORDS, WSP 1552: 1951-54. WDR NJ-86-2: 1985. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Orange and Rockland Utilities, Inc.). All capacity figures given herein are based on zero storage at minimum operating pool level, 1,010 ft.

REMARKS.--Reservoir is formed by an earthfill dam. Storage began Jan. 19, 1930. Usable capacity, 1,436.6 mil ft^3 between elevations 1,010.0 ft, minimum operating pool, and 1,071.2 ft, top of flashboards. Capacity below elevation 1,010.0 ft, minimum operating pool, about 212.7 mil ft^3. Reservoir is used for storage of water for power. Figures given herein represent contents above 1,010.0 ft. Water is received from Cliff Lake, Lebanon Lake, and Toronto Reservoir.

COOPERATION.--Records provided by Orange and Rockland Utilities, Inc.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 1,461.6 mil ft^3, Mar. 14, 1977, elevation, 1,071.8 ft; minimum (after first filling), -141.4 mil ft^3, Dec. 2, 1938, elevation, 987.5 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 1,375.2 mil ft^3, Apr. 13, elevation, 1,069.7 ft; minimum, 757.9 mil ft^3, Feb. 14, elevation, 1,052.2 ft.

01433100 TORONTO RESERVOIR.--Lat 41°37'15", long 74°49'55", Sullivan County, NY, Hydrologic Unit 02040104, at dam on Black Lake Creek, and 2.5 mi southeast of village of Black Lake, NY. DRAINAGE AREA, 23.2 mi^2. PERIOD OF RECORD, January 1926 to current year. REVISED RECORDS, WSP 1552: 1951-54. WSP 1702: 1959(M). WDR NJ-85-2: 1984. WDR NJ-86-2: 1985. Nonrecording gage. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Orange and Rockland Utilities, Inc.). All capacity figures given herein are based on zero storage at minimum operating pool level, 1,165.0 ft.

REMARKS.--Reservoir is formed by an earthfill dam completed July 24, 1926. Storage began Jan. 13, 1926. Usable capacity, 1,098.2 mil ft^3 between elevations 1,165.0 ft, minimum operating pool, and operating pool, about 26.8 mil ft^3. Reservoir is used for storage of water for power. Figures given herein represent contents above 1,165.0 ft.

COOPERATION.--Records provided by Orange and Rockland Utilities, Inc.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents observed, 1,171.2 mil ft^3, July 20, 1945, elevation, 1,222.0 ft. minimum observed (after first filling), -26.8 mil ft^3, Nov. 15, 1928, elevation, 1,144.5 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents observed, 968.0 mil ft^3, May 20, 31, June 1, elevation, 1,216.2 ft; minimum observed, 311.7 mil ft^3, Nov. 12, elevation, 1,190.7 ft.

01433200 CLIFF LAKE.--Lat 41°35'00", long 74°47'40", Sullivan County, NY, Hydrologic Unit 02040104, at dam on Black Lake Creek, and 2.5 mi northwest of Fowlersville, NY. DRAINAGE AREA, 6.46 mi^2 excluding area above Toronto Reservoir. PERIOD OF RECORD, January 1939 to current year. REVISED RECORDS, WSP 1552: 1951-54. WRD NY-75-1: 1974(m). WDR NJ-86-2: 1985. Nonrecording gage. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Orange and Rockland Utilities, Inc.). All capacity figures given herein are based on zero storage at minimum operating pool level, 1,043.3 ft.

REMARKS.--Reservoir is formed by a concrete gravity-type dam. Storage began Jan. 6, 1939. Usable capacity, 136.06 mil ft^3 between elevations 1,043.3 ft, minimum operating pool, and 1,072.0 ft, top of permanent flashboards. Capacity below elevation 1,043.3 ft, minimum operating pool, about 6.54 mil ft^3. Reservoir is used for storage of water for power. Water is received from Toronto and Lebanon Lake reservoirs and is discharged through a tunnel into Swinging Bridge Reservoir. Figures given herein represent contents above 1,043.3 ft.

COOPERATION.--Records provided by Orange and Rockland Utilities, Inc.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents observed, 145.44 mil ft^3, July 30, 31, 1945, elevation, 1,073.1 ft; minimum observed (after first filling), about -6.54 mil ft^3, Mar. 16, 1963, elevation, 1,038.0 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents observed, 118.10 mil ft^3, Sept. 21, elevation, 1,069.8 ft; minimum observed, 20.0 mil ft^3, Feb. 13, elevation, 1,051.6 ft.

01435900 NEVERSINK RESERVOIR.--Lat 41°49'40", long 74°38'21", Sullivan County, NY, Hydrologic Unit 02040104, at a gate-house at Neversink Dam on Neversink River, and 2 mi southwest of Neversink, NY. DRAINAGE AREA, 91.8 mi^2. PERIOD OF RECORD, June 1953 to current year. Nonrecording gage read daily at 0900. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Board of Water Supply, City of New York).

REMARKS.--Reservoir is formed by an earthfill rockfaced dam. Storage began June 2, 1953. Usable capacity 34,941 mil gal between minimum operating level, elevation, 1,319.0 ft and crest of spillway, elevation, 1,440.0 ft. Capacity at crest of spillway, 37,146 mil gal; at minimum operating level, 2,205 mil gal; dead storage belowand outlet sill at elevation 1,314.0 ft, 1,680 mil gal. Figures given herein represent total contents. Reservoir impounds water for diversion through Neversink-Grahamsville Tunnel to Rondout Reservoir on Rondout Creek, in Hudson River basin, for water supply of City of New York (see Delaware River basin, diversions); for release during periods of low flow in the lower Delaware River basin, as directed by the Delaware River Master; and for conservation release. No diversion prior to Dec. 3, 1953.

COOPERATION.--Records provided by Bureau of Water Resources Development and Department of Environmental Protection, City of New York.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents observed, 37,978 mil gal, Apr. 25, 1961, elevation, 1,441.67 ft; minimum observed (after first filling), 1,985 mil gal, Nov. 25, 1964, elevation, 1,316.98 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents observed, 37,569 mil gal, Apr. 13, elevation, 1,440.85 ft; minimum observed, 19,122 mil gal, Nov. 8, 20, elevation, 1,396.46 ft.

01447780 FRANCIS E. WALTER RESERVOIR (formerly published as Bear Creek Reservoir).--Lat 41°06'45", long 75°43'15", Luzerne County, PA, Hydrologic Unit 02040106, at dam on Lehigh River, 2,200 ft downstream from Bear Creek and 5 mi northwest of White Haven, PA. DRAINAGE AREA, 289 mi^2. PERIOD OF RECORD, February 1961 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Corps of Engineers).

REMARKS.--Reservoir formed by an earthfill embankment covered with a rock shell, with concrete spillway at elevation 1,450.0 ft; storage began Feb. 17, 1961; water in reservoir first reached conservation pool elevation in June 1961. Total capacity at elevation 1,450.0 ft is 110,700 acre-ft of which 108,700 acre-ft is controlled storage above elevation 1,300.0 ft or (conservation pool). Dead storage is 2,000 acre-ft. Reservoir is used for flood control and recreation. Figures given herein represent total contents. Flow regulated by three gates and low flow by-pass system.

COOPERATION.--Records provided by U.S. Army Corps of Engineers.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 62,100 acre-ft, Sept. 28, 1985, elevation, 1,417.08 ft; minimum (after establishment of conservation pool), 981 acre-ft, July 6, 1982, elevation, 1,287.70 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 29,800 acre-ft, Apr. 6, elevation, 1,382.60 ft; minimum, 1,510 acre-ft, July 19, elevation, 1,295.11 ft.

01449400 PENN FOREST RESERVOIR.--Lat 40°55'45", long 75°33'45", Carbon County, PA, Hydrologic Unit 02040106, at dam on Wild Creek near Hatchery, PA, 0.7 mi upstream from Hatchery, 2.6 mi upstream from Wild Creek Dam, 4.4 mi upstream from mouth, and 10 mi northeast of Palmerton, PA. DRAINAGE AREA, 16.5 mi². PERIOD OF RECORD, October 1958 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by city of Bethlehem).

REMARKS.--Reservoir formed by an earthfill dam, with ungated concrete spillway at elevation 1,000.00 ft; storage began in October 1958. Capacity at elevation 1,000.00 ft is 19,980 acre-ft. Reservoir is used for municipal water supply. Figures given herein represent total contents. Regulation is done by valves on pipe through dam. Figures given herein include diversion, since October 1969, from Tunkhannock Creek basin into Wild Creek basin.

COOPERATION.--Records provided by city of Bethlehem.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 20,560 acre-ft, Apr. 6, 1984, elevation, 1,001.19 ft; minimum, 176 acre-ft, Oct. 6, 1965, elevation, 902.40 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 20,390 acre-ft, Apr. 5, elevation, 1,000.71 ft; minimum, 14,980 acre-ft, Nov. 20, elevation, 988.28 ft.

01449700 WILD CREEK RESERVOIR.--Lat 40°53'50", long 75°33'50", Carbon County, PA, Hydrologic Unit 02040106, at dam on Wild Creek near Hatchery, PA, 1.6 mi upstream from mouth, 2.4 mi south of Hatchery, and 7.5 mi northeast of Palmerton, PA. DRAINAGE AREA, 22.2 mi². PERIOD OF RECORD, January 1941 to current year. Nonrecording gage. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by city of Bethlehem).

REMARKS.--Reservoir formed by earthfill dam, with concrete ungated spillway at elevation 820.00 ft; storage began January 27, 1941; water in reservoir first reached minimum pool elevation in February 1941. Total capacity at elevation 820.00 ft is 12,500 acre-ft of which 12,000 acre-ft is controlled storage. Reservoir is used for municipal water supply. Figures given herein represent usable contents. Regulation is accomplished by valves on pipe through dam. Since October 1969 the basin upstream has received diversion from Tunkhannock Creek basin.

COOPERATION.--Records provided by City of Bethlehem.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 12,880 acre-ft, May 23, 1942, elevation, 822.93 ft; minimum (after first filling), 2,680 acre-ft, Nov. 15, 1966, elevation, 774.10 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 12,280 acre-ft, Apr. 5, elevation, 820.92 ft; minimum, 11,000 acre-ft, Feb. 28, elevation, 816.06 ft.

01449790 BELTZVILLE LAKE.--Lat 40°50'56", long 75°38'19", Carbon County, PA, Hydrologic Unit 02040106, at dam on Pohopoco Creek, 0.45 mi upstream from gaging station on Pohopoco Creek, 0.55 mi upstream from Sawmill Run and 2.3 mi northeast of Parryville, PA. DRAINAGE AREA, 96.3 mi². PERIOD OF RECORD, February 1971 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Corps of Engineers).

REMARKS.--Reservoir formed by an earth and rockfill dam with ungated, partially lined spillway at elevation 651.00 ft; storage began Feb. 8, 1971. Capacity at elevation 651.00 ft is 68,300 acre-ft. Ordinary minimum (conservation) pool elevation, 628.00 ft, capacity, 41,250 acre-ft. Dead storage is 1,390 acre-ft. Reservoir is used for recreation, flood control, low flow augmentation and water supply. Figures given herein represent total contents. Regulation is accomplished by a multi-level water-quality outlet system and two flood-control gates.

COOPERATION.--Records provided by Corps of Engineers.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents 49,730 acre-ft, Jan. 29, 1976, elevation, 636.30 ft; minimum, 15,110 acre-ft, March 31, 1983 elevation, 588.79

EXTREMES FOR CURRENT YEAR.--Maximum contents 45,460 acre-ft, Sept. 14, elevation, 632.26 ft; minimum, 35,800 acre-ft, Sept. 30, elevation, 621.94 ft.

01455400 LAKE HOPATCONG.--Lat 40°55'00", long 74°39'50", Morris County, Hydrologic Unit 02040105, in gatehouse of Lake Hopatcong Dam on Musconetcong River at Landing. DRAINAGE AREA, 25.3 mi². PERIOD OF RECORD, February 1887 to current year. Monthend contents only prior to October 1950, published in WSP 1302. REVISED RECORDS, WDR NJ-82-2: Drainage area; WDR NJ-83-2: Corrections 1981 (m/m). GAGE, max-mim recorder and staff gage. Prior to June 24, 1928, daily readings obtained by measuring from high-water mark to water surface converted to gage height, present datum. Datum of gage is 914.57 ft National Geodetic Vertical Datum of 1929.

REMARKS.--Lake is formed by concrete spillway and earthfill dam completed about 1828. Crest of spillway was lowered 0.11 ft in 1925. Usable capacity, 7,459,000,000 gal between (gage height -2.6 ft, sills of gates and 9.00 ft, crest of spillway). Flow regulated by four gates (3 by 5 ft, also by one 24-inch pipe with gate valve to recreation fountain 250 ft downstream from dam. Dead storage, about 8,117,000,000 gal. Figures given herein represent usable capacity. Lake used for recreation. CORRECTIONS.--Once-daily staff readings furnished by New Jersey Department of Environmental Protection.

COOPERATION.--Records provided by New Jersey Department of Environmental Protection.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 8,777,000,000 gal, August 19, 1955 correction, gage height, 10.55 ft; minimum, 1,525,000,000 gal, Dec. 29, 1960, gage height, 0.65 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 7,930,000,000 gal, Apr. 8, 9, 10, gage height, 9.56 ft; minimum, 5,365,000,000 gal, Jan. 7, gage height, 6.40 ft.

01459350 NOCKAMIXON RESERVOIR.--Lat 40°28'13", long 75°11'10", Bucks County, PA, Hydrologic Unit 02040105, at dam on Tohickon Creek, 6.2 mi upstream from gaging station on Tohickon Creek, 2.9 mi upstream from Mink Run and 1.3 mi east of Ottsville. DRAINAGE AREA, 73.3 mi². PERIOD OF RECORD, December 1973 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Pennsylvania Department of Environmental Resources).

REMARKS.--Reservoir formed by earthfill dam with concrete spillway at elevation 395.0 ft. Storage began Decmeber 1973. Total capacity 66,500 acre-ft at elevation 410 ft. Reservoir is used primarily for recreation, but can be used for water supply and flood control.

COOPERATION.--Records provided by Pennsylvania Department of Environmental Resources.

EXTRMES FOR PERIOD OF RECORD.--Maximum contents, 44,380 acre-ft, Jan. 20, 1979, elevation 397.85 ft; minimum (after first filling) 15,900 acre-ft, around Dec. 31, 1975, elevation 372.78 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 42,200 acre-ft, Apr. 5, elevation 396.40 ft; minimum, 38,800 acre-ft, Nov. 2, elevation 394.00 ft.

RESERVOIRS IN DELAWARE RIVER BASIN--Continued

01469200 STILL CREEK RESERVOIR.--Lat 40°51'25", long 75°59'30". Schuylkill County, PA, Hydrologic Unit 02040106, at dam on Still Creek, 1 mi upstream from mouth and 2.3 mi north of Hometown, PA. DRAINAGE AREA, 8.5 mi^2. PERIOD OF RECORD, January 1933 to current year. Nonrecording gage. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Panther Valley Water Co.).

REMARKS.--Reservoir formed by earth fill dam, with ungated concrete spillway at elevation 1,182.00 ft; storage began in February 1933. Capacity at elevation, 1,182.00 ft is 8,290 acre-ft. Reservoir is used for municipal water supply. Figures given herein represent total contents. Regulation is accomplished by valves on pipe through dam.

COOPERATION.--Records provided by Panther Valley Water Co.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 8,570 acre-ft, Oct. 15, 1955, elevation, 1,182.92 ft, but may have been greater during 1950 and 1951 water years; minimum (after initial filling), 588 acre-ft, Dec. 8, 1944, elevation, 1,136.70 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 8,350 acre-ft, Sept. 21, elevation, 1,182.2 ft; minimum, 3,840 acre-ft, Nov. 8, elevation, 1,165.1 ft.

01470870 BLUE MARSH LAKE.--Lat 40°22'45", long 76°01'59", Berks County, PA, Hydrologic Unit 02040203, at dam on Tulpehocken Creek, 0.8 mi upstream from gaging station on Tulpehocken Creek, 1.0 mi northeast of Blue Marsh, PA, 1.9 mi upstream from Reber's Bridge, and 5.1 mi southeast of Bernville, PA. DRAINAGE AREA, 175 mi^2. PERIOD OF RECORD, April 1979 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Corps of Engineers).

REMARKS.--Reservoir formed by earthfill dam, with concrete ungated spillway at elevation 307.00 ft. Storage began April 23, 1979. Capacity at elevation, 307.00 ft is 50,000 acre-ft. Dead storage is 3,000 acre-ft. Reservoir is used for flood control, water supply, and recreation. Figures herein represent total contents.

COOPERATION.--Records provided by U.S. Army Corps of Engineers.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 39,480 acre-ft, Apr. 17, 1983, elevation, 301.65 ft; minimum, 17,440 acre-ft, Nov. 28, 1983 elevation, 284.49 ft.

EXTREMES FOR CURRENT YEAR: Maximum contents, 23,970 acre-ft, Sept. 14, elevation, 292.56 ft; minimum, 17,340 acre-ft, Nov. 20, Mar. 5, elevation, 284.70 ft.

01472200 GREEN LANE RESERVOIR.--Lat 40°20'30", long 75°28'45", Montgomery County, PA, Hydrologic Unit 02040203, at dam on Perkiomen Creek at Green Lane, PA, 0.4 mi west of Green Lane and 2.1 mi upstream from Unami Creek. DRAINAGE AREA, 70.9 mi^2. PERIOD OF RECORD, December 1956 to current year. GAGE, water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Philadelphia Suburban Water Co.).

REMARKS.--Reservoir formed by concrete, gravity-type dam, with ungated spillway at elevation 286.00 ft; storage began December 21, 1956. Capacity at spillway level, elevation 286.00 ft, 13,430 acre-ft. Reservoir is used for municipal water supply. Figures given herein represent total contents. Regulation is accomplished by valves on pipe through dam.

COOPERATION.--Records provided by Philadelphia Suburban Water Co.

EXTREMES FOR PERIOD OF RECORD: Maximum contents, 17,030 acre-ft, June 23, 1972, elevation, 290.05 ft; minimum (after first filling), 1,270 acre-ft, Aug. 25, 1957, elevation, 251.60 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 14,320 acre-ft, Sept. 9, elevation, 287.00 ft; minimum, 9,890 acre-ft, Nov. 4, elevation, 281.21 ft.

MONTHEND ELEVATION AND CONTENTS, WATER YEAR OCTOBER 1986 TO SEPTEMBER 1987

Date	Elevation (feet)‡	Contents (million gallons)	Change in contents (equivalent in ft^3/s)	Elevation (feet)‡	Contents (million gallons)	Change in contents (equivalent in ft^3/s)	Elevation (feet)‡	Contents (acre-feet)	Change in contents (equivalent in ft^3/s)
	01416900 PEPACTON RESERVOIR			01424997 CANNONSVILLE RESERVOIR			01428900 PROMPTON RESERVOIR		
Sept. 30...	1,265.66	124,670	-	1,135.26	77,238	-	1,124.28	3,300	-
Oct. 31...	1,258.81	113,565	-554	1,131.76	72,587	-232	1,125.20	3,560	+4.2
Nov. 30...	1,264.43	122,634	+468	1,146.93	93,948	+1,102	1,126.55	3,930	+6.2
Dec. 31...	1,267.01	126,925	+214	1,150.73	99,792	+292	1,125.69	3,690	-3.9
CAL YR 1986			+101			+92.6			+0.2
Jan. 31...	1,263.11	120,468	-322	1,150.47	99,374	-20.9	1,125.18	3,550	-2.3
Feb. 28...	1,257.21	111,054	-520	1,149.20	97,401	-109	1,124.75	3,430	-2.2
Mar. 31...	1,266.47	126,020	+747	1,151.60	101,193	+189	1,126.55	3,930	+8.1
Apr. 30...	1,279.46	148,806	+1,175	1,149.85	98,390	-145	1,124.95	3,490	-7.4
May 31...	1,274.31	139,517	-464	1,145.98	92,503	-294	1,124.68	3,410	-1.3
June 30...	1,268.17	128,883	-548	1,142.94	88,035	-230	1,124.15	3,260	-2.5
July 31...	1,263.79	121,580	-365	1,137.26	80,001	-401	1,124.02	3,230	-0.5
Aug. 31...	1,257.71	111,836	-486	1,121.90	60,103	-993	1,125.43	3,620	+6.3
Sept. 30...	1,259.89	115,278	+178	1,129.60	69,746	+497	1,125.21	3,560	-1.0
WTR YR 1987			-39.8			-31.8			+0.4

REFERENCE NO. 22

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

BOROUGH OF
BELLMAWR,
NEW JERSEY
CAMDEN COUNTY

ONLY PANEL PRINTED

COMMUNITY-PANEL NUMBER
340124 0001 B

EFFECTIVE DATE:
FEBRUARY 15, 1980

U.S. DEPARTMENT OF HOUSING
AND URBAN DEVELOPMENT
FEDERAL INSURANCE ADMINISTRATION

KEY TO MAP

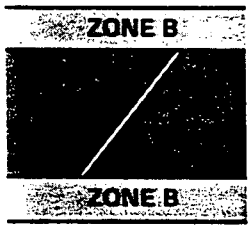
500-Year Flood Boundary

100-Year Flood Boundary

Zone Designations* With Date of Identification e.g., 12/2/74

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 ×

River Mile — • M1.5

**Referenced to the National Geodetic Vertical Datum of 1929

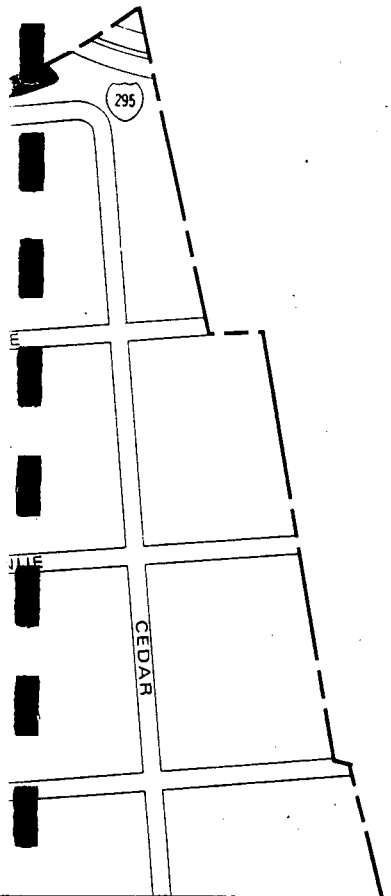
*EXPLANATION OF ZONE DESIGNATIONS

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

Certain areas not in the special flood hazard areas (zones A and V) may be protected by flood control structures.

This map is for flood insurance purposes only; it does not necessarily show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.



INITIAL IDENTIFICATION:
JUNE 21, 1974

FLOOD HAZARD BOUNDARY MAP REVISIONS:
NOVEMBER 7, 1975

FLOOD INSURANCE RATE MAP EFFECTIVE:
FEBRUARY 15, 1980

FLOOD INSURANCE RATE MAP REVISIONS:

Refer to the FLOOD INSURANCE RATE MAP EFFECTIVE date shown on this map to determine when actuarial rates apply to structures in the zones where elevations or depths have been established.

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, or (800) 424-8872.

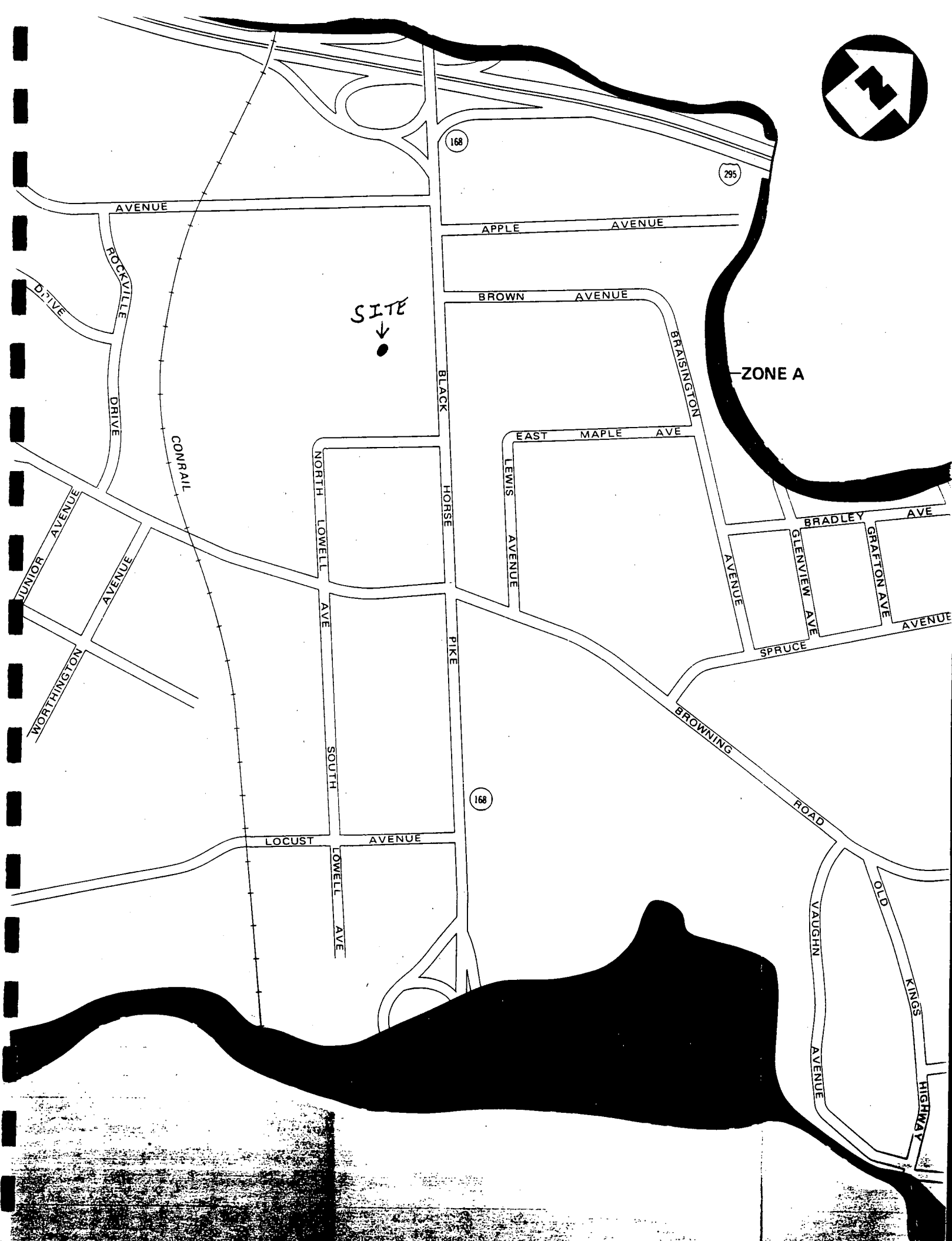
APPROXIMATE SCALE

500 0 500 FEET

ELEVATION REFERENCE MARKS

REFERENCE MARK	ELEVATION (FT. NGVD)	DESCRIPTION OF LOCATION
RM1	**24.48**	A square cut on the top of the downstream wall on the southbound lanes of Interstate 295 over the centerline of Big Timber Creek. Established by U.S. Army Corps of Engineers.
RM2*	**12.51**	A square cut on the concrete post in the center of the north wall of the Kings Highway Bridge over Little Timber Creek. Established by U.S. Army Corps of Engineers.
RM3	**29.18**	A U.S. Coast and Geodetic Survey disk set in a private lawn at the southwest corner of the intersection of Kings Highway and Adams Avenue in Bellmawr, New Jersey.
RM4	**16.77**	Top of fire hydrant at northeast corner of the intersection of Creek Road and Mercer Avenue, in Bellmawr, New Jersey. Established by U.S. Army Corps of Engineers.

*OUTSIDE CORPORATE LIMITS


168
295
AVENUE
APPLE AVENUE
ROCKVILLE
DRIVE
SITE
BROWN AVENUE
BRAISINGTON
ZONE A
BLACK
HORSE
PIKE
EAST MAPLE AVE
LEWIS AVENUE
NORTH LOWELL AVE
CONRAIL
JUNIOR AVENUE
AVENUE
WORTHINGTON
SOUTH LOWELL AVE
BRADLEY AVE
GLENVIEW AVE
GRAFTON AVE
AVENUE
SPRUCE AVENUE
BROWNING ROAD
LOCUST AVENUE
VAUGHN AVENUE
OLD KINGS HIGHWAY

REFERENCE NO. 23

DELAWARE RIVER
WATER QUALITY ASSESSMENT

1986-87 305(b) Report

Delaware River Basin Commission
West Trenton, New Jersey

March 1988

the most important spawning grounds of the American Shad, an anadromous fish. Shad populations were drastically reduced in the past due to pollution in the Delaware Estuary that prevented passage of migrating shad in the spring and fall months. A resurgence of shad has been noted as the Delaware Estuary became cleaner and in recent years spawning has been documented throughout the non-tidal section of river. Other fish migrating to the non-tidal river for spawning are herring, the American eel and others. Small commercial fisheries are centered around the shad and eel migrations and sport fishing is of economic significance. A recent study of shad fishing, for example, placed a $3.2 million annual value on this fishery alone.

For water quality management purposes, the non-tidal river has been designated Zone 1. This zone is divided into 5 sub-zones which reflect minor changes in the water quality standards adopted by the Delaware River Basin Commission and the States of New Jersey, New York and Pennsylvania.

DELAWARE ESTUARY (ZONES 2, 3, 4 AND 5) - NEW JERSEY, PENNSYLVANIA AND DELAWARE

The Delaware River becomes tidal at Trenton, New Jersey, the head of tide. The upper 85 miles of tidally-influenced river is called the Delaware Estuary although it is a freshwater river in its upper half and, thus not entirely a true estuary in an oceanographic sense. The Delaware Estuary flows by Trenton, New Jersey; Philadelphia, Pennsylvania; Camden, New Jersey; and Wilmington, Delaware. This area is one of the world's greatest concentrations of heavy industry and the nation's second largest complex of oil refining and petrochemical plants.

Manufacturing, although declining in importance, is still a major factor affecting water quality in the estuary. Major industries include paper-making, chemicals, oil-refining, shipbuilding, food processing, and others. The estuary's ports form the largest freshwater port in the world, the largest U.S. port in terms of international tonnage and the second largest U.S. port in total tonnage. A navigation channel running from the Atlantic Ocean to Trenton is maintained by dredging. The depth of the channel varies from 40 feet in most reaches to 25 feet deep near Trenton, with a channel width of 300 to 400 feet.

The estuary region has a population exceeding 5.7 million people - a population greater than in 40 states. Zones 3 and 4 flow through the fifth largest U.S. urban area, the Philadelphia-Camden metropolitan area. The majority of residents in the estuary region use the Delaware as their source of water - either directly through intakes on the river or indirectly via the recharge of ground water aquifers. For water quality management purposes, the estuary has been divided into four zones:

Zone 2, the uppermost of these zones, begins at the head of tide at Trenton, N.J. (R.M. 133) and extends down river twenty-five miles to a point midway between the mouth of Pennypack Creek, a small tributary that runs through the northeast portion of the City of Philadelphia near the Tacony-Palmyra Bridge. Although tidal, Zone 2 contains freshwater. In the Torresdale section of Philadelphia, the city withdraws over 200 million gallons of water per day for domestic and industrial use. Smaller water supply intakes and many industrial intakes are also located in this zone.

Zone 2 is characterized by diversity. In the upstream portion of the zone are Trenton, New Jersey (pop. 92,000) and Morrisville, Pennsylvania (pop. 10,000). Major land uses include various industries and urban/suburban development. The largest tributary is the Delaware River itself at the head of tide, having an average annual flow of 11,671 cfs and a 6780 square mile drainage area. Freshwater flow into the tidal Delaware River, however, varies seasonally and annually causing (along with other factors) changes in water quality.

Below Trenton, Zone 2 is characterized by small towns such as Bordentown (pop. 4,500), Fieldsboro (pop. 600), Florence (pop. 9,000), and Burlington (pop. 10,000) in New Jersey and Bristol, (pop. 11,000) in Pennsylvania. Also present are freshwater wetlands, and industrial plants, highway complexes and increasing suburbanization of the remaining open space. On the Pennsylvania side of Zone 2 is the U.S. Steel Fairless Works, a large integrated steel-making facility. In the lower reach of Zone 2 urbanization increases dramatically, with the last three miles of Zone 2 within the city limits of Philadelphia. Large suburban developments include Levittown in Bucks County, Pennsylvania and Willingboro in Burlington County, New Jersey.

Major tributaries include Crosswicks Creek, Assiscunk Creek and Rancocas Cre in New Jersey and Neshaminy Creek, Poquessing Creek and Pennypack Creek in Pennsylvania. Water quality in each is highly influenced by wastewater discharges and urban-suburban development. Tributaries are tidal in their lowest reaches and, thus, affected by inflow of Delaware River water.

Zone 2 is used extensively for recreation. Power boating, sailing and fishing are the predominant recreational uses. River sight-seeing boats operate out of Philadelphia; at least two dozen marinas, boat yards and public boat ramps are operated; and parks have been developed adjacent to the river. Swimming occurs in undesignated areas.

Fishing in Zone 2 is for a variety of fish species, both migratory and resident. Studies in 1984 identified 43 species of fish in the zone. Fish species using Zone 2 waters for spawning, nursery or passage include largemouth bass, walleye, alewife, herring, shad, yellow and white perch, striped bass, catfish, smallmouth bass and others. The short-nosed sturgeon, a federally-designated endangered species, is found in Zone 2 in relatively large numbers. In 1987 shad spawning was documented in Zone 2, a recent response to the cleanup of the estuary.

Zones 3 and 4 begin in Northeast Philadelphia and extend downstream to the Delaware-Pennsylvania-New Jersey state line at Marcus Hook. The thirty mile reach has historically been one of the most polluted rivers in the United States (see Chapter 2). In years past, massive amounts of untreated wastes entered the river in Zones 3 and 4 causing widespread septic conditions and noxious gases emissions. Due to the cleanup of these wastes, major improvements in water quality and fisheries have been documented in recent years, making the Delaware Estuary one of the premier water pollution control success stories in the U.S.

Zones 3 and 4 flow through the Philadelphia-Camden metropolitan area and adjacent urban and suburban areas. In Philadelphia, Camden, Gloucester City

and Chester are found extensive networks of combined sewers that discharge untreated wastewater during rain and dry periods. Industrial development is extensive and a major influence on water quality as well. In Zones 3 and 4, 14 major industries including oil-refineries, paper manufacturing and others discharge directly into the river after treatment. Many others send their wastewater to regional (municipal) treatment plants for treatment.

Major tributaries to Zones 3 and 4 are Pennsauken Creek, Cooper River, Big Timber Creek, Mantua Creek and Raccoon Creek in New Jersey; and Frankford Creek, Schuylkill River and Darby Creek in Pennsylvania. The Schuylkill is the largest Delaware River tributary, draining 15% of the Delaware River Basin. The lower 8 miles of the Schuylkill is tidal, with a dredged navigation channel and large oil refining and terminal facilities.

The intensive industrial and port development along Zones 3 and 4 preclude much recreational access to the river. Minor amounts of swimming occur although pollution and safety considerations make such activity dangerous. Boating is the primary recreational activity during the warmer months. At least a dozen marinas are found in Zones 3 and 4 and tour boats are operated out of Philadelphia. In recent years Philadelphia, Camden and adjoining counties have developed recreation areas along the river. Several waterfront restaurants have opened in recent years, and this portion of the estuary appears to be on the threshold of intense commercial, residential and recreational development. This new interest in the old urban waterfronts is a testimony to cleaner water and represents significant economic benefits accrued from investments made in water pollution control facilities.

Fishing occurs in Zones 3 and 4 although diminished by pollution and lack of river access. A variety of fish can be found in Zones 3 and 4, but their numbers at any one location or time are uncertain. Studies in 1985 and 1986 found 36 species of fish including herring, white perch, American shad, various catfish species, blue crab, alewife and many others. Important sport fishes migrate through the zones or reside temporarily in the zones, but do not use them for spawning or as a nursery area. Recent increases in the size and distribution of American shad runs in the non-tidal Delaware River and the establishment of a viable year-round (albeit marginal) fish population in

the downstream 10 miles of this reach could be raised to support primary-contact recreation designated uses. Currently standards and designated uses are less than necessary to meet the federal "swimmable" water quality goal. Subsequently the DRBC Water Quality Advisory Committee concurred with this recommendations and the recommendation will be presented in the DEL USA Project report.

Various water quality issues have existed prior to the DEL USA Project or have emerged as a result of the project. These are:

- Toxics in water, sediments and fish tissue which represent both a human health (via fish consumption and water supplies) and aquatic life threat are a major concern.
- The need to reallocate point source wasteloads in the zone. DEL USA studies indicate that the impact of point sources is evenly distributed proportionately among dischargers and that nitrogenous oxygen demand controls are required to maintain or raise existing dissolved oxygen standards.
- DEL USA studies and other data indicate polluted tributaries entering the reach of the Delaware Estuary. Correction actions are warranted.
- Growth and development is occurring rapidly with a concurrent increase in point and non-point source loads to the estuary.

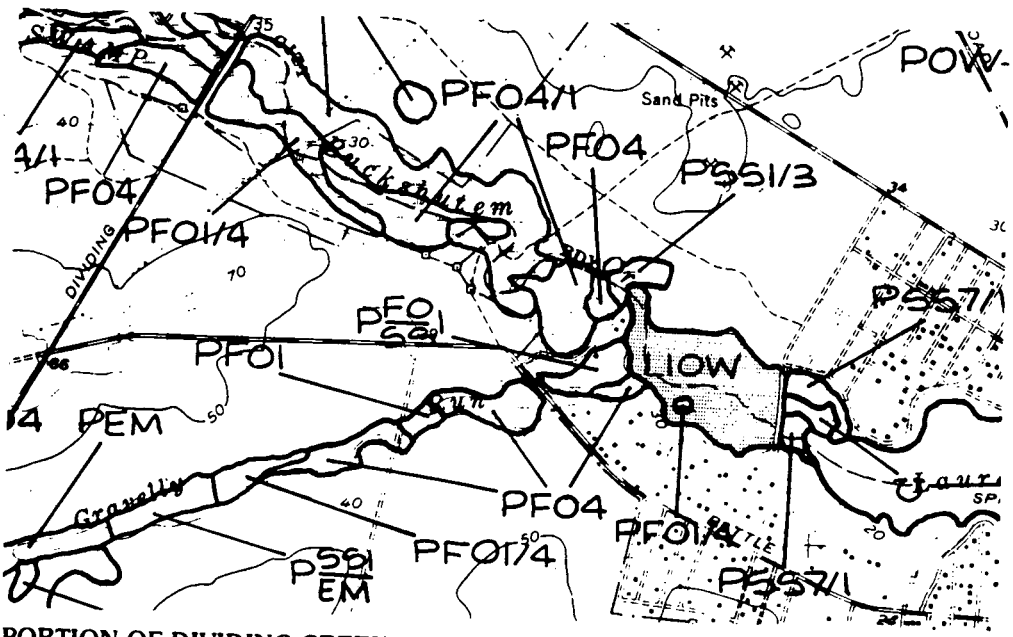
NORTHEAST PHILADELPHIA TO PENNSYLVANIA/DELAWARE BOUNDARY (ZONES 3 AND 4)

Water quality of this reach of the Delaware estuary can be characterized as fair to poor. This portion of the estuary is the most pollution-stressed reach of the Delaware River and water quality reflects the impact of point and non-point sources. Because of past pollution problems, this area was the focus of much of the activity for the DEL USA project. Observations from the DEL USA Project and routine monitoring activities indicate the following:

- The DEL USA Fish Population Study based on 1984-86 Pennsylvania Fish Commission surveys, found 36 and 35 species of fish in Zones 3 and 4, respectively. The number of species found in Zone 3 is significant since data from the 1959-1982 period indicated only 16 fish species.

REFERENCE NO. 24

ATLAS
OF
NATIONAL WETLANDS INVENTORY MAPS
FOR
NEW JERSEY



PORTION OF DIVIDING CREEK MAP

SCALE: 1:24,000

UNITED STATES
DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Region Five
Habitat Resources
One Gateway Center, Suite 700
Newton Corner, Massachusetts

1984

ATLAS OF

NATIONAL WETLANDS INVENTORY MAPS

FOR NEW JERSEY

Ralph W. Tiner, Jr.
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February 1984

HOW TO USE THIS ATLAS

The Atlas contains reductions of all 1:24,000 National Wetlands Inventory maps. Maps appear in alphabetical order. Map names can be located on the index map (Figure 2). Each map shows the configuration, location and type of wetlands and deepwater habitats found within a given area.

WETLAND LEGEND

Wetland data are displayed on maps by a series of letters and numbers (alpha-numerics). Mixing of classes and subclasses are represented by a diagonal line. The more common symbols are shown below; less common symbols have been omitted for simplicity. For identifying these latter symbols, the reader should refer to an actual NWI map legend.

Examples of Alpha-numerics:

E2EMN6	=	Estuarine (E), Intertidal(2), Emergent Wetland(EM), Regularly Flooded(N), Oligohaline(6)
E2FL	=	Estuarine(E), Intertidal(2), Flat(FL)
PF01	=	Palustrine(P), Forested Wetland(FO), Broad-leaved Deciduous(1)
PEM/OW	=	Palustrine(P), Emergent Wetland/Open Water(EM/OW)
PFO/SS1	=	Palustrine(P), Forested Wetland/Scrub-Shrub Wetland(FO/SS), Broad-leaved Deceduous(1)

SYMBOLOGY

Systems and Subsystems:

M 1	=	Marine Subtidal	R 3	=	Riverine Upper Perennial
M 2	=	Marine Intertidal	R 4	=	Riverine Intermittent
E 1	=	Estuarine Subtidal	L 1	=	Lacustrine Limnetic
E 2	=	Estuarine Intertidal	L 2	=	Lacustrine Littoral
R 1	=	Riverine Tidal	P	=	Palustrine
R 2	=	Riverine Lower Perennial	U	=	Upland

Classes (subclasses and modifers designated where appropriate):

AB	=	Aquatic Bed
BB	=	Beach/Bar
EM	=	Emergent Wetland
EMN6	=	Emergent Wetland, Regularly Flooded, Oligohaline
EMP6	=	Emergent Wetland, Irregularly Flooded, Oligohaline
EMR	=	Emergent Wetland, Seasonally Flooded-Tidal
FL	=	Flat
FO1	=	Forested Wetland, Broad-leaved Deciduous
FO2	=	Forested Wetland, Needle-leaved Deciduous
FO4	=	Forested Wetland, Needle-leaved Evergreen
OW	=	Open Water/Unknown Bottom
SS1	=	Scrub=Shrub Wetland, Broad-leaved Deciduous
SS3	=	Scrub-Shrub Wetland, Broad-leaved Evergreen
SS4	=	Scrub-Shrub Wetland, Needle-leaved Evergreen
SS5	=	Scrub-Shrub Wetland, Dead
SS7	=	Scrub-Shrub Wetland, Evergreen

INTRODUCTION

The U.S. Fish and Wildlife Service, Office of Habitat Resources, is conducting an inventory of the wetlands of the United States using convential aerial photo interpretation techniques. All wetlands are classified according to the Service's new system - "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin, et al. 1979). The National Wetlands Inventory (NWI) is establishing a wetland data base, in both map and computer forms for the entire country. The present emphasis is on map production and in the future, wetland data will be digitized to create an automated wetland data base, as funding becomes available. The NWI information will serve to identify the current status of the U.S. wetlands and can be used as a reference point from which future changes in wetlands can be evaluated.

The New Jersey inventory commenced in 1982 and was completed in 1984. Wetland maps and acreage summaries are now available for the entire state. A state wetland report that describes in detail the procedures and results of the inventory is in preparation and should be ready for distribution in late 1984.

The Atlas includes reductions of all NWI maps for New Jersey. It was developed mainly to facilitate office use of NWI information. The Atlas presents a good picture of the distribution of wetlands within large geographic areas. It also serves as the companion document for the forthcoming state wetland report. The Atlas is not intended to replace the use of NWI maps. The original NWI maps are available at the standard U.S. Geological Survey topographic map scale of 1:24,000. These maps are the best products to use in the field for site-specific wetland evaluations.

Copies of original NWI maps for New Jersey can be ordered from the New Jersey Department of Environmental Protection, Maps and Publications, Bureau of Collections and Licensing, Maps and Publications CN-402, Trenton, NJ 08625 (609-292-2506). Other information, including a topical brief about the NWI program, can be obtained by contacting the Regional Wetland Coordinator, U.S. Fish and Wildlife Service, One Gateway Center, Newton Corner, MA 02158.

WETLAND DEFINITION

Wetlands include the variety of wet habitats commonly called marshes, bogs, and swamps. They are lands where saturation with water or periodic flooding during the growing season determines the nature of soil development and types of plants and animals living there. The Service specifically defines "wetland" as follows: "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more

of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year" (Cowardin, et al. 1979).

HYDRIC SOILS

The presence of undrained hydric soil is one of the three major criteria used to define wetlands (Cowardin, et al. 1979). Hydric soils are soils that are either: (1) saturated at or near the soil surface with water that is virtually lacking free oxygen for significant periods during the growing season or (2) flooded frequently for long periods during the growing season (U.S.D.A. Soil Conservation Service 1982). The U.S.D.A Soil Conservation Service is preparing a list of hydric soils to accompany the Fish and Wildlife Service's wetland classification system. Table 1 is a list of hydric soils for New Jersey.

For specific information regarding hydric soils in New Jersey, contact the State Soil Scientist, U.S.D.A. Soil Conservation Service, P.O. Box 219, Somerset, NJ 08873.

WETLAND COMMUNITIES

The Fish and Wildlife Service is preparing a list of wetland plants (i.e., hydrophytes) to help identify wetlands. Hydrophytes are defined as any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content (Cowardin, et al. 1979). A tentative regional list is now available for distribution. In the future, the Service plans to develop a list of the Nation's wetland plant communities. At this time, however, such information is not available.

Table 2 represents a list of major wetland plant communities observed during inventory work in New Jersey. Map symbols are also given. They reflect dominant vegetative life-form and water regimes where identified (i.e., the degree of flooding and/or soil saturation).

TABLE 2. Examples of major New Jersey wetland plant communities. Note: This is not a comprehensive list, but is based on actual field observations. Plant names generally follow Gray's Manual of Botany (Fernald 1970).

Wetland Type (Mapping Symbol)	Dominance Types	Plant Common Names	Water Regime
E2AB	*Zostera marina*	Eelgrass	Subtidal
	Ruppia maritima	Widgeon-grass	
	Potamogeton pectinatus	Pondweed	
	Ulva lactuca	Sea Lettuce	
E2EM	*Spartina alterniflora* (tall form)	Smooth Cordgrass	Regularly Flooded
	S. alterniflora (short form)	Smooth Cordgrass	Irregularly Flooded
	Spartina patens	Marsh Hay	
	Distichlis spicata	Salt Grass	
	Typha angustifolia	Cattail	
E2EMN6	*Peltandra virginica*	Arrow Arum	Regularly Flooded
	Zizania aquatica	Wild Rice	
E2EMP6	*Typha angustifolia*	Cattail	Irregularly Flooded
	Phragmites australis	Reed	
E2SS1	*Iva frutescens*	Hightide Bush	Irregularly Flooded
	Baccharis halimifolia	Sea Myrtle	
PEMN	*Nuphar advena*	Spatterdock	Regularly Flooded
	Zizania aquatica	Wild Rice	
	Peltandra virginica	Arrow Arum	
PEMR	*Typha angustifolia*	Cattail	Seasonally Flooded Tidal
	Phragmites australis	Reed	
PEM	*Typha latifolia*	Cattail	Seasonally Flooded
	Carex stricta	Tussock Sedge	
	Lythrum salicaria	Purple Loosestrife	
	Polygonum spp.	Smartweeds	
	Calamagrostis canadensis	Blue Joint	
	Pontederia cordata	Pickerelweed	Semipermanently Flooded
	Zizania aquatica	Wild Rice	Semipermanently Flooded
	Phalaris arundinacea	Canary Grass	Temporarily Flooded And Others
PSS1	*Cephalanthus occidentalis*	Buttonbush	Semipermanently Flooded
	Alnus spp.	Alder	Seasonally Flooded and Others
	Cornus amomum	Silky Dogwood	
	Vaccinium corymbosum	Highbush Blueberry	
	Viburnum dentatum	Arrowwood	
	Clethra alnifolia	Sweet Pepperbush	
	Acer rubrum (saplings)	Red Maple	
	Salix spp.	Willows	
PSS3	*Chamaedaphne calyculata*	Leatherleaf	Saturated
	Kalmia angustifolia	Sheep Laurel	
PF01	*Acer rubrum*	Red Maple	Seasonally Flooded
	Nyssa sylvatica	Black Gum	
	Fraxinus spp.	Ashes	
	Acer saccharinum	Silver Maple	Temporarily Flooded
	Platanus occidentalis	Sycamore	
	Quercus palustris	Pin Oak	
	Salix nigra	Black Willow	
	Betula nigra	River Birch	
	Quercus bicolor	Swamp White Oak	
PF02	*Larix laricina*	Larch	Saturated
PF04	*Chamaecyparis thyoides*	Atlantic White Ceder	Seasonally Flooded and Saturated
	Tsuga canadensis	Hemlock	Seasonally Flooded and Saturated

Table 3. Wetland acreage summaries for New Jersey counties.

County	Wetland Acreage	% of County	County	Wetland Acreage	% of County
Atlantic	148,149	40.7	Mercer	11,819	8.1
Berger	10,084	6.7	Middlesex	24,022	12.0
Burlington	136,297	26.0	Monmouth	32,700	10.7
Camden	20,922	14.8	Morris	40,264	13.4
Cape May	89,581	52.4	Ocean	128,531	31.3
Cumberland	98,950	30.9	Passaic	5,042	4.1
Essex	6,833	8.2	Salem	58,987	25.3
Gloucester	36,844	17.5	Somerset	11,127	5.7
Hudson	3,897	13.0	Sussex	30,771	9.1
Hunterdon	5,450	2.0	Union	3,053	4.6
			Warren	12,637	5.5

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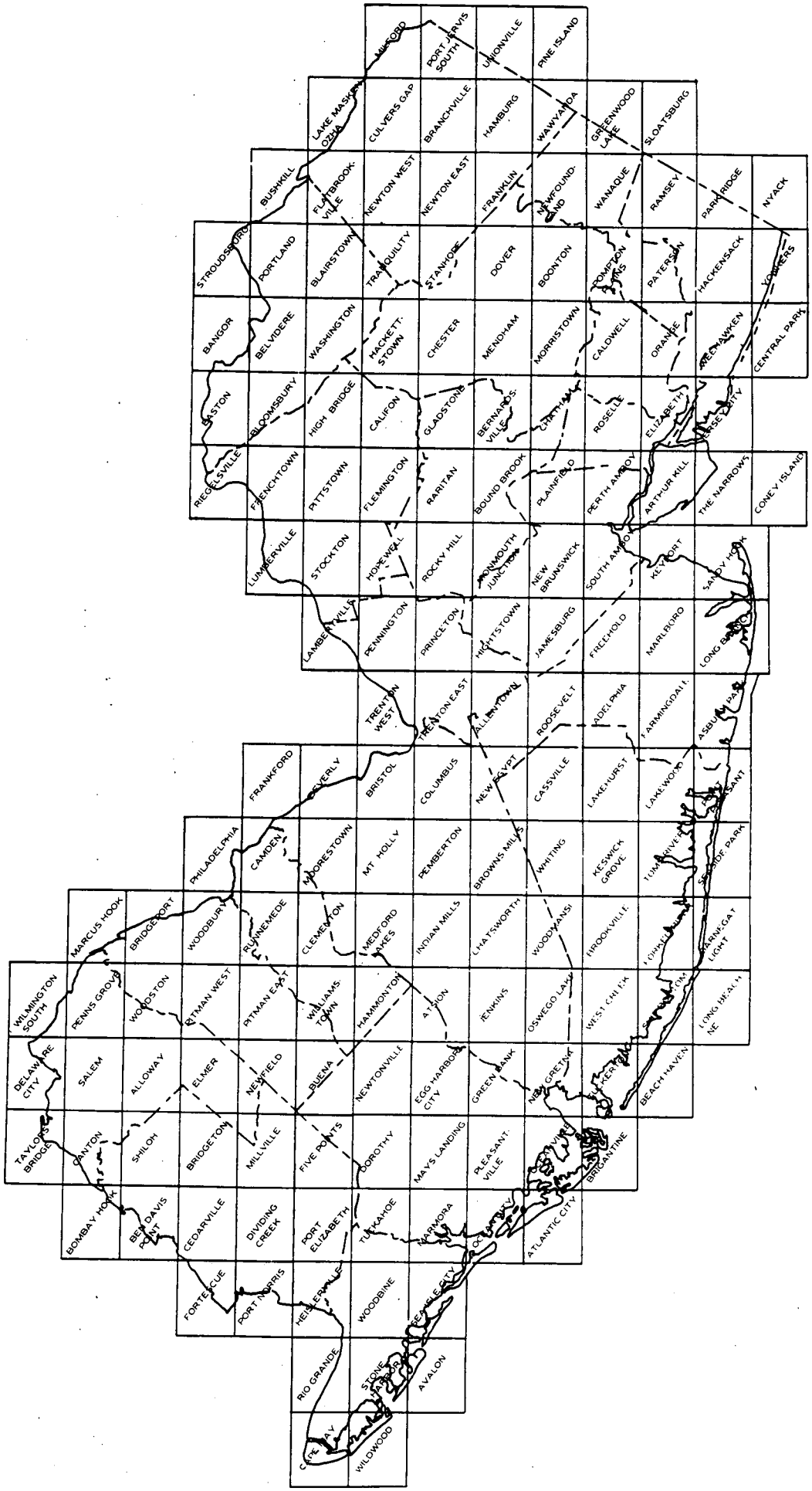


Figure 2. Location and names of 1:24,000 maps for New Jersey.

Contractor For Photo Interpretations: Martel Laboratories, Clearwater, Florida

Field Checking: Approximately six weeks were spent in the field from the spring of 1978 to the present, collecting site-specific information on the variety of wetland plant communities.

Collateral Data Used:

(1) U.S. Geological Survey Topographic Maps;
(2) U.S.D.A. Soil Conservation Service Soil Surveys;
(3) State of New Jersey Submerged Vegetation and Coastal Wetland Maps (NJ DE
(4) The Pine Barrens: Vegetation Geography (McCormick and Jones 1973);
(5) Delaware River Estuarine Marsh Survey (Walton and Patrick 1973).

Minimum Mapping Unit: The minimum mapping unit is generally one to three acres, although wetlands less than one acre are commonly mapped.

Reviewers Of Draft Maps:

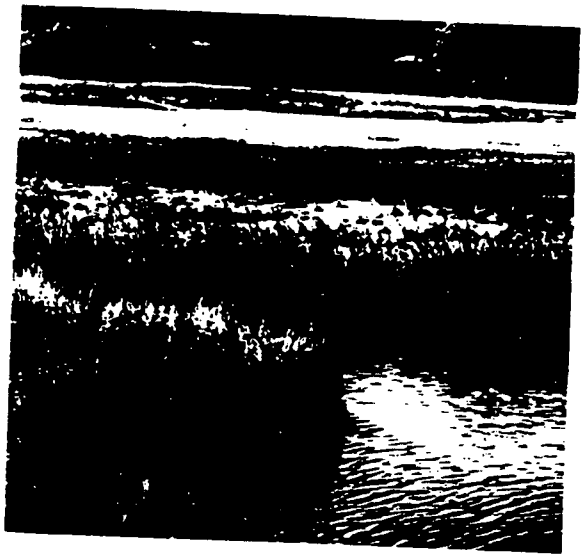
(1) New Jersey Department of Environmental Protection
(2) New Jersey Pinelands Commission
(3) National Marine Fisheries Service
(4) U.S.D.A. Soil Conservation Service
(5) U.S. Army Corps of Engineers (New York and Philadelphia Districts)
(6) U.S. Environmental Protection Agency (Region II)
(7) U.S. Fish and Wildlife Service

REFERENCE NO. 25

National Wetlands Inventory

JULY 1985

WETLANDS OF NEW JERSEY



U.S. Department of the Interior

Fish and Wildlife Service

WETLANDS OF NEW JERSEY

by

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JULY 1985

This report should be cited as follows:

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Special attention and appreciation is given to Larry Vinzant who performed nearly all of the photo interpretation. His work serves as the foundation of this report. I also thank John Organ, my former assistant, for his help in providing quality control of interpreted photos and draft maps and in reviewing the draft of this report. The efforts of Bill Zinni in completing photo interpretation (Frankfort and Lumberville maps), preparing Figures 14 and 22, and reviewing parts of the draft manuscript are also appreciated.

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Table of Contents

	Page
Acknowledgements	i
Table of Contents	ii
List of Figures	iv
List of Tables	v
Chapter 1. Introduction	1
Need for a Wetlands Inventory in New Jersey	2
Description of the Study Area	2
Purpose and Organization of this Report	2
Chapter 2. U.S. Fish and Wildlife Service's Wetland Definition and Classification System	4
Introduction	4
The Service's Definition of Wetland	4
The Service's Wetland Classification System	7
References	12
Chapter 3. National Wetlands Inventory Techniques and Results	13
Introduction	13
Wetlands Inventory Techniques	13
Review of Existing Wetlands Inventories	13
Mapping Photography	13
Field Investigations	13
Photo Interpretation and Collateral Data	13
Draft Map Production	16
Draft Map Review	17
Final Map Production	17
Wetland Database Construction	17
Wetlands Inventory Results	17
National Wetlands Inventory Maps	17
Wetland and Deepwater Habitat Acreage Summaries	17
State Totals	17
County Totals	19
Summary	28
References	28
Chapter 4. Wetland Formation and Hydrology	29
Introduction	29
Wetland Formation	29
Inland Wetland Formation	29
Coastal Wetland Formation	31
Wetland Hydrology	32
Tidal Wetland Hydrology	33
Nontidal Wetland Hydrology	34
References	37
Chapter 5. Hydric Soils of New Jersey	38
Introduction	38
Definition of Hydric Soil	38
Major Categories of Hydric Soils	38
National List of Hydric Soils	39
New Jersey Hydric Soils	40
County Acreage of Hydric Soils	41
Description of Hydric Soils	46
References	53

Chapter 6. Vegetation and Plant Communities of New Jersey's Wetlands 54
Introduction 54
Hydrophyte Definition and Concept 54
New Jersey Hydrophytes 54
Factors Influencing Wetland Vegetation 54
Wetland Plant Communities 54
Marine Wetlands 56
Estuarine Wetlands 56
Riverine Wetlands 56
Palustrine Wetlands 61
Lacustrine Wetlands 64
Rare and Endangered Wetland Plants 77
Summary 77
References 77
..... 79

Chapter 7. Wetland Values 82
Introduction 82
Fish and Wildlife Values 82
Fish and Shellfish Habitat 82
Waterfowl and Other Bird Habitat 82
Furbearer and Other Wildlife Habitat 83
Environmental Quality Values 84
Water Quality Improvement 85
Aquatic Productivity 85
Socio-economic Values 86
Flood and Storm Damage Protection 88
Erosion Control 88
Water Supply 89
Ground-water Recharge 89
Harvest of Natural Products 90
Recreation and Aesthetics 90
Summary 90
References 91
..... 91

Chapter 8. New Jersey Wetland Trends 95
Introduction 95
Forces Changing Wetlands 95
Natural Processes 95
Human Actions 95
Wetland Trends 95
Quantitative Changes 96
Qualitative Changes 96
Coastal Wetland Losses 97
Statewide Wetland Losses 98
Future Outlook 98
Summary 100
References 100
..... 101

Chapter 9. Wetland Protection 102
Introduction 102
Wetland Regulation 102
Wetland Acquisition 102
Future Actions 106
References 107
..... 108

Appendix: List of New Jersey Wetland Plants 109

Enclosure: General Distribution of New Jersey's Wetlands

List of Figures

No.		Page
1.	Physiographic regions of New Jersey	3
2.	Schematic diagram showing wetlands, deepwater habitats, and uplands on the landscape	5
3.	Classification hierarchy of wetlands and deepwater habitats showing systems, subsystems, and classes	8
4.	Diagram showing major wetland and deepwater habitat systems	9
5.	Index of aerial photography used for the National Wetlands Inventory in New Jersey	15
6.	Example of a National Wetlands Inventory map	18
7.	Relative abundance of New Jersey's wetlands	19
8.	Percentage of each New Jersey county covered by wetland	21
9.	Relative distribution of estuarine wetland in New Jersey	22
10.	Relative distribution of palustrine wetland in New Jersey	22
11.	Extent of recent glaciation in New Jersey	29
12.	Marsh and bog successional patterns	30
13.	Coastal marshes naturally develop behind barrier islands and along tidal rivers	32
14.	Hydrology of coastal marsh, showing different zones of flooding	33
15.	Hydrology of surface water wetlands	34
16.	Hydrology of ground-water wetlands	35
17.	Example of water table fluctuations in a seasonally flooded wetland	35
18.	Soil characteristics change from well-drained uplands to very poorly drained wetlands	39
19.	Many hydric soils are subjected to flooding for variable periods during the year	47
20.	Farmed Shrewsbury soil showing water ponding in depression	52
21.	Examples of New Jersey salt marsh communities	57
22.	Generalized distribution of vegetation in New Jersey salt marshes	59
23.	Mesohaline marsh in southern New Jersey	60
24.	The Hackensack Meadowlands are part of the largest estuarine wetland complex in northern New Jersey	60
25.	High-tide bush characterizes the majority of estuarine scrub-shrub wetlands in New Jersey	61
26.	Freshwater tidal marsh in Burlington County, New Jersey	61
27.	Generalized plant zonation in a freshwater tidal wetland	62
28.	Aquatic vegetation is present in many New Jersey streams	64
29.	Examples of palustrine emergent wetlands in northern New Jersey	67
30.	Examples of palustrine emergent wetlands in southern New Jersey	67
31.	Leatherleaf wetland in southern New Jersey	70
32.	Highbush blueberry is abundant throughout the State	70
33.	Examples of palustrine forested wetlands in New Jersey	71
34.	Pitch pine occurs in a wide variety of habitats both wet and dry	76
35.	Migratory birds depend on wetlands	84
36.	The muskrat is a common resident of freshwater marshes	84
37.	Relative productivity of wetland ecosystems in relation to other ecosystems	87
38.	Simplified food pathways from estuarine wetland vegetation to commercial and recreational fishes of importance to humans	87
39.	Wetland value in reducing flood crests and flow rates after rainstorms	88
40.	Urban development increases peak discharge in rivers	89
41.	Blueberries and cranberries are important natural products cultivated in wetlands	91
42.	Increased urban development of wetlands has heightened flood damages, especially in northern New Jersey communities	97
43.	Prior to the 1970's, many estuarine wetlands were filled for residential housing and other development	99
44.	Many freshwater wetlands remain vulnerable to development pressures	100
45.	General extent of major State wetland protection efforts	103
46.	Great Swamp National Wildlife Refuge near Basking Ridge is part of one of the largest wetland complexes in northern New Jersey	106

List of Tables

No.		Page
1.	Definitions of "wetland" according to selected Federal agencies and State statutes	6
2.	Classes and subclasses of wetlands and deepwater habitats	10
3.	Water regime modifiers, both tidal and nontidal groups	11
4.	Salinity modifiers for coastal and inland areas	12
5.	Wetland inventories conducted in New Jersey	14
6.	Wetland acreage of New Jersey counties	20
7.	Deepwater habitat acreage of New Jersey counties	20
8.	Tidal ranges of mean and spring tides at selected locations in New Jersey	33
9.	Examples of plant indicators of the predominant tidal water regimes for New Jersey's estuarine wetlands	34
10.	Examples of plant indicators of nontidal water regimes for New Jersey's palustrine wetlands	36
11.	Hydric soils of New Jersey	40
12.	Ranking of counties according to total acreage of hydric soils and percentage of county represented by these soils	41
13.	Acreage of hydric soils within each county	42
14.	Examples of wetland plant types occurring in New Jersey	55
15.	Representative estuarine wetland plant communities in New Jersey	58
16.	Major freshwater tidal wetland communities in the Hamilton Marshes, Trenton, New Jersey	63
17.	Examples of hydrophyte-water regime relationships in New Jersey's nontidal wetlands	65
18.	Common dominance types for New Jersey's palustrine emergent wetlands	66
19.	Examples of palustrine scrub-shrub wetland communities in New Jersey	69
20.	Examples of palustrine forested wetland communities in northern New Jersey	73
21.	Examples of palustrine forested wetland communities in southern New Jersey	75
22.	Plants of freshwater lakes, ponds, and slow moving rivers and streams	78
23.	List of New Jersey plants under review for Federal listing as endangered species	79
24.	List of major wetland values	83
25.	Major causes of wetland loss and degradation in New Jersey	95
26.	Losses of tidal marshes between 1953 and 1973	98
27.	Comparison between NWI results and SCS hydric soil statistics	99
28.	Summary of primary Federal and State laws relating to wetland protection in New Jersey	104

CHAPTER 1.

Introduction

Wet habitats generally occurring between uplands and deepwater areas are considered wetlands. They are commonly referred to by a number of terms based on their location and characteristics, including salt marsh, tidal marsh, wet meadow, shrub swamp, bog, hardwood swamp, cedar swamp and pitch pine lowland. These areas are important natural resources with numerous values, e.g., fish and wildlife habitat, flood protection, erosion control, water quality maintenance, and recreation.

The U.S. Fish and Wildlife Service and other conservation organizations have always recognized the importance of wetlands to waterfowl, other migratory birds and wildlife. The Service's responsibility for protecting these habitats comes largely from international treaties between the United States and other countries concerning migratory birds and from the Fish and Wildlife Coordination Act. The Service has been active in protecting these resources through various programs. The National Wildlife Refuge System was established to preserve and enhance migratory bird habitat in strategic locations across the country. The Service also reviews Federal projects and applications for Federal permit that involve wetland alteration.

Since the 1950's, the Service has been particularly concerned about wetland losses and their impact on fish and wildlife populations. In 1954, the Service conducted the first nationwide wetlands inventory which focused on important waterfowl wetlands. This survey was performed to provide information for considering fish and wildlife impacts in land-use decisions. The results of this inventory were published in a well-known Service report entitled **Wetlands of the United States**, commonly referred to as Circular 39 (Shaw and Fredine 1956).

Since this survey, wetlands have continued to change due to both natural processes and human activities, such as the conversion of wetlands for agriculture, residential and industrial developments and other uses. During the 1960's, the general public in many States became more aware of wetland values and concerned about wetland losses. They began to realize that wetlands provided significant public benefits besides fish and wildlife habitat, especially flood protection and water quality maintenance. Prior to this time, wetlands were regarded by most people as wastelands, whose best use could only be attained through alteration, e.g., draining for agriculture, dredging and filling for industrial and housing developments and filling with sanitary landfill. Scientific studies demonstrating wetland values, especially for coastal marshes, were instrumental in increasing public awareness of wetland benefits and stimulating concern for wetland protection. Consequently, several States passed laws to protect coastal wetlands, including Massachusetts (1963), Rhode Island (1965), Connecticut (1969), New Jersey (1970), Maryland (1970), Georgia (1970), New York (1972) and Delaware (1973). Several of these States subsequently adopted inland wetland protection legislation: Massachusetts, Rhode Island, Connecticut and New York. Most other States with coastal wetlands followed the lead of these northeastern States. During the early 1970's, the Federal government also assumed greater responsibility for wetland protection through Section 404 of the Federal Water Pollution Control Act (later amended as the Clean Water Act of 1977). Federal permits from the U.S. Army Corps of Engineers are now required for many types of construction in wetlands, although normal agricultural and forestry practices are exempt.

With increased public interest in wetlands and strengthened government regulation, the Service considered how it could contribute to this resource management effort. Because it has prime responsibility for protection and management of the Nation's fish and wildlife and their habitats, the Service recognized the need for sound ecological information to make decisions regarding policy, planning, and management of the country's wetland resources. In 1974, the National Wetlands Inventory Project was established to generate and disseminate scientific information on the characteristics and extent of the Nation's wetlands. The purpose of this information is to foster wise use of U.S. wetlands and to provide data for making accurate resource decisions.

Two very different kinds of information are needed: (1) detailed maps and (2) status and trends reports. First, detailed wetland maps for geographic areas of critical concern are needed for impact assessment of site-specific projects. These maps serve a purpose similar to the Soil Conservation Service's soil survey maps, the National Oceanic and Atmospheric Administration's coastal geodetic survey maps, and the Geological Survey's topographic maps. Detailed wetland maps are used by local, State and Federal agencies as well as by private industry and organizations for many purposes including watershed management plans, environmental impact assessments, permit reviews, facility and corridor siting, oil spill contingency plans, natural resource inventories, wildlife surveys and other uses. To date, over 10,000 maps have been produced, covering 40% of the lower 48 States, 10% of Alaska, and all of Hawaii. Present plans are to complete wetland mapping for at least 55% of the conterminous

U.S. and 16% of Alaska by 1988. Secondly, national estimates of the current status and recent losses and gains of wetlands are needed in order to provide improved information for reviewing the effectiveness of existing Federal programs and policies, for identifying national or regional problems and for general public awareness. Technical and popular reports about these trends have been recently published (Frayer, *et al.* 1983; Tiner 1984).

Need for a Wetlands Inventory in New Jersey

New Jersey is the most densely populated of our 50 States, with almost 10% of the U.S. population living within 50 miles of New Brunswick (Robichaud and Buell 1973). This dense population creates a high demand for real estate for housing and industry and numerous municipalities encourage wetland development by zoning wetlands for such uses.

A wetlands inventory was needed for New Jersey for several reasons: (1) no detailed statewide information existed on the distribution and extent of New Jersey's wetlands and deepwater habitats, (2) increasing development pressures threatened the remaining inland wetlands, and (3) many inland wetlands were still not adequately protected by State or Federal law. Although extensive mapping of coastal wetlands had been completed by the State, no comparable maps existed for inland wetlands, except for the Pine Barrens. Also, changes in coastal wetlands undoubtedly occurred since the State's maps were prepared in the early 1970's. While coastal wetlands were protected through the Wetlands Act of 1970, development pressures on inland wetlands intensified particularly in northern New Jersey, where wetlands, in many cases, represented the last large tracts of undeveloped land. In the late 1970's, the Pinelands Area and Pinelands National Reserve were being established in southern New Jersey, which ultimately provided special protection to wetlands. Yet many inland wetlands outside the Pinelands were still relatively unprotected, although the Federal Clean Water Act of 1977 provided some regulation over wetland uses involving deposition of fill. Thus, in 1979, the Service initiated a wetlands inventory in New Jersey to provide government administrators, private industry and others with improved information for project planning and impact evaluation and for making land-use decisions. This inventory would produce detailed wetland maps for the entire State, identify the current status of New Jersey's wetlands and serve as the base from which future changes can be determined.

Description of the Study

New Jersey is one of the 13 northeastern states within the Service's Northeast Region. New Jersey's landscape is highly varied as a result of differences in geology, soils, climate, and vegetation. Robichaud and Buell (1973) described in great detail the relationship between vegetation and other factors. Five physiographic regions can be found within the State: (1) Outer Coastal Plain, (2) Inner Coastal Plain, (3) Piedmont, (4) Highlands, and (5) Ridge and Valley (Figure 1). The nearly level coastal plain in the south is contrasted by more hilly area of the north. The climate is continental with cold winters and hot, humid summers. The growing season begins as early as March 15 in the southwestern part of the State and as late as April 4 in the northwest. Length of the growing season varies from 220-240 days in northern New Jersey to 245-255 days in southern New Jersey. Precipitation averages 42.94 inches along the coast, 44.95 inches in the south and 46.96 inches in the north

Purpose and Organization of this Report

The purpose of this publication is to report the findings of the Service's wetlands inventory of New Jersey - the first State completed by the National Wetlands Inventory Project - and to summarize existing information on New Jersey's wetlands. The following chapters will include discussions of wetland concept and classification (Chapter 2), National Wetlands Inventory techniques and results (Chapter 3), wetland formation and hydrology (Chapter 4), hydric soils (Chapter 5), wetland vegetation and plant communities (Chapter 6), wetland values (Chapter 7), wetlands trends (Chapter 8), and wetland protection (Chapter 9). The Appendix contains a list of plants found in New Jersey's wetlands. Scientific names of plants follow the **National List of Scientific Plant Names** (U.S.D.A. Soil Conservation Service 1982). A figure showing the general distribution of New Jersey's wetlands and deepwater habitats is provided as an enclosure at the back of this report.

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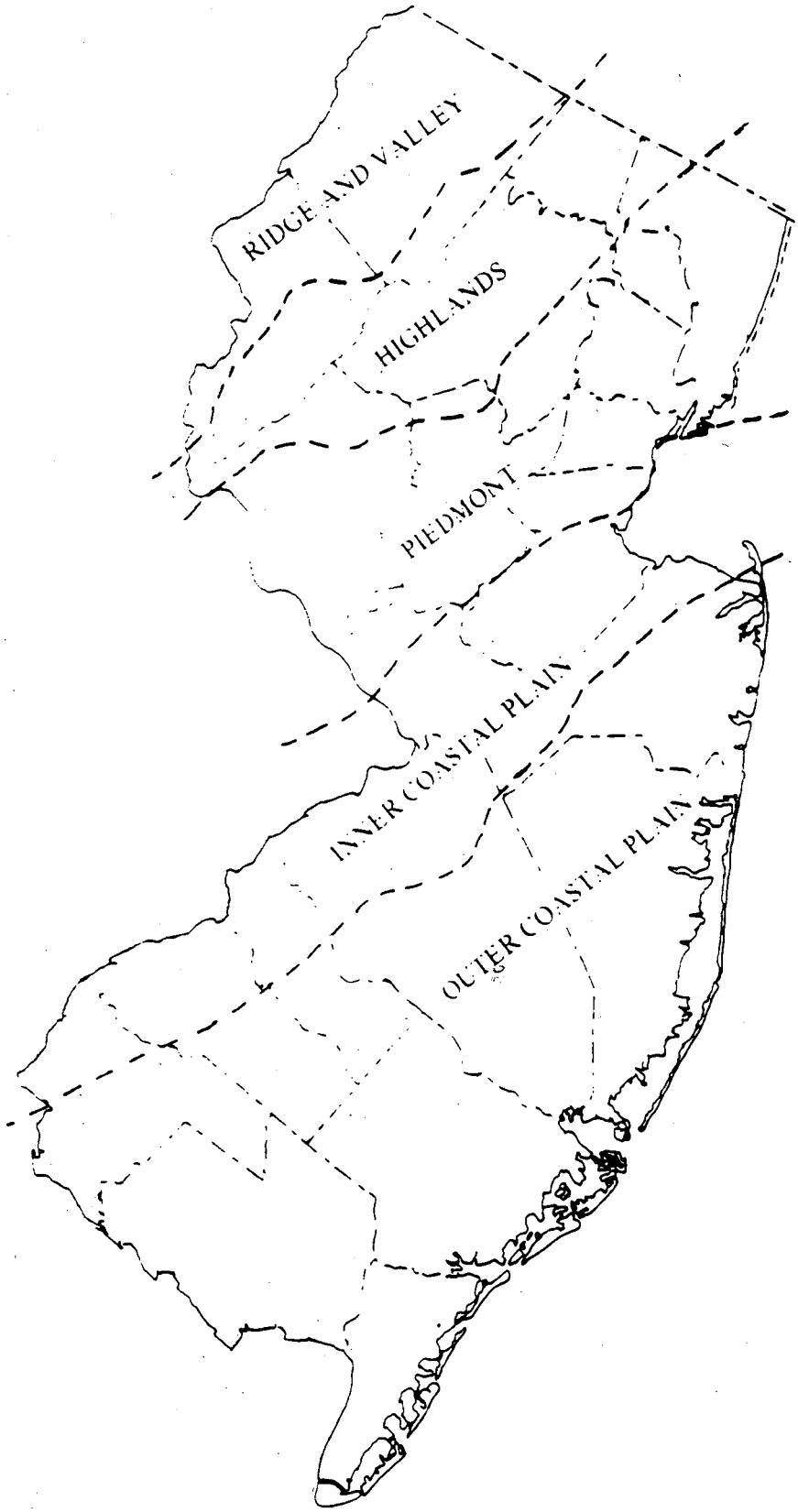

Figure 1. Physiographic regions of New Jersey.

CHAPTER 2.
U.S. Fish and Wildlife Service's Wetland Definition and Classification System

Introduction

To begin inventorying the Nation's wetlands, the Service needed a definition of wetland and a classification system to identify various wetland types. The Service, therefore, examined recent wetland inventories throughout the country to learn how others defined and classified wetlands. The results of this examination were published as **Existing State and Local Wetlands Surveys (1965-1975)** (U.S. Fish and Wildlife Service 1976). More than 50 wetland classification schemes were identified. Of those, only one classification - the Martin, *et al.* system (1953) - was nationally based, while all others were regionally focused. In January 1975, the Service brought together 14 authors of regional wetland classifications and other prominent wetland scientists to help decide if any existing classification could be used or modified for the national inventory or if a new system was needed. They recommended that the Service attempt to develop a new national wetland classification. In July 1975, the Service sponsored the National Wetland Classification and Inventory Workshop, where more than 150 wetland scientists and mapping experts met to review a preliminary draft of the new wetland classification system. The consensus was that the system should be hierarchial in nature and built around the concept of ecosystems (Sather 1976).

Four key objectives for the new system were established: 1) to develop ecologically similar habitat units, 2) to arrange these units in a system that would facilitate resource management decisions, 3) to furnish units for inventory and mapping, and 4) to provide uniformity in concept and terminology throughout the country (Cowardin, *et al.* 1979).

The Service's wetland classification system was developed by a four member team, i.e., Dr. Lewis M. Cowardin (U.S. Fish and Wildlife Service), Virginia Carter (U.S. Geological Survey), Dr. Francis C. Golet (University of Rhode Island) and Dr. Edward T. LaRoe (National Oceanic and Atmospheric Administration), with assistance from numerous Federal and State agencies, university scientists, and other interested individuals. The classification system went through three major drafts and extensive field testing prior to its publication as **Classification of Wetlands and Deepwater Habitats of the United States** (Cowardin, *et al.* 1979). Since its publication, the Service's classification system has been widely used by Federal, State, and local agencies, university scientists, and private industry and non-profit organizations for identifying and classifying wetlands. At the First International Wetlands Conference in New Delhi, India, scientists from around the world adopted the Service's wetland definition as an international standard and recommended testing the applicability of the classification system in other areas, especially in the tropics and subtropics (Gopal, *et al.* 1982). Thus, the system appears to be moving quickly towards its goal of providing uniformity in wetland concept and terminology.

The Service's Definition of Wetland

Conceptually, wetlands lie between the better drained, rarely flooded uplands and the permanently flooded deep waters of lakes, rivers and coastal embayments (Figure 2). Wetlands generally include the variety of marshes, bogs, swamps, and bottomland forests that occur throughout the country. They usually lie in upland depressions or along rivers, lakes and coastal waters where they are subject to periodic flooding. Some wetlands, however, occur on slopes where they are associated with ground-water seeps. To accurately inventory this resource, the Service had to determine where along this natural wetness continuum wetland ends and upland begins. While many wetlands lie in distinct depressions or basins that are readily observable, the wetland-upland boundary is not always that easy to identify. This is especially true in the Pine Barrens where many wetlands occur in almost imperceptably shallow depressions, covering vast acreages with just a slight change in elevation. In these areas, only a skilled wetland ecologist or other specialist can accurately identify the wetland boundary. To help ensure accurate and consistent wetland determination, an ecologically based definition was constructed by the Service.

Wetlands were historically defined by scientists working in specialized fields, such as botany or hydrology. A botanical definition would focus on the plants adapted to flooding and/or saturated soil conditions, while a hydrologist's definition would emphasize fluctuations in the position of the water table relative to the ground surface over time. A more complete definition of wetland involves a multi-disciplinary approach. The U.S. Fish and Wildlife Service has taken this approach in developing its wetland definition and classification system.

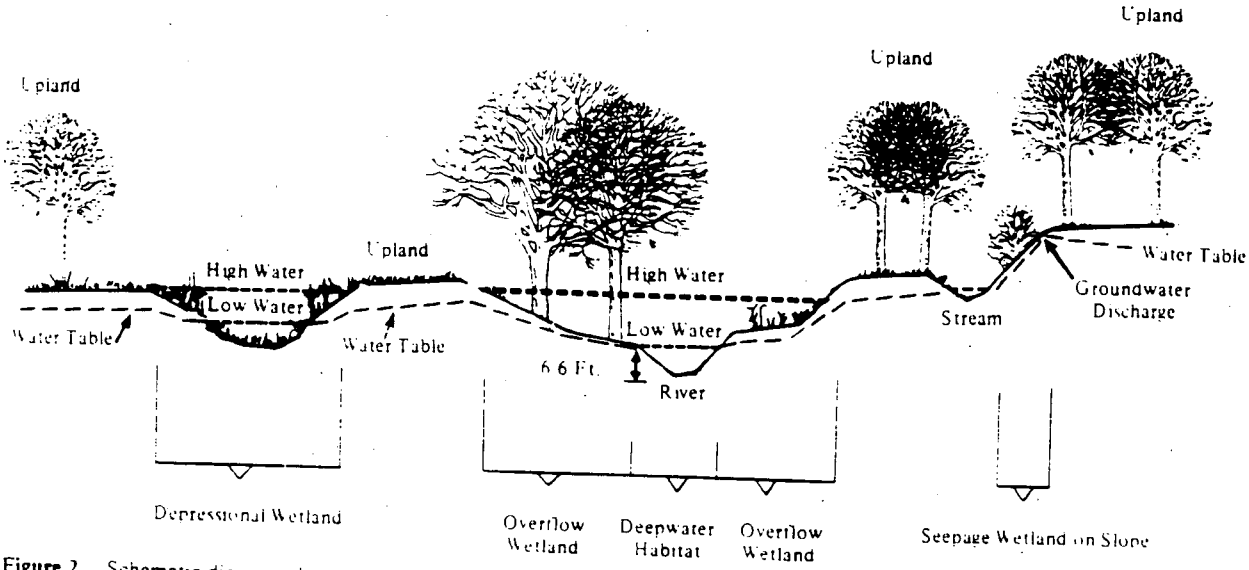

Figure 2. Schematic diagram showing wetlands, deepwater habitats, and uplands on the landscape. Note differences in wetlands due to hydrology and topographic position.

In developing a multi-disciplinary definition of wetland, the Service first acknowledged that "There is no single, correct, indisputable, ecologically sound definition for wetlands, primarily because of the diversity of wetlands and because the demarcation between dry and wet environments lies along a continuum" (Cowardin, *et al.* 1979). After all, a wealth of wetland definitions grew out of different needs for defining wetlands among various groups or organizations, e.g., wetland regulators, waterfowl managers, hydrologists, flood control engineers and water quality experts. The Service has not attempted to legally define wetland, since each State or Federal regulatory agency has defined wetland somewhat differently to suit its administrative purposes (Table 1). Therefore, according to existing wetland laws, a wetland is whatever the law says it is. For example, New Jersey's Coastal Wetland Protection Act (N.J. Stat. Ann. 13:9A-1 to 13:9A-10) defines coastal wetland as "any bank, marsh, swamp, meadow, flat or other low land subject to tidal action in the State of New Jersey along the Delaware Bay and Delaware River, Raritan Bay . . . . including those areas now or formerly connected to tidal action whose surface is at or below an elevation of one foot above local extreme high water and upon which may grow or is capable of growing some, but not necessarily all, of the following: salt meadow grass (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardi*), salt marsh grass (*Spartina alterniflora*). . . . ." This definition also specifically excludes land "subject to the jurisdiction of the Hackensack Meadowlands Development Commission," even though the Commission controls the use of extensive tidal marshes. Thus, this legal definition restricts the term "coastal wetland" to tidal marshes having a specific assemblage of plants within certain geographical boundaries. The Service needed a definition that would allow accurate identification and delineation of the Nation's wetlands for resource management purposes.

The Service specifically defines wetlands as follows: "*Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.*" (Cowardin, *et al.* 1979)

In defining wetlands from an ecological standpoint, the Service emphasizes three key attributes of wetlands: (1) hydrology - the degree of flooding or soil saturation, (2) wetland vegetation (hydrophytes), and (3) hydric soils. All areas considered wetland must have enough water at some time during the growing season to stress plants and animals not adapted for life in water or saturated soils. Most wetlands have hydrophytes and hydric soils present. The Service has prepared a preliminary list of wetland plants and the Soil Conservation Service has developed a list of hydric soils to help identify wetland.

Particular attention should be paid to the reference to flooding or soil saturation during the growing season in the Service's wetland definition. When soils are covered by water or saturated to the surface, free oxygen is not available to plant roots. During the growing season, most plant roots must have access to free oxygen for respiration

Table 1. Definitions of "wetland" according to selected Federal agencies and State statutes.

Organization (Reference)	Wetland Definition	Comments
U.S. Fish and Wildlife Service (Cowardin, *et al.* 1979)	"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."	This is the official Fish and Wildlife Service definition and is being used for conducting an inventory of the Nation's wetlands. It replaces the previous definition which is also outlined in this table. Emphasizes flooding and/or soil saturation, hydric soils and vegetation. Shallow lakes and ponds are included as wetland. Comprehensive lists of wetland plants and soils are being developed to further clarify this definition.
U.S. Fish and Wildlife Service and U.S. Soil Conservation Service (Shaw and Fredine 1956)	"Wetlands are lowlands covered with shallow and sometimes temporary or intermittent waters." They include marshes, swamps, bogs, wet meadows, potholes, sloughs, river overflow lands, and shallow lakes and ponds.	Former Fish and Wildlife Service definition. Although this definition is generally weak, 20 individual wetland types were described in terms of water permanence and depth, salinity and vegetation. This is the official definition of the U.S.D.A. Soil Conservation Service. Wetland definition includes shallow lakes and ponds, but not permanent waters of streams, reservoirs and deep lakes.
U.S. Army Corps of Engineers (Federal Register, July 19, 1977; July 22, 1982)	Wetlands are "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."	Regulatory definition in response to Section 404 of the Clean Water Act of 1977. Excludes similar areas lacking vegetation, such as tidal flats, and does not define lakes, ponds and rivers as wetland.
State of New Jersey (N.J. Pinelands Comprehensive Management Plan, 1980; Pinelands Protection Act - N.J. STAT. ANN. Section 13:18-1 to 13:29.)	"Wetlands are those lands which are inundated or saturated by water at a magnitude, duration and frequency sufficient to support the growth of hydrophytes. Wetlands include lands with poorly drained or very poorly drained soils as designated by the National Cooperative Soils Survey of the Soil Conservation Service of the United States Department of Agriculture. Wetlands include coastal wetlands and inland wetlands, including submerged lands." "Coastal wetlands are banks, low-lying marshes, meadows, flats, and other lowlands subject to tidal inundation which support or are capable of supporting one or more of the following plants:" twenty-nine plants are listed. "Inland wetlands" are defined as including, but not limited to, Atlantic white cedar swamps (15 plants listed), hardwood swamps (19 plants specified), pitch pine lowlands (10 plants listed), bogs (12 plants identified), inland marshes (6 groups of plants listed), lakes and ponds, and rivers and streams.	State regulatory definition. Emphasizes geographic location (i.e., Pinelands Area), vegetation, wet soils, and flooding or soil saturation. Lakes, ponds, rivers and streams are included in this wetland definition.
State of New Jersey (Coastal Wetland Protection Act-N.J. STAT ANN. Section 13:9A-1 to 13:9A-10)	"Coastal wetlands" are "any bank, marsh, swamp, meadow, flat or other low land subject to tidal action in the Delaware Bay and Delaware River, Raritan Bay, Sandy Hook Bay, Shrewsbury River including Navesink River, Shark River, and the coastal inland waterways extending southerly from Manasquan Inlet to Cape May Harbor, or at any inlet,estuary or those areas now or formerly connected to tidal whose surface is at or below an elevation of 1 foot above local extreme high water, and upon which may grow or is capable of growing some, but not necessarily all, of the following:" 19 plants are listed. Coastal wetlands exclude "any land or real property subject to the jurisdiction of the Hackensack Meadowlands Development Commission . . . ."	State regulatory definition for tidal wetlands. Emphasizes tidal flooding, geographic location, elevation and vegetation.

and growth: flooding at this time would have serious implications for the growth and survival of most plants. In a wetland situation, plants must be adapted to cope with these stressful conditions. If, however, flooding only occurs in winter when the plants are dormant, there is little or no effect on them.

Wetlands typically fall within one of the following five categories: (1) areas with both hydrophytes and hydric soils (e.g., marshes, swamps and bogs), (2) areas without hydrophytes, but with hydric soils (e.g., tidal flats), (3) areas with hydrophytes but with non-hydric soils (e.g., margins of impoundments where hydrophytes have colonized non-hydric but now flooded soils), (4) areas without soils but with hydrophytes (e.g., seaweed-covered rocky shores), and (5) periodically flooded areas without soil and without hydrophytes (e.g., gravel beaches). Completely drained hydric soils that are no longer capable of supporting hydrophytes due to a change in water regime are not considered wetland. Areas with completely drained hydric soils are, however, good indicators of historic wetlands which may be suitable for restoration through irrigation projects.

[illegible] important to mention that the Service does not [illegible] include permanently flooded deepwater areas [illegible] although shallow waters are classified as [illegible] Instead, these deeper water bodies are defined as [illegible] habitats, since water and not air is the principal medium in which dominant organisms live. Along the coast in tidal areas, the deepwater habitat begins at the extreme spring low tide level. In nontidal freshwater areas, however, this habitat starts at a depth of 6.6 feet (2m) because the shallow water areas are often vegetated with emergent wetland plants.

The Service's Wetland Classification System

[illegible] following section represents a simplified overview of the Service's wetland classification system. Consequently, some of the more technical points have been [illegible] from this discussion. When actually classifying a wetland, the reader is advised to refer to the official [illegible] document (Cowardin, *et al.* 1979) and [illegible] solely on this overview.

The Service's wetland classification system is hierarchial [illegible] vertical in nature proceeding from general to specific, as [illegible] in Figure 3. In this approach, wetlands are first defined at a rather broad level - the **system**. The term **system** represents "a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors." Five systems are defined: Marine, Estuarine, Riverine, Lacustrine and Palustrine. The Marine System generally consists of the open ocean and its associated coastline, while the Estuarine System encompasses salt and brackish marshes and brackish waters of coastal rivers and embayments. Freshwater wetlands and deepwater habitats fall into one of the other three systems: Riverine (e.g., rivers and streams), Lacustrine, (e.g., lakes, reservoirs and large ponds) or Palustrine (e.g., marshes, bogs, swamps and small shallow ponds). Thus, at the most general level, wetlands can be defined as either Marine, Estuarine, Riverine, Lacustrine or Palustrine (Figure 4).

Each system, with the exception of the Palustrine, is further subdivided into subsystems. The Marine and Estuarine Systems both have the same two subsystems, which are defined by tidal water levels: (1) Subtidal - continuously submerged areas and (2) Intertidal - areas alternately flooded by tides and exposed to air. Similarly, the Lacustrine System is separated into two systems based on water depth: (1) Littoral - wetlands extending from the lake shore to a depth of 6.6 feet (2m) below low water or to the extent of nonpersistent emergents (e.g., arrowheads, pickerelweed or spatterdock) if they grow beyond that depth, and (2) Limnetic - deepwater habitats lying beyond the 6.6 (2m) feet at low water. By contrast, the Riverine System is further defined by four subsystems which represent different reaches of a flowing freshwater or lotic system: (1) Tidal - water levels subject to tidal fluctuations, (2) Lower Perennial - permanent, slow-flowing waters with a well-developed floodplain, (3) Upper Perennial - permanent, fast-flowing water with very little or no floodplain development, and (4) Intermittent - channel containing nontidal flowing water for only part of the year.

Below the subsystem, we encounter the **class** level which describes the general appearance of the wetland or deepwater habitat in terms of the dominant vegetative life form or the composition of the substrate, where vegetative cover is less than 30% (Table 2). Of the 11 classes, five refer to areas where vegetation covers 30% or more of the surface: Aquatic Bed, Moss-Lichen Wetland, Emergent Wetland, Scrub-Shrub Wetland and Forested Wetland. The remaining six classes represent areas generally lacking vegetation, where the composition of the substrate and degree of flooding distinguish classes: Rock Bottom, Unconsolidated Bottom, Reef (sedentary invertebrate colony), Streambed, Rocky Shore, and Unconsolidated Shore. Permanently flooded unvegetated areas are classified as either Rock Bottom or Unconsolidated Bottom, while exposed areas are typed as Streambed, Rocky Shore or Unconsolidated Shore. Invertebrate reefs are found in both permanently flooded and exposed areas.

Each class is further divided into subclasses to better define the type of substrate in unvegetated areas (e.g., bedrock, rubble, cobble-gravel, mud, sand, and organic) or the type of dominant vegetation (e.g., persistent or nonpersistent emergents, moss, lichen, or broad-leaved deciduous, needle-leaved deciduous, broad-leaved ever-

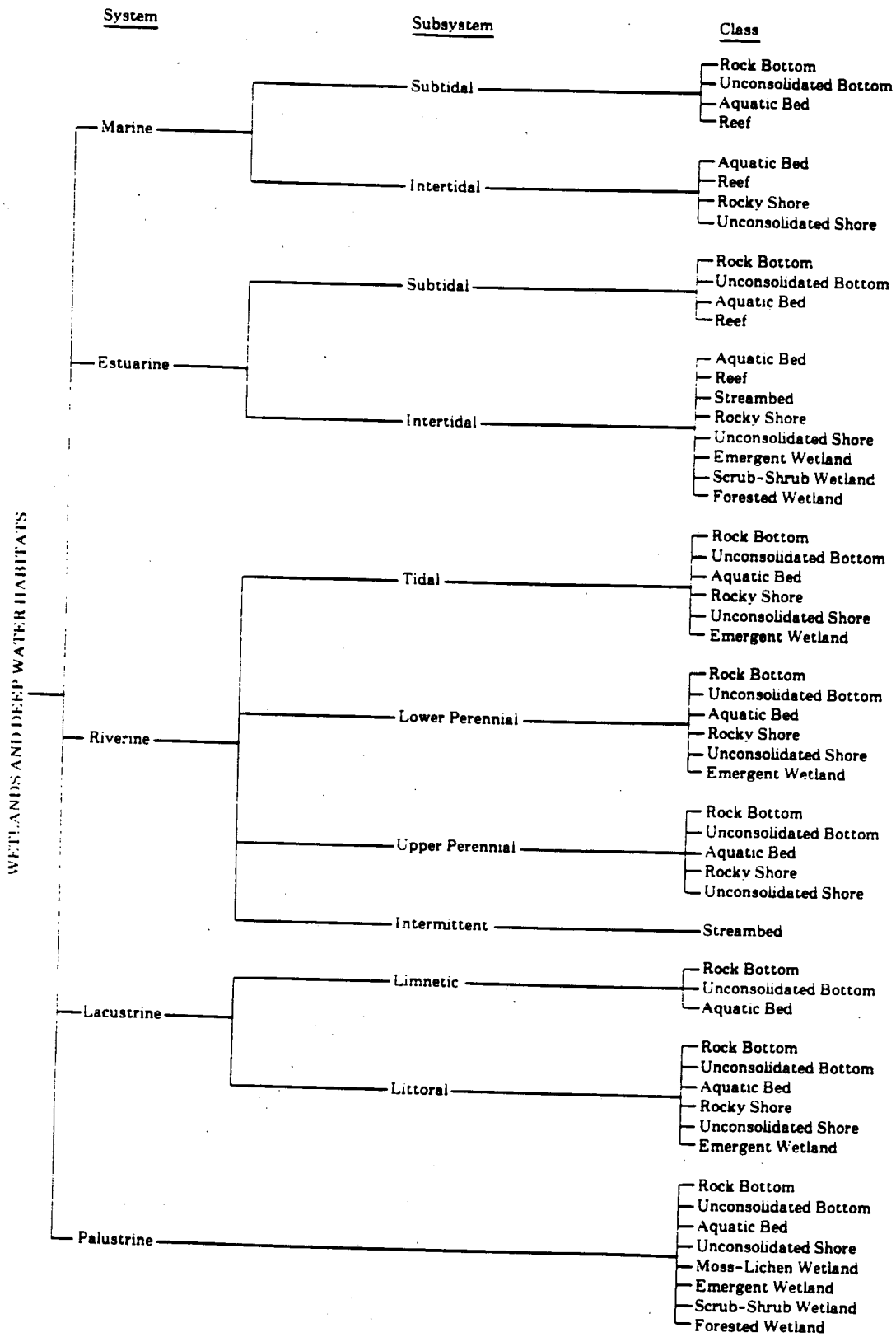

Figure 3. Classification hierarchy of wetlands and deepwater habitats showing systems, subsystems, and classes. The Palustrine System does not include deepwater habitats (Cowardin, *et al.* 1979).

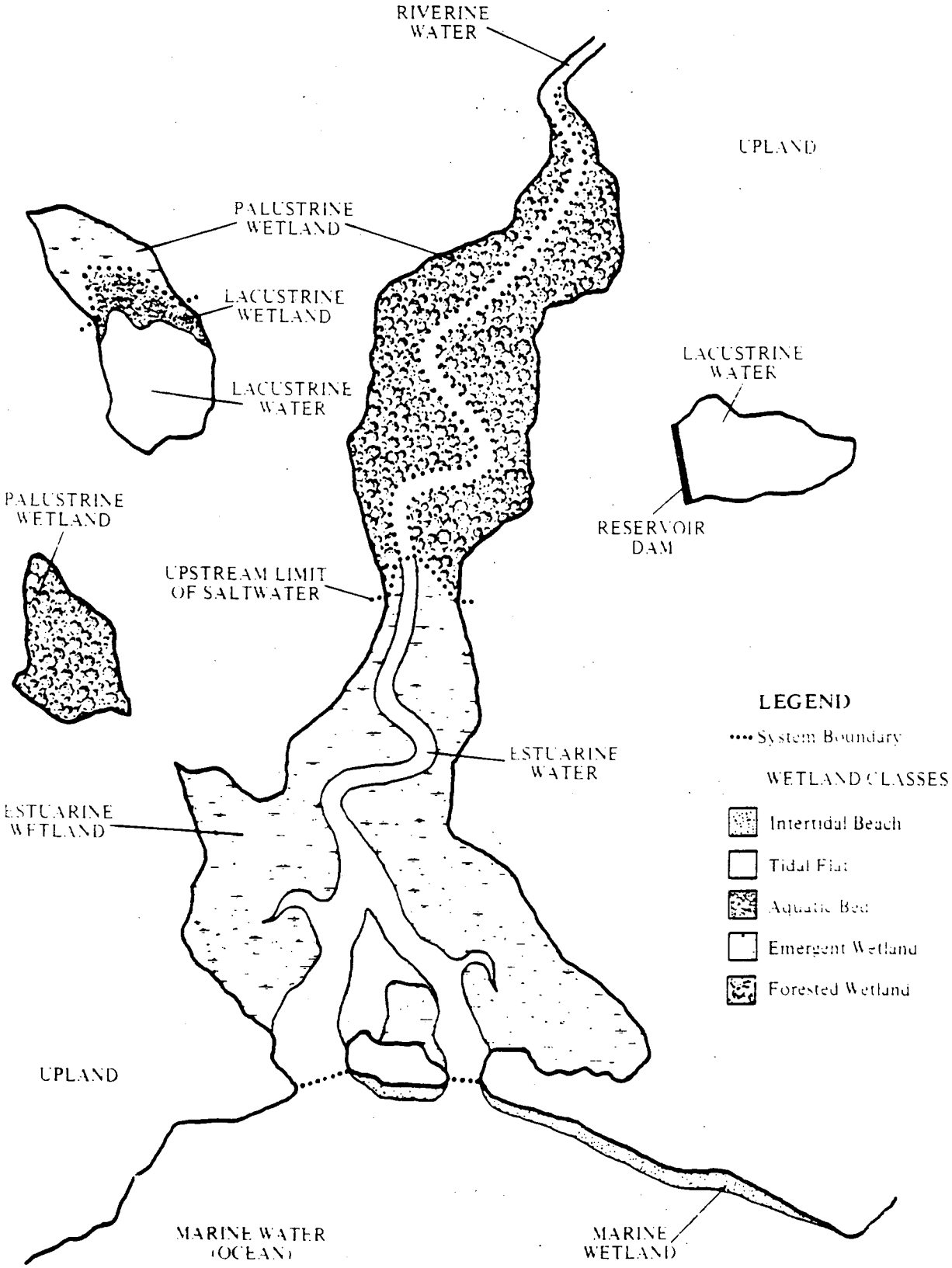

Figure 4. Diagram showing major wetland and deepwater habitat systems. Predominant wetland classes for each system are also designated.

Table 2. Classes and subclasses of wetlands and deepwater habitats (Cowardin, *et al.* 1979).

Class	Brief Description	Subclasses
Rock Bottom	Generally permanently flooded areas with bottom substrates consisting of at least 75% stones and boulders and less than 30% vegetative cover.	Bedrock: Rubble
Unconsolidated Bottom	Generally permanently flooded areas with bottom substrates consisting of at least 25% particles smaller than stones and less than 30% vegetative cover.	Cobble-gravel: Sand: Mud: Organic
Aquatic Bed	Generally permanently flooded areas vegetated by plants growing principally on or below the water surface line.	Algal: Aquatic Moss: Rooted Vascular: Floating Vascular
Reef	Ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates.	Coral: Mollusk: Worm
Streambed	Channel whose bottom is completed dewatered at low water periods.	Bedrock: Rubble: Cobble-gravel: Sand: Mud: Organic: Vegetated
Rocky Shore	Wetlands characterized by bedrock, stones or boulders with areal coverage of 75% or more and with less than 30% coverage by vegetation.	Bedrock: Rubble
Unconsolidated Shore*	Wetlands having unconsolidated substrates with less than 75% coverage by stone, boulders and bedrock and less than 30% vegetative cover, except by pioneer plants. (*NOTE: This class combines two classes of the 1977 operational draft system - Beach/Bar and Flat)	Cobble-gravel: Sand: Mud: Organic: Vegetated
Moss-Lichen Wetland	Wetlands dominated by mosses or lichens where other plants have less than 30% coverage.	Moss: Lichen
Emergent Wetland	Wetlands dominated by erect, rooted, herbaceous hydrophytes.	Persistent: Nonpersistent
Scrub-Shrub Wetland	Wetlands dominated by woody vegetation less than 20 feet (6 m) tall.	Broad-leaved Deciduous: Needle-leaved Deciduous: Broad-leaved Evergreen: Needle-leaved Evergreen: Dead
Forested Wetland	Wetlands dominated by woody vegetation greater than 20 feet (6 m) tall.	Broad-leaved Deciduous: Needle-leaved Deciduous: Broad-leaved Evergreen: Needle-leaved Evergreen: Dead

green, needle-leaved evergreen and dead woody plants). Below the subclass level, dominance type can be applied to specify the predominant plant or animal in the wetland community.

To allow better description of a given wetland or deepwater habitat in regard to hydrologic, chemical and soil characteristics and to human impacts, the classification system contains four types of specific modifiers: (1) Water Regime, (2) Water Chemistry, (3) Soil, and (4) Special. These modifiers may be applied to class and lower levels of the classification hierarchy.

Water regime modifiers describe flooding or soil saturation conditions and are divided into two main groups: (1) tidal and (2) nontidal. Tidal water regimes are used where water level fluctuations are largely driven by oceanic tides. Tidal regimes can be subdivided into two general categories, one for saltwater and brackish water tidal areas and another for freshwater tidal areas. This distinction is needed because of the special importance of seasonal river overflow in freshwater tidal areas. By contrast, nontidal modifiers define conditions where surface water runoff, ground-water discharge, and/or wind effects (i.e., lake seiches) cause water level changes. Both tidal and nontidal water regime modifiers are presented and briefly defined in Table 3.

Water chemistry modifiers are divided into two categories which describe the water's salinity or hydrogen

Table 3. Water regime modifiers, both tidal and nontidal groups (Cowardin, *et al.* 1979).

Group	Type Of Water	Water Regime	Definition
Tidal	Saltwater and brackish areas	Subtidal	Permanently flooded by tides
		Irregularly exposed	Exposed less often than daily by tides
		Regularly flooded	Daily tidal flooding and exposure to air
		Irregularly flooded	Flooded less often than daily and typically exposed to air
	Freshwater	Permanently flooded-tidal	Permanently flooded by tides and river or exposed irregularly by tides
		Semipermanently flooded-tidal	Flooded for most of the growing season by river overflow but with tidal fluctuation in water levels
		Regularly flooded	Daily tidal flooding and exposure to air
		Seasonally flooded-tidal	Flooded irregularly by tides and seasonally by river overflow
		Temporarily flooded-tidal	Flooded irregularly by tides and for brief periods during growing season by river overflow
Nontidal	Inland freshwater and saline areas	Permanently flooded	Flooded throughout the year in all years
		Intermittently exposed	Flooded year-round except during extreme droughts
		Semipermanently flooded	Flooded throughout the growing season in most years
		Seasonally flooded	Flooded for extended periods in growing season, but surface water is usually absent by end of growing season
		Saturated	Surface water is seldom present, but substrate is saturated to the surface for most of the season
		Temporarily flooded	Flooded for only brief periods during growing season, with water table usually well below the soil surface for most of the season
		Intermittently flooded	Substrate is usually exposed and only flooded for variable periods without detectable seasonal periodicity (Not always wetland: may be upland in some situations)
		Artificially flooded	Duration and amount of flooding is controlled by means of pumps or siphons in combination with dikes or dams

ion concentration (pH): (1) salinity modifiers and (2) pH modifiers. Like water regimes, salinity modifiers have been further subdivided into two groups: halinity modifiers for tidal areas and salinity modifiers for nontidal areas. Estuarine and marine waters are dominated by sodium chloride, which is gradually diluted by fresh water as one moves upstream in coastal rivers. On the other hand, the salinity of inland waters is dominated by four major cations (i.e., calcium, magnesium, sodium and potassium) and three major anions (i.e., carbonate, sulfate, and chloride). Interactions between precipitation, surface runoff, ground-water flow, evaporation, and sometimes

Table 4. Salinity modifiers for coastal and inland areas (Cowardin, *et al.* 1979).

Coastal Modifiers[1]	Inland Modifiers[2]	Salinity (o/oo)	Approximate Specific Conductance (Mhos at 25° C)
Hyperhaline	Hypersaline	>40	>60,000
Euhaline	Eusaline	30-40	45,000-60,000
Mixohaline (Brackish)	Mixosaline[3]	0.5-30	800-45,000
Polyhaline	Polysaline	18-30	30,000-45,000
Mesohaline	Mesosaline	5-18	8,000-30,000
Oligohaline	Oligosaline	0.5-5	800-8,000
Fresh	Fresh	<0.5	< 800

[1]Coastal modifiers are employed in the Marine and Estuarine Systems.

[2]Inland modifiers are employed in the Riverine, Lacustrine and Palustrine Systems.

[3]The term "brackish" should not be used for inland wetlands or deepwater habitats.

plant evapotranspiration form inland salts. Table 4 shows ranges of halinity and salinity modifiers which are modifications of the Venice System (Remane and Schlieper 1971). The other set of water chemistry modifiers are pH modifiers for identifying acid (pH<5.5), circumneutral (5.5-7.4) and alkaline (pH>7.4) waters. Some studies have shown a good correlation between plant distribution and pH levels (Sjors 1950; Jeglum 1971). Moreover, pH can be used to distinguish between mineral-rich and mineral-poor wetlands.

The third group of modifiers - soil modifiers - are presented because the nature of the soil exerts strong influences on plant growth and reproduction as well as on the animals living in it. Two soil modifiers are given: (1) mineral and (2) organic. In general, if a soil has 20% or more organic matter by weight in the upper 16 inches, it is considered an organic soil, whereas if it has less than this amount, it is a mineral soil. For specific definitions, please refer to Appendix D of the Service's classification system (Cowardin, *et al.* 1979) or to **Soil Taxonomy** (U.S.D.A. Soil Conservation Service 1975).

The final set of modifiers - special modifiers - were established to describe the activities of people or beavers affecting wetlands and deepwater habitats. These modifiers include: excavated, impounded (i.e., to obstruct outflow of water), diked (i.e., to obstruct inflow of water), partly drained, farmed, and artificial (i.e., materials deposited to create or modify a wetland or deepwater habitat).

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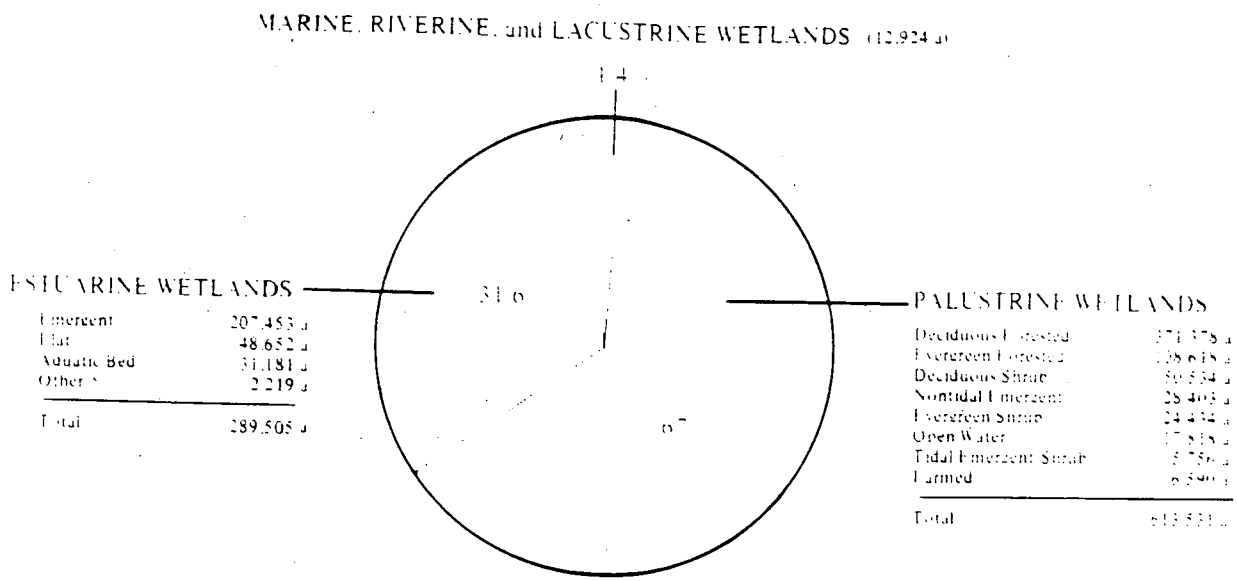


Figure 7. Relative abundance of New Jersey wetlands.

Of the 289,505 estuarine wetland acres, 72% was emergent wetland. Most of this acreage was salt and brackish marsh (201,448 acres), while 6,005 acres of slightly brackish or oligohaline marsh were inventoried. Intertidal flats accounted for 48,652 acres and aquatic beds for 31,181 acres.

Other wetlands found included 1,578 acres of lacustrine wetlands associated with lakes and reservoirs and 7,481 acres of marine beaches and bars. Lacustrine wetlands consisted of either nonpersistent emergent wetlands, aquatic beds or flats.

Deepwater habitat acreage in New Jersey totaled 412,949 acres, excluding marine waters. Most of this (87% or 357,523 acres) was represented by estuarine or brackish tidal water of bays and coastal rivers. Tidal fresh water rivers amounted to 11,708 acres, while other freshwater rivers totaled 5,484 acres. Lakes and reservoirs covered 38,234 acres.

County Totals

Acreages of wetland and deepwater habitat for each county are found in Tables 6 and 7, respectively, while Figure 8 shows the relative abundance of wetland in each county. Atlantic County had the largest extent of wetland (148,149 acres) and was closely followed by two other coastal counties: Burlington (136,297 acres) and Ocean (128,531 acres). If the percentage of the county occupied by wetland is examined, Cape May County led all others with more than half the county being wetland. Atlantic, Ocean, Cumberland, Burlington and Salem Counties followed with 40.7%, 31.3%, 30.9%, 26% and 25.3%, respectively. The presence of vast acreages of coastal marshes in these counties was responsible for their lead over non-coastal counties in this category.

Considering the extent of deepwater habitat, the coastal counties again had more acreage than inland counties (Table 7). The existence of large bays behind barrier islands in coastal areas greatly contributed to this difference. Cumberland County with much of the New Jersey portion of Delaware Bay far exceeded all other counties in deepwater habitat acreage. Lakes and reservoirs (lacustrine waters), by contrast, were most extensive in northern New Jersey, particularly Morris and Sussex Counties.

The relative abundance of the more extensive wetlands - the estuarine and palustrine wetlands - are displayed in Figures 9 and 10, respectively. The extent of different wetland types and deepwater habitats for each county is discussed in the following subsections.

Atlantic County

Atlantic County had more wetland than any other county. Its 148,149 acres of wetland covered nearly 41% of the county. This county ranked only second to Cape May County in the percentage of its land area that is represented by wetland. Slightly more than 33% of Atlantic's wetland resource was palustrine deciduous forested wetland, while estuarine emergent wetland made up 30%. Evergreen forested wetland was also quite abundant, comprising 16% of all wetland acreage.

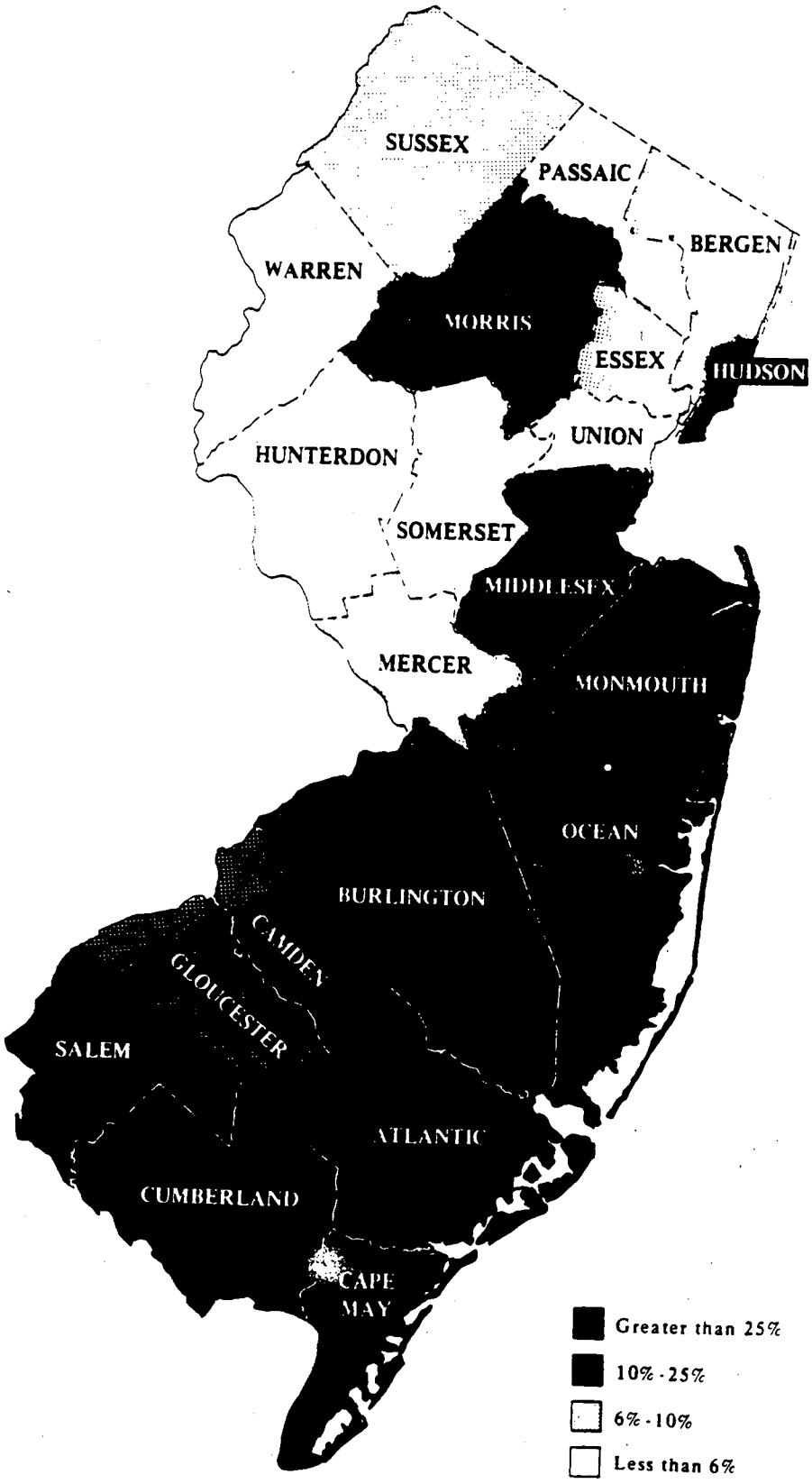


Figure 8. Percentage of each New Jersey county covered by wetland.

Table 6. Wetland acreage of New Jersey counties. Percentage of county represented by wetland and ranking based on wetland acreage are also indicated. Land area figures based on **The World Almanac and Book of Facts** (Delury 1979).

County	Land Area (sq. mi.)	Land Area (Acres)	Wetland Area (Acres)	% County Represented by Wetland	Ranking Order By Wetland Acreage
Atlantic	569	364,160	148,149	40.7	1
Bergen	234	149,760	10,084	6.7	16
Burlington	819	524,160	136,297	26.0	2
Camden	221	141,440	20,922	14.8	12
Cape May	267	170,880	89,581	52.4	5
Cumberland	500	320,000	98,950	30.9	4
Essex	130	83,200	6,833	8.2	17
Gloucester	329	210,560	36,844	17.5	8
Hudson	47	30,080	3,897	13.0	20
Hunterdon	423	270,720	5,450	2.0	18
Mercer	228	145,920	11,819	8.1	14
Middlesex	312	199,680	24,022	12.0	11
Monmouth	476	304,640	32,700	10.7	9
Morris	468	299,520	40,264	13.4	7
Ocean	642	410,880	128,531	31.3	3
Passaic	192	122,880	5,042	4.1	19
Salem	365	233,600	58,987	25.3	6
Somerset	307	196,480	11,127	5.7	15
Sussex	527	337,280	30,771	9.1	10
Union	103	65,920	3,053	4.6	21
Warren	362	231,680	12,637	5.5	13
State Total	**7,521**	**4,813,440**	**915,960**	**19.0**	

Table 7. Deepwater habitat acreage of New Jersey counties. Note: (1) Figures do not include marine waters: (2) Riverine acreages are conservative, since linear map features were not measured: (3) Part of Delaware Bay was not mapped because no U.S.G.S. topographic maps exist; estuarine water acreage for this area was approximated and not included within Cumberland or Cape May totals.

County	Estuarine Waters (Acres)	Riverine Waters (Acres)	Lacustrine Waters (Acres)	Total (Acres)	Ranking Order
Atlantic	13,744	146	1,584	15,474	6
Bergen	5,324	336	2,089	7,749	8
Burlington	1,755	3,429	1,880	7,064	11
Camden	0	2,245	343	2,588	17
Cape May	39,747*	4	572	40,323	3
Cumberland	89,586*	166	3,129	92,881	1
Essex	1,151	161	662	1,974	18
Gloucester	764	4,406	656	5,826	12
Hudson	9,170	0	0	9,170	7
Hunterdon	0	1,125	3,504	4,629	14
Mercer	0	1,068	424	1,492	19
Middlesex	4,688	103	887	5,678	13
Monmouth	30,284	5	1,547	31,838	4
Morris	0	162	6,921	7,083	10
Ocean	49,196	9	1,595	50,800	2
Passaic	0	493	3,688	4,181	15
Salem	21,248	343	928	22,519	5
Somerset	0	447	77	524	21
Sussex	0	886	6,405	7,291	9
Union	866	81	251	1,198	20
Warren	0	1,577	1,090	2,667	16
(Unmapped Area within Delaware Bay)	90,000			90,000	
State Total	**357,523**	**17,192**	**38,234**	**412,949**	

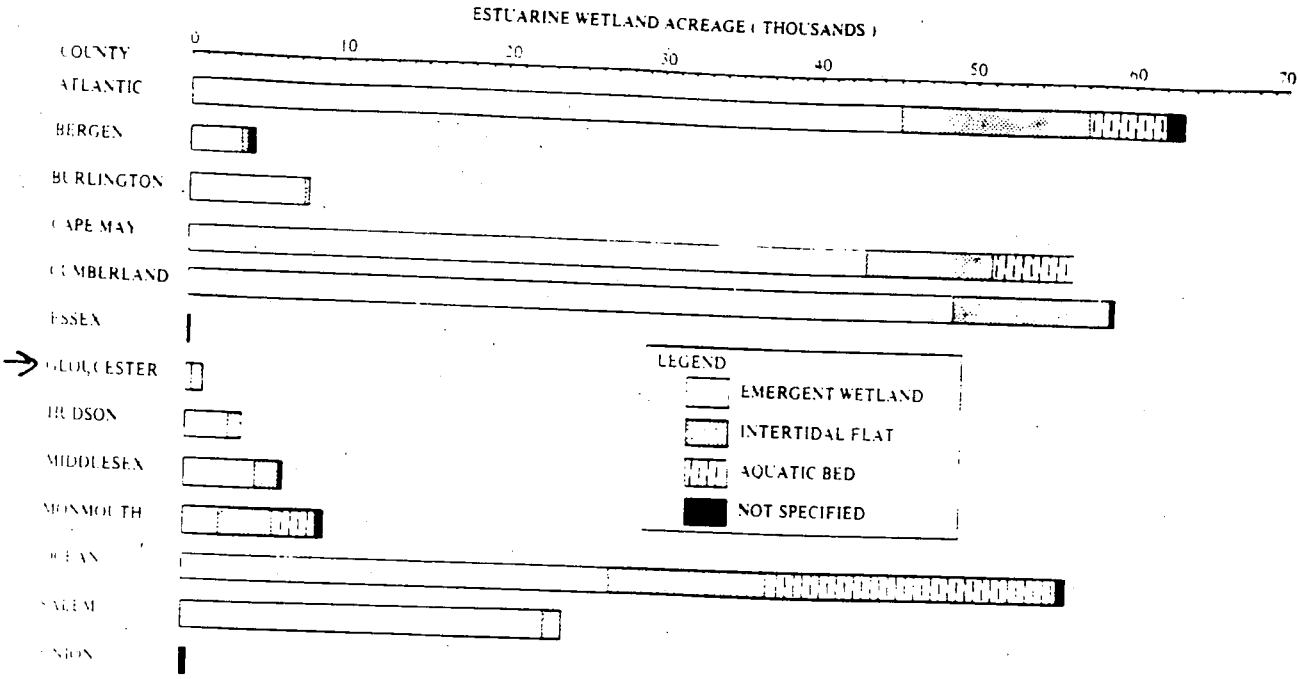


Figure 9. Relative distribution of estuarine wetland in New Jersey.

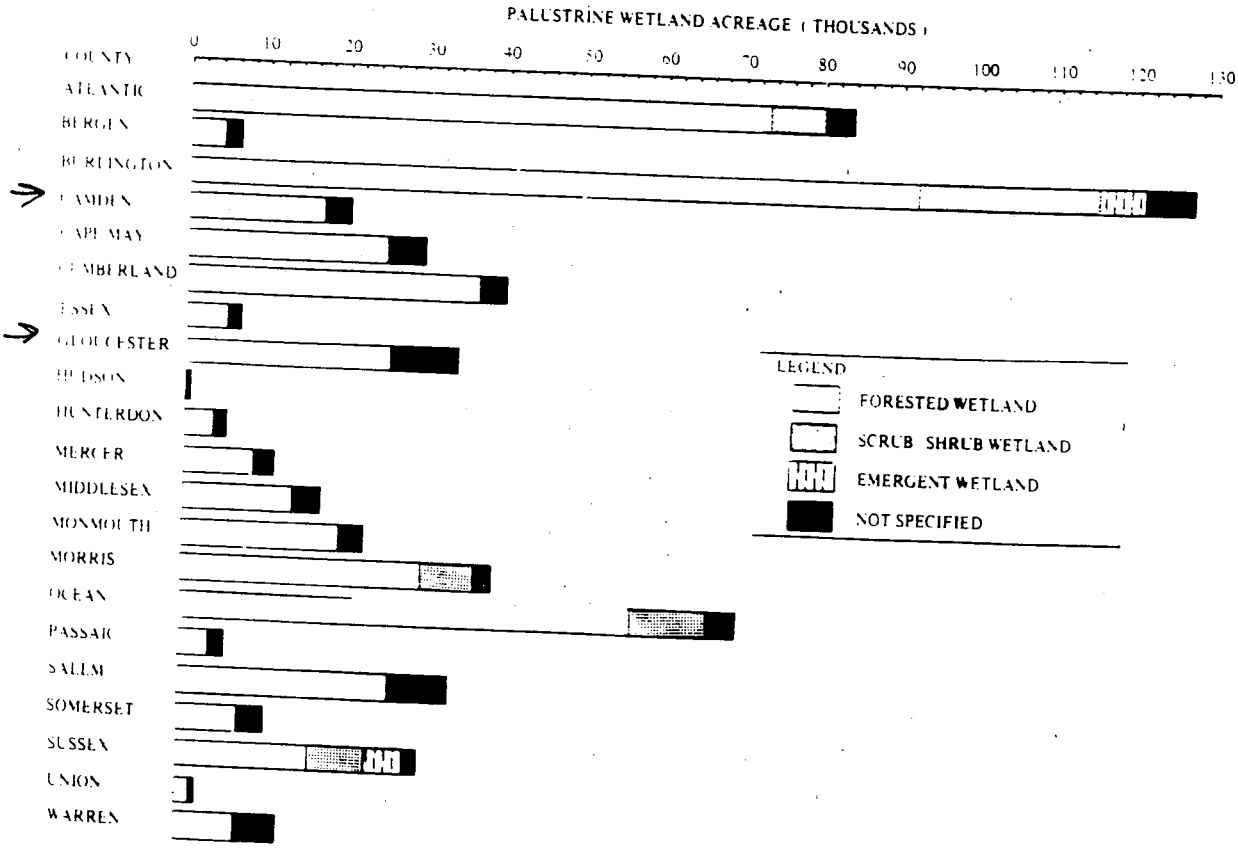


Figure 10. Relative distribution of palustrine wetland in New Jersey.

Marine Wetlands	1,722 a.
Estuarine Wetlands	
Aquatic Bed	4,861 a.
Emergent	45,089 a.
Flat	11,827 a.
Other	874 a.
Estuarine Subtotal	62,651 a.
Riverine Tidal Wetlands	132 a.
Lacustrine Wetlands	13 a.
Palustrine Wetlands	
Open Water	815 a.
Tidal Emergent/Shrub	332 a.
Nontidal Emergent	1,383 a.
Deciduous Scrub-Shrub	3,093 a.
Evergreen Scrub-Shrub	4,158 a.
Deciduous Forested	49,365 a.
Evergreen Forested	23,528 a.
Farmed	957 a.
Palustrine Subtotal	83,631 a.
Atlantic County Total	148,149 a.

Deepwater habitat in Atlantic County amounted to 15,474 acres which were mostly estuarine waters. Marine waters were not included in this figure.

Bergen County

Bergen County was ranked 16th among counties in the extent of wetlands. Only about 7% of the county was covered by wetland (10,084 acres). Most of this resource was palustrine wetland (6,319 acres), with deciduous forested wetland comprising 43% of the county's wetland acreage. Estuarine emergent wetland was also extensive, accounting for about 33% of the acreage.

Estuarine Wetlands	
Emergent	3,230 a.
Other	494 a.
Estuarine Subtotal	3,724 a.
Riverine Tidal Wetlands	41 a.
Palustrine Wetlands	
Open Water	679 a.
Emergent	560 a.
Deciduous Scrub-Shrub	753 a.
Deciduous Forested	4,327 a.
Palustrine Subtotal	6,319 a.
Bergen County Total	10,084 a.

This county also possessed 7,749 acres of deepwater habitat. Most of this was estuarine water, with lacustrine water (e.g., reservoirs) also important.

Burlington County

With a total of 136,297 acres of wetland, Burlington County was the second leading county in wetland acreage, surpassed only by Atlantic County. Wetland represented 26% of the county's land area. Sixty-seven percent of the wetland acreage was forested wetland, with 38% being deciduous and 29% evergreen. Only 5% of Burlington's wetland acreage was estuarine emergent wetland.

Estuarine Wetlands	
Emergent	7,482 a.
Flat	137 a.
Estuarine Subtotal	7,619 a.
Riverine Tidal Wetlands	846 a.
Lacustrine Wetlands	756 a.
Palustrine Wetlands	
Open Water	1,754 a.
Tidal Emergent/Shrub	1,774 a.
Nontidal Emergent	3,887 a.
Deciduous Scrub-Shrub	10,882 a.
Evergreen Scrub-Shrub	12,422 a.
Deciduous Forested	51,980 a.
Evergreen Forested	39,645 a.
Farmed	4,732 a.
Palustrine Subtotal	127,076 a.
Burlington County Total	136,297 a.

Burlington County had 7,064 acres of deepwater habitat, with freshwater rivers predominating.

Camden County ★

Camden County had 20,922 acres of wetland, which represented nearly 15% of the county. Nearly all of this acreage was palustrine wetland, while a few hundred acres of freshwater tidal flat were also inventoried. Forested wetland comprised 81% of Camden's wetland resource.

Riverine Tidal Flats	417 a.
Lacustrine Wetlands	41 a.
Palustrine Wetlands	
Open Water	737 a.
Tidal Emergent/Shrub	399 a.
Nontidal Emergent	445 a.
Deciduous Scrub-Shrub	970 a.
Evergreen Scrub-Shrub	872 a.
Deciduous Forested	10,353 a.
Evergreen Forested	6,688 a.
Palustrine Subtotal	20,464 a.
Camden County Total	20,922 a.

Most of Camden's 2,588 acres of deepwater habitat were freshwater rivers and streams. Only 343 acres of lakes and reservoirs were found.

Cape May County

More than half of Cape May County was wetland and no other county had a higher proportion of this resource. Cape May's 89,581 acres of wetland made it fifth-ranked among other counties in wetland acreage. Cape May was also fourth-ranked in the extent of estuarine wetland. This wetland type made up 63% of the county's wetland acreage, while palustrine wetland, mostly deciduous forested wetland, comprised nearly all of the remainder. Estuarine emergent wetland alone accounted for 48% of the wetland resource.

Marine Wetlands	3,611 a.
Estuarine Wetlands	
Aquatic Bed	5,135 a.
Emergent	42,854 a.
Flat	7,862 a.
Other	260 a.
Estuarine Subtotal	56,111 a.
Palustrine Wetlands	
Open Water	782 a.
Tidal Emergent/Shrub	40 a.
Nontidal Emergent	1,510 a.
Deciduous Scrub-Shrub	1,817 a.
Evergreen Scrub-Shrub	238 a.
Deciduous Forested	21,785 a.
Evergreen Forested	3,687 a.
Palustrine Subtotal	29,859 a.
Cape May County Total	89,581 a.

Cape May County ranked third in deepwater habitat acreage. Due to the presence of a good portion of Delaware Bay in the county, estuarine waters prevailed, comprising nearly all of this resource.

Cumberland County

Cumberland County ranked fourth in wetland abundance. Its 98,950 wetland acres covered slightly less than a third of the county. Estuarine wetland predominated, representing nearly 60% of the wetland acreage. Almost half of the county's wetlands was made up of estuarine emergent wetland, while 41% was palustrine wetland, with deciduous forested wetland most abundant.

Estuarine Wetlands	
Emergent	48,764 a.
Flat	9,823 a.
Other	69 a.
Estuarine Subtotal	58,656 a.
Lacustrine Wetlands	55 a.
Palustrine Wetlands	
Open Water	854 a.
Tidal Emergent	44 a.
Nontidal Emergent	541 a.
Deciduous Scrub-Shrub	1,665 a.
Evergreen Scrub-Shrub	441 a.
Deciduous Forested	29,994 a.
Evergreen Forested	6,700 a.
Palustrine Subtotal	40,239 a.
Cumberland County Total	98,950 a.

Cumberland County had more deepwater habitat than any other county. Its 92,881 mapped acres were comprised largely of a portion of Delaware Bay. Not included in this figure are estuarine waters in the middle of the Bay where no maps were produced. A total of 3,129 acres of lacustrine water was also significant.

Essex County

Only about 8% of Essex County was comprised of wetland. Almost all of its 6,833 wetland acres were palustrine. Deciduous forested wetland accounted for 77% of the wetland acreage. Only 31 acres of estuarine wetland were inventoried.

Estuarine Wetlands	31 a.
Riverine Tidal Wetlands	2 a.
Palustrine Wetlands	
Open Water	141 a.
Emergent	522 a.
Deciduous Scrub-Shrub	855 a.
Deciduous Forested	5,282 a.
Palustrine Subtotal	6,800 a.
Essex County Total	6,833 a.

A total of 1,974 acres of deepwater habitat was found in Essex County. Most of this was estuarine water.

Gloucester County

Gloucester County was eighth-ranked in wetland abundance. Its 36,844 wetland acres covered nearly 18% of the county. Ninety-three percent of this acreage was palustrine wetland, with the remainder being estuarine and riverine tidal wetland. Freshwater tidal emergent wetland (4,033 acres) was more abundant than brackish emergent marsh (1,027 acres), but both types were overshadowed by the 21,383 acres of deciduous forested wetland that accounted for 58% of the county's wetland acreage.

Estuarine Wetlands	
Emergent	548 a.
Flat	479 a.
Estuarine Subtotal	1,027 a.
Riverine Tidal Wetlands	1,634 a.
Lacustrine Wetlands	6 a.
Palustrine Wetlands	
Open Water	1,156 a.
Tidal Emergent/Shrub	2,399 a.
Nontidal Emergent	2,045 a.
Deciduous Scrub-Shrub	2,058 a.
Evergreen Scrub-Shrub	326 a.
Deciduous Forested	21,383 a.
Evergreen Forested	4,743 a.
Farmed	67 a.
Palustrine Subtotal	34,177 a.
Gloucester County Total	36,844 a.

Deepwater habitat covered 5,826 acres of Gloucester County with riverine water predominating.

Hudson County

Hudson County ranked next to last in wetland acreage, with only 3,897 acres. Thirteen percent of the county was covered by wetland. Estuarine wetland made up nearly all (94%) of the wetland acreage. Estuarine emergent wetland was more than twice as extensive as estuarine intertidal flat.

Estuarine Wetlands	
Emergent	2,476 a.
Flat	1,179 a.
Estuarine Subtotal	3,655 a.
Palustrine Wetlands	
Open Water	100 a.
Emergent	111 a.
Other	31 a.
Palustrine Subtotal	242 a.
Hudson County Total	3,897 a.

Hudson County was seventh-ranked in deepwater habitat. Estuarine water made up all of the 9,170 deepwater habitat acres inventoried.

Hunterdon County

Only 2% of Hunterdon County was wetland, totaling 5,450 acres. Nearly all of it was palustrine wetland with deciduous forested wetland alone representing 68% of the acreage.

Riverine Wetlands	9 a.
Lacustrine Wetlands	214 a.
Palustrine Wetlands	
Open Water	690 a.
Emergent	401 a.
Deciduous Scrub-Shrub	429 a.
Deciduous Forested	3,707 a.
Palustrine Subtotal	5,227 a.
Hunterdon County Total	5,450 a.

Hunterdon County had 4,629 acres of deepwater habitat, mostly comprised of lakes and reservoirs.

Mercer County

Wetland covered 11,819 acres or 8% of Mercer County. Nearly all was palustrine wetland, with about 77% being deciduous forested wetland. The only tidal wetlands in Mercer County were freshwater tidal marshes and flats.

Riverine Tidal Wetlands	35 a.
Lacustrine Wetlands	66 a.
Palustrine Wetlands	
Open Water	427 a.
Tidal Emergent/Shrub	422 a.
Nontidal Emergent	419 a.
Deciduous Scrub-Shrub	1,356 a.
Deciduous Forested	9,094 a.
Palustrine Subtotal	11,718 a.
Mercer County Total	11,819 a.

Only 1,492 acres of deepwater habitat were found in Mercer County. This led to a 19th ranking among counties.

Middlesex County

Middlesex County was middle-ranked (11th) in wetland abundance. Its 24,022 wetland acres covered 12% of the county. About 73% of this acreage was palustrine wetland, with the rest being estuarine wetland. Deciduous forested wetland accounted for 58% of the county's wetland acreage, while estuarine emergent wetland comprised 19%.

Estuarine Wetlands	
Emergent	4,575 a.
Flat	1,668 a.
Other	95 a.
Estuarine Subtotal	6,338 a.

CHAPTER 4.
Wetland Formation and Hydrology

Introduction

Historical events and present hydrologic conditions have combined to create and maintain a diversity of wetlands in New Jersey. Human activities have also exerted influence on wetland formation and hydrology. The following subsections address general differences between New Jersey's inland and coastal wetlands in their formation and hydrology.

Wetland Formation

The area's glacial history was especially significant in wetland formation throughout the State. Recent events like rising sea level and natural accretion and erosion along rivers and behind coastal barrier islands and beaches continue to build or modify wetlands. Construction of farm ponds, impoundments, and reservoirs may also create wetlands.

Inland Wetland Formation

Major factors creating wetlands vary throughout the State, but past glaciation has played an important role in most areas. Wolfe (1977) described in detail the relationship between geology and New Jersey's landscapes and much of the following discussion is based on his work. From 80,000 to 18,000 years ago, northern New Jersey was buried under glacial ice (Figure 11). This great ice sheet was nearly a mile thick. During this Ice Age, roughly one third of the world's land area was covered by ice compared to only 10% of today's surface. The presence of the glacier also affected the climate of southern New Jersey, making it tundra-like.

Most of northern New Jersey's wetlands were formed in glacial lakes and depressions during the post-glacial period, beginning about 18,000 years ago. Almost all of the State's natural lakes lie north of the glacier's southern edge (terminal moraine). Glacial lakes were created in three ways: (1) in rock basins scoured by glacial erosion (e.g., Sand Pond), (2) in depressions formed by melting ice blocks left by the retreating glacier (e.g., Lake Grinnel and Franklin Lake), and (3) in basins produced by glacial drift obstructions of river valleys (e.g., Swartswood Lake, Green Pond, Lake Hopatcong and Macopin Lake). Ice blocked north flowing streams like the Wallkill River, Black River, and Pequest River, creating lakes in the valleys. Large glacial lakes were also associated with major watersheds, i.e., the Passaic, the Hackensack and the Hudson. Lake Passaic was one of the largest of these now extinct glacial lakes. At its peak, it was about 30 miles long, 8 to 10 miles wide and 160 to 240 feet deep (Wolfe 1977). When the glacier receded, Lake Passaic and numerous other glacial lakes drained and wetlands formed in these basins (Figure 12). Large wetland complexes like Great Swamp, Great Piece Meadows, Troy Meadows and Black Meadows now exist where Lake Passaic once did.

Filling of shallow glacial lakes is still occurring. Niering (1953) described this situation as hydrarch succession for Pine Bog in High Point State Park. The center of the Bog is an open water body called Lost Lake. The Lake is surrounded by a floating peat moss mat, where leatherleaf dominates and other typical northern bog species are also present. Closer to the land's edge, trees like red maple, black spruce, black gum and yellow birch are abundant. Eventually, the entire lake may become wetland. This natural succession is occurring elsewhere in the State. Dansereau and Segadas-Vianna (1952) have described the evolution of bogs in eastern North America.

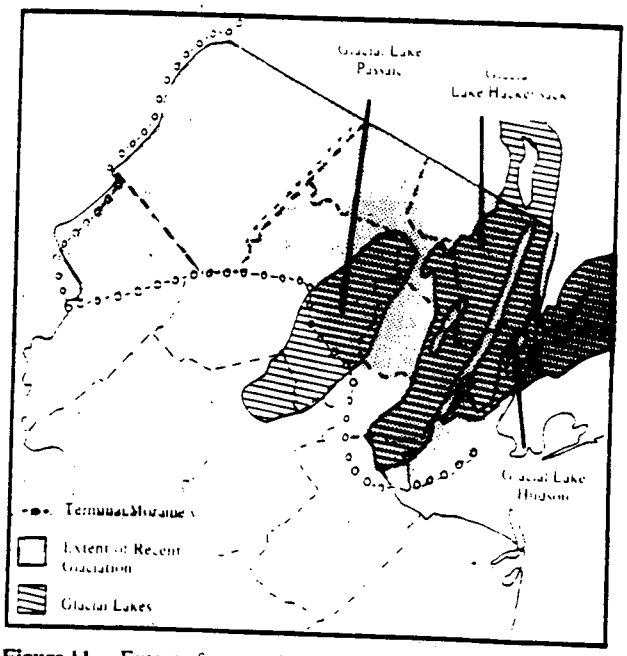


Figure 11. Extent of recent glaciation in New Jersey (modified from Wolfe 1977). Much of northern New Jersey was buried under glacial ice from 80,000 to 18,000 years ago.

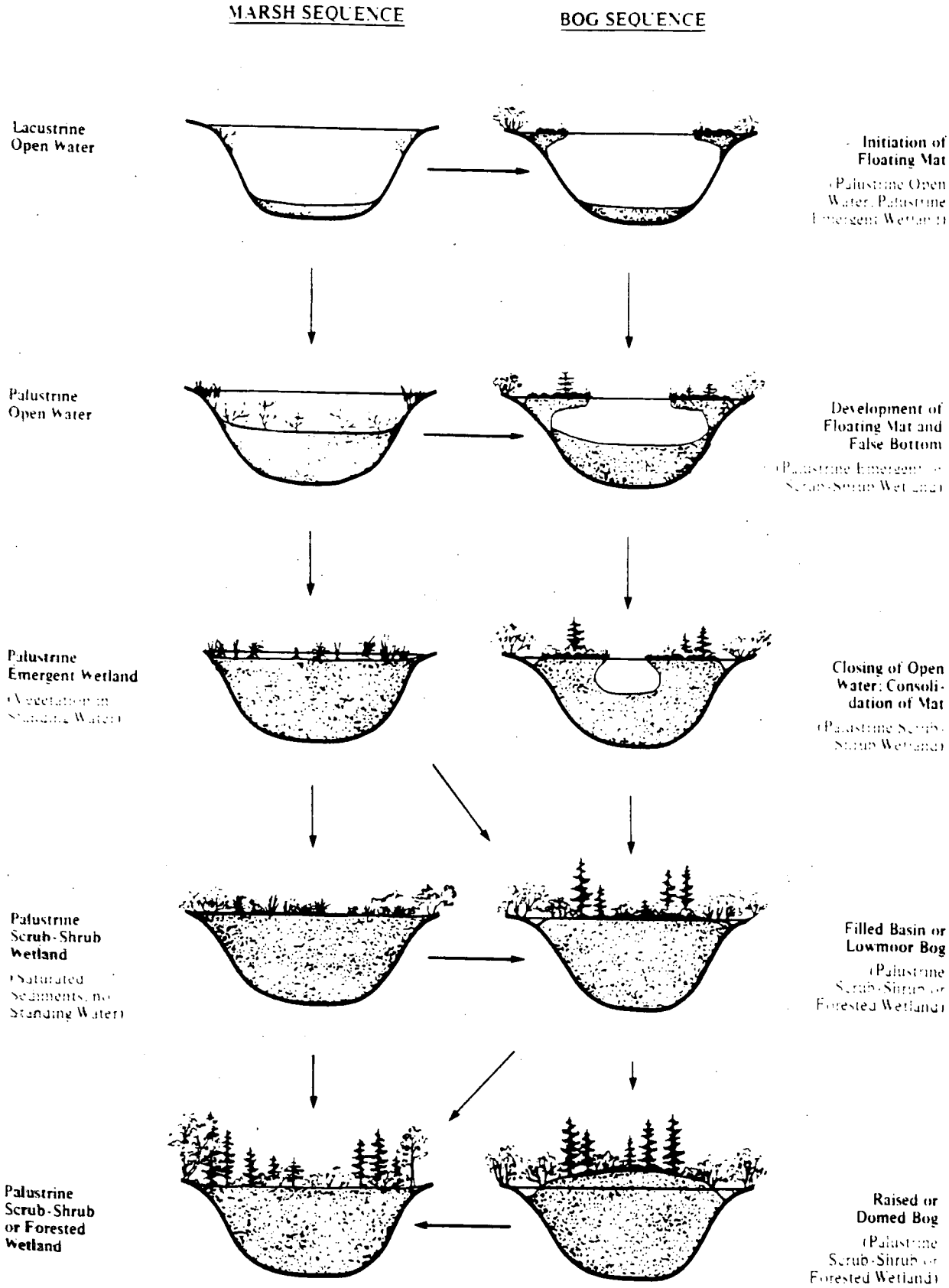


Figure 12. Marsh and bog successional patterns (adapted from Dansereau and Segadas-Vianna 1952).

Beaver activity and human actions may also create wetlands by altering hydrologic regimes to flood former upland areas. In these situations, wetland plants quickly invade to take advantage of the wetter conditions. Beaver activity is now of minor importance, although prior to heavy trapping, beaver played a more prominent role in wetland formation. Today, beaver populations are increasing due to wildlife management practices and they are most common in Sussex County (Ferrigno 1984). Farm pond, artificial lake, and reservoir construction may also create wetlands, yet in many instances natural vegetated wetlands are altered by permanent flooding. Farm ponds may be completely overgrown with vegetation including emergent, submergent, floating-leaved, and floating plants. Along the shorelines of larger water bodies, emergent wetlands and aquatic beds may become established in shallow water. Niering (1953) noted that sedimentation of artificial impoundments is favoring colonization by emergent wetland plants. In time, these areas could become shrub wetlands and eventually forested wetlands. Recently, wetlands have also been created in conjunction with government-financed projects, such as highway construction, port expansion, and flood control impoundments, to mitigate for unavoidable losses of natural wetlands. The U.S. Army Corps of Engineers has successfully established wetlands, particularly in tidal areas at several locations across the country. Restoration of previously drained wetlands has also been successfully accomplished by the Service and others in the Prairie Pothole Region of North and South Dakota. Similar opportunities exist in New Jersey where wetlands have been drained for crop production.

In southern New Jersey, glacial events created a climate where temperatures were below freezing for much of the year from 80,000 to 18,000 years ago. Permafrost developed under these conditions which now exist in Alaska, Canada, and Siberia. A boreal forest of spruce, pine and fir covered the southern New Jersey landscape during the Ice Age (Sirkin, *et al.* 1970). Thermokarst basins formed due to alternate freezing and thawing. Where underlain by impervious clays, these basins became ponds or vegetated wetlands as the climate warmed with the retreat of the glacier. Today, wetlands are prevalent along streams and in isolated depressions largely due to the high water table characteristic of the Pine Barrens. For further information on the vegetational history of the Pine Barrens, please refer to Heusser (1979).

Wetlands have also formed on floodplains along rivers and large streams throughout the State. In mature floodplains, wetlands are found on the inner floodplain terrace behind the natural levees. The levees are composed of coarser materials and are better drained than the inner floodplain which is characterized by silts and clays and poor drainage. Early stages in floodplain development are characterized by extensive marshes bordering streams which gradually become shrub and forested wetlands as sedimentation raises surface elevations (Nichols 1915). Wistendahl (1958) reported on the hydrology and vegetation of the Raritan River floodplain which represents a relatively mature stage.

Coastal Wetland Formation

At maximum glaciation nearly 18,000 years ago, much of the world's ocean waters were stored as glacial ice. This lowered sea levels approximately 425 feet from their present levels. The New Jersey coastline was then 80 miles east of its present position and the coastal plain was more than twice its current size (Wolfe 1977). When the glacier began to melt, water was released to the ocean, thereby raising sea levels. Sea level continues to rise at about one foot per century at Atlantic City and at 1.5 feet per century at Sandy Hook (Hicks 1972). With this increase in sea level, barrier islands have moved landward and stream valleys have been submerged. Evidence of submergence can be found in salt marshes where dead Atlantic white cedar trees and stumps may be present. Jaworski (1980) found that salt marsh vegetation has covered the remains of freshwater plants, providing further evidence of coastal submergence and the landward migration of salt marshes.

Heusser (1949) investigated the history of the Secaucus Bog, which is part of the Hackensack Meadowlands. In the 1800's, it was an Atlantic white cedar-dominated wetland and black spruce and larch reached their southernmost limit here. By 1935, the last of the cedars died. Today, the former bog is flooded by saline tidal waters and occupied by common reed and narrow-leaved cattail. Rising sea level and dredging of the Hackensack River have increased salt water tidal influence in this area.

Coastal marshes typically develop behind barrier islands or beaches and along tidal rivers (Figure 13). Sediments are transported by rivers flowing to the sea as well as by ocean currents. When the river meets the sea, sediments begin to settle out of solution forming deltas and bars at the river's mouth and intertidal flats. Sedimentation also takes place when tidal currents slow as during slack water periods. The rate and extent of sedimentation depends on the original size and age of the estuary, present erosion rate upstream and deposition by the river and marine tides and currents (Reid 1961). Redfield (1972) has described salt marsh development. Initially, mud and silt are deposited to form tidal flats in shallow areas. As elevations exceed mean sea level, smooth cordgrass becomes established. The presence of this vegetation further slows the velocity of flooding waters, causing more sedimentation. Sediments continue to build up to a level where erosion and deposition are in relative equilibrium. The high salt marsh is formed in this way. In many areas along the

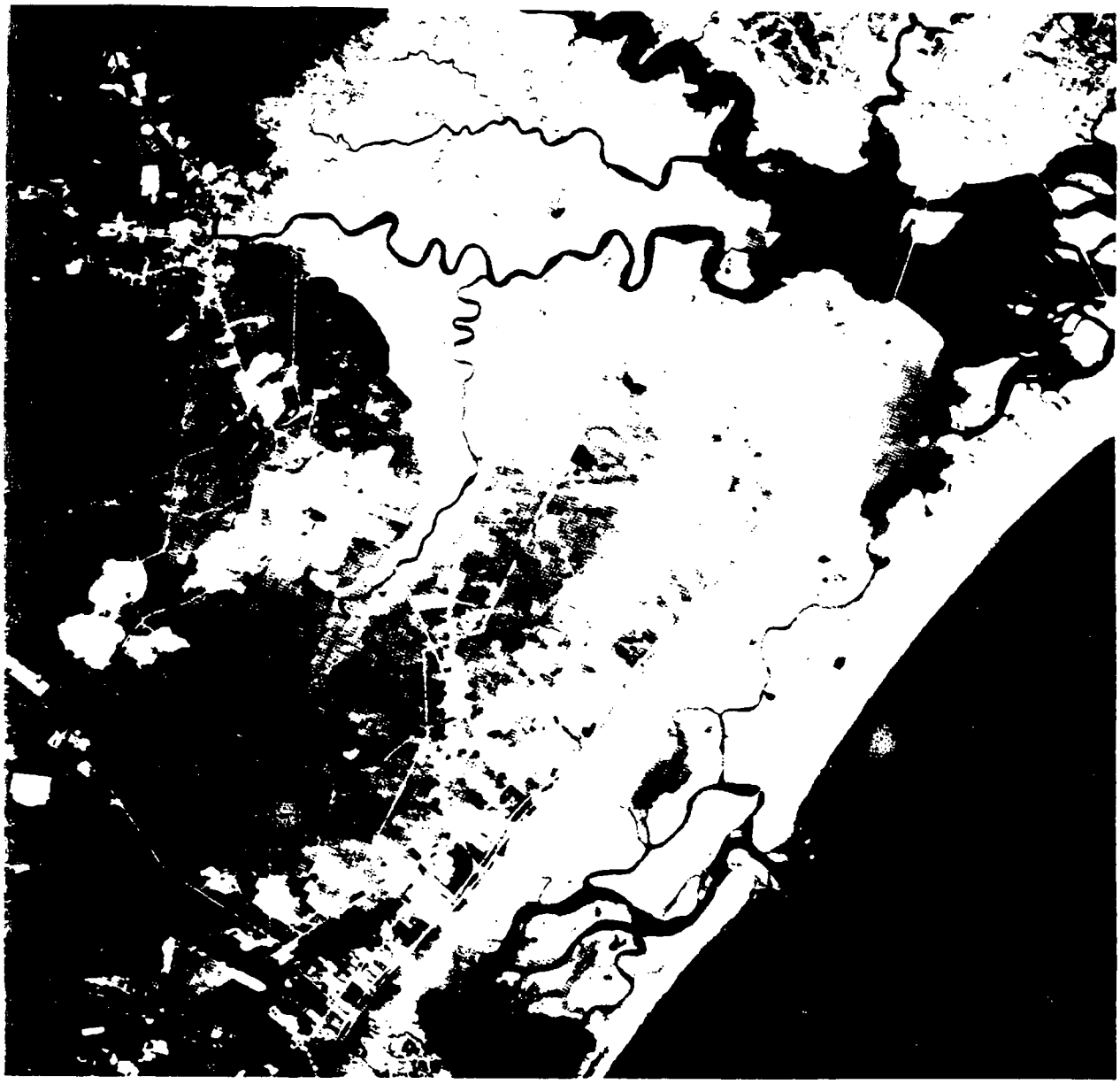


Figure 13. Coastal marshes naturally develop behind barrier islands and along tidal rivers.

Atlantic coast, salt marshes are gradually advancing into low-lying uplands or into nontidal wetlands. This latter situation has been described by Heusser (1949) and Potzger (1952). This landward migration is largely attributed to the global rise in sea level.

Wetland Hydrology

The presence of water from flooding, surface water runoff, ground-water discharge, or tides is the driving force creating and maintaining wetlands. These hydrologic mechanisms determine the nature of the soils and the types of plants and animals living in wetlands. An accurate assessment of hydrology unfortunately requires extensive knowledge of the frequency and duration of flooding, water table fluctuations and ground-water relationships. This information can only be gained through intensive and long term studies. There are, however, ways to generally recognize differences in hydrology or water regime. At certain times of the year, like during spring floods or high tides in coastal areas, hydrology is apparent. Yet, for most of the year, such obvious evidence is lacking in many wetlands. At these times, less conspicuous signs of flooding may be observed: (1) water marks on vegetation, (2) water transported debris on plants or collected around their bases, and (3) water-stained leaves on the ground. These signs and knowledge of the water table and wetland vegetation help us recognize hydrologic differences between wetlands. The Service's wetland classification

Table 8. Tidal ranges of mean and spring tides at selected locations in New Jersey (U.S. Department of Commerce 1978).

Location	Mean Tide Range (ft.)	Spring Tide Range (ft.)	Mean Tide Level (ft.)
Hackensack River at Kearny Point	5.0	6.0	2.5
Raritan River at South Amboy	5.0	6.0	2.5
at New Brunswick	5.8	7.0	2.9
Shrewsbury River at Sea Bright	1.7	2.1	0.6
Barnegat Bay at Mantoloking	0.5	0.6	0.2
at Barnegat Inlet	3.1	3.8	1.5
Little Egg Harbor at Beach Haven	2.2	2.7	1.1
Great Bay at Graveling Point	3.4	4.1	1.7
Great Egg Harbor River at Mays Landing	4.0	4.8	2.0
Maurice River at Millville	6.0	7.0	3.0
Delaware Bay at Miah Maull Shoal Light	5.5	6.5	[illegible]
Delaware River at Oldsman Point	5.6	2.9	2.8
at Trenton	6.8	7.1	3.4

system (Cowardin, *et al.* 1979) includes water regime modifiers to descibe hydrologic characteristics. Two groups of water regimes are identified: (1) tidal and (2) nontidal. Tidal water regimes are driven by oceanic tides, while nontidal regimes are largely influenced by surface water runoff and ground-water discharge. The state of our knowledge in wetland hydrology has been reported by Carter and others (1979) and Leitch (1981).

Tidal Wetland Hydrology

In coastal areas, ocean-driven tides are the dominant hydrologic feature of wetlands. Along the Atlantic coast, tides are semidiurnal and symmetrical with a period of 12 hours and 25 minutes. In other words, there are roughly two high tides and two low tides each day. Since the tides are largely controlled by the position of the moon relative to the sun, the highest and lowest tides (i.e., "spring tides") usually occur during full and new moons. In New Jersey, tidal ranges vary from 0.5 feet (0.15m) in Barnegat Bay to 7.1 feet (2.17m) in the Delaware River at Trenton (Table 8). Coastal storms can also cause extreme high and low tides. Strong winds over a prolonged period have a great impact on the normal tidal range in large coastal bays. For example, strong winds in Barnegat Bay may raise or lower normal high and low tides by as much as 3 feet (U.S. Department of Commerce 1964).

In coastal wetlands, differences in hydrology (tidal flooding) create two zones that can be readily identified: (1) regularly flooded zone and (2) irregularly flooded zone (Figure 14). The regularly flooded zone is alternately flooded and exposed at least once daily by the tides. It includes both the "low marsh" and the more seaward intertidal mud and sand flats. Above the regularly flooded zone, the marsh is less frequently flooded by the tides. This irregularly flooded zone, or "high marsh", is exposed to the air for long periods and flooded only for brief periods of variable length. The high marsh is usually flooded during spring tides. The upper margins of the high marsh may be flooded, however, only during storm tides which are more frequent in winter. Estuarine plants have adapted to these differences in hydrology and certain plants are good indicators of different water regimes (Table 9).

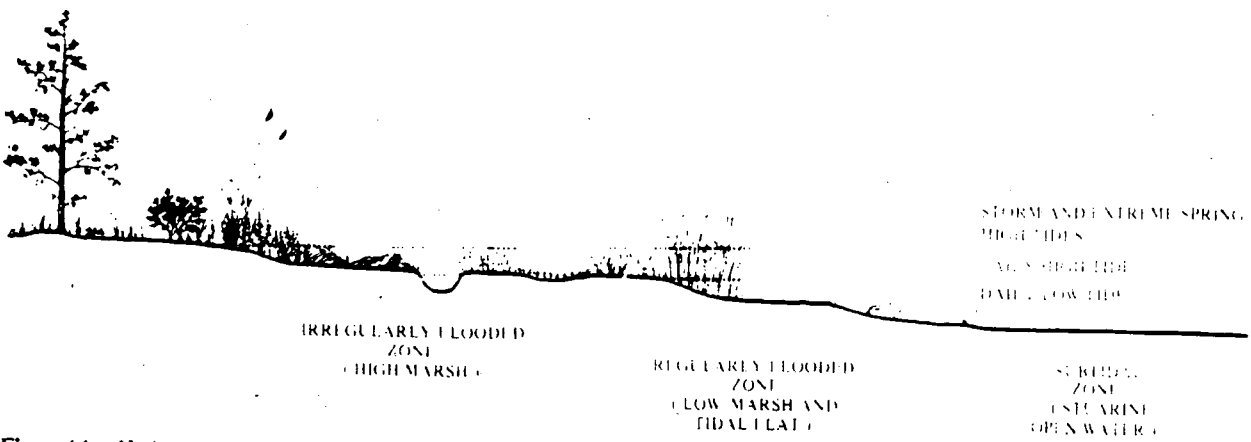


Figure 14. Hydrology of coastal marsh, showing different zones of flooding. The regularly flooded zone is flooded at least once daily by the tides, while the irregularly flooded zone is flooded less often.

Table 9. Examples of plant indicators of the predominant tidal water regimes for New Jersey's estuarine wetlands. These plants are generally good indicators of tidal flooding regimes.

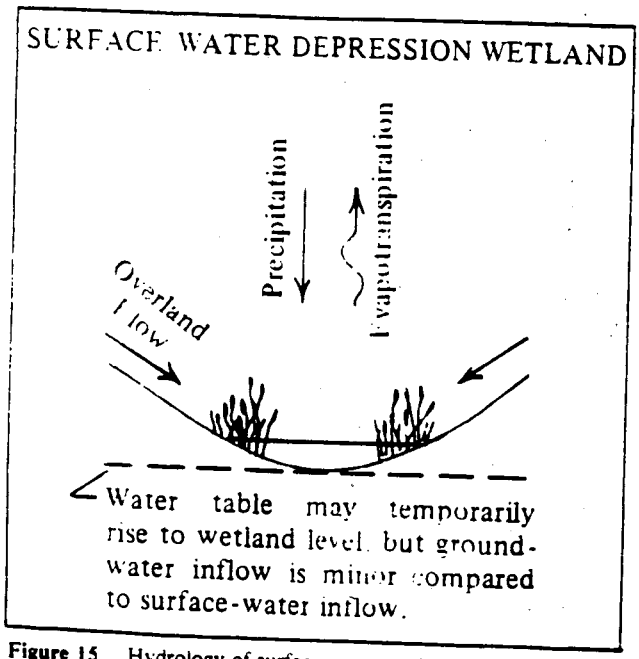
Water Regime	Indicator Plants
Regularly Flooded	Smooth Cordgrass (tall form) Water Smartweed Spatterdock Water Hemp Pickerelweed
Irregularly Flooded	Salt Hay Grass Spike Grass Smooth Cordgrass (short form) Black Grass Switchgrass Big Cordgrass Olney Three-square Bur Marigold

Some strictly freshwater wetlands are also subject to tidal flooding. They lie above the estuary where virtually no ocean-derived salts (i.e., less than 0.5 parts per thousand) are found. Here river flow and tidal flooding interact to create a rather complicated hydrology. Areas flooded and exposed at least once daily by the tides are considered regularly flooded like they are downstream in the estuary, yet wetlands that are not subject to daily tidal flooding are generally classified as seasonally flooded-tidal and temporarily flooded-tidal. They represent the more common water regimes in these situations, with the frequency and duration of flooding being the main hydrologic differences between them. Seasonally flooded-tidal wetlands are often flooded by tides and flooded waters may be present for long periods, especially during spring runoff. Temporarily flooded-tidal areas are flooded infrequently and when flooded, water does not usually persist for more than a few days. These wetlands, especially forested wetlands, are quite similar in appearance to their nontidal counterparts, yet water levels are subject to tidal fluctuations.

Nontidal Wetland Hydrology

Beyond the influence of the tides, two hydrologic forces regulate water levels or soil saturation in wetlands: (1) surface water runoff and (2) ground-water discharge. In certain cases, wind driven waves (i.e., seiches) across large freshwater lakes (e.g., Great Lakes) cause flooding of shoreline wetlands. Surface water runoff from the land either collects in depressional wetlands or overflows from rivers and lakes after snowmelt or rainfall periods (Figure 15). Ground water discharges into depressional wetlands when directly connected to the water table or into sloping wetlands in "seepage" areas (Figure 16). An individual wetland may exist due to surface water runoff or ground-water discharge or both. The Great Swamp in northern New Jersey is a good example of the latter (Vecchioli, *et al.* 1962; Miller 1965). Streamflow and associated wetlands in the Pine Barrens are largely maintained by ground-water discharge from the underlying aquifer (Rhodehamel 1979). The role of hydrology in maintaining freshwater wetlands is discussed by Gosselink and Turner (1978).

Freshwater rivers and streams usually experience greatest flooding in winter and early spring, with maximum flooding occurring in March. Such flooding is



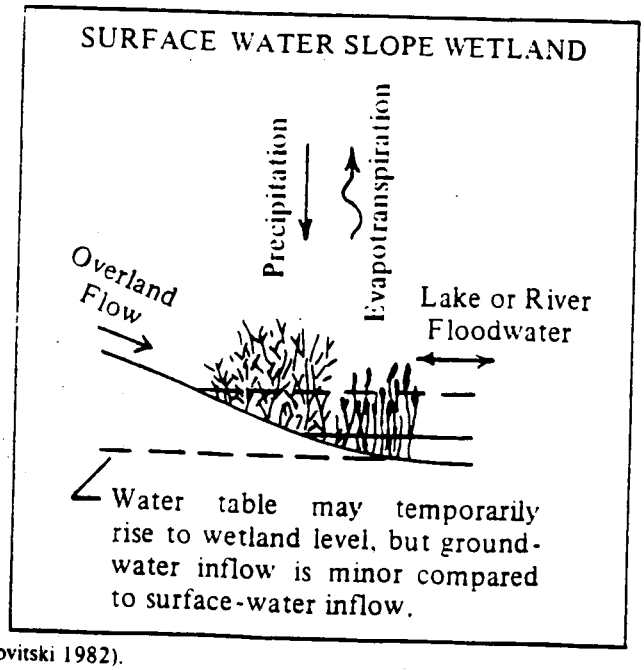


Figure 15 Hydrology of surface water wetlands (redrawn from Novitski 1982).

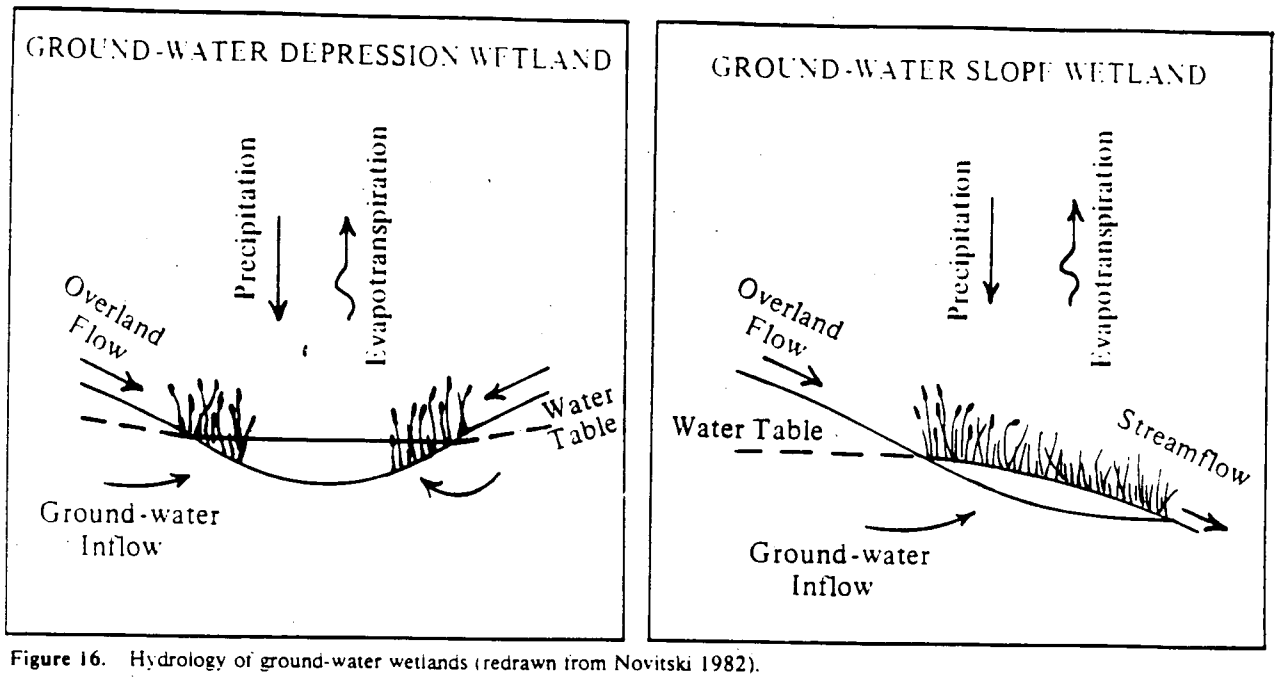


Figure 16. Hydrology of ground-water wetlands (redrawn from Novitski 1982).

associated with frozen soil, snow melt, and/or spring rains. In the Raritan River, for example, flooding reaches its maximum in March near the start of the growing season (Wistendahl 1958). Flooding in this river is variable and unpredictable, with as many as 16 floods occurring in a single year. Normally, however, flooding is less frequent. In the North Branch of the Raritan River, Buchholz (1981) found that flooding results from overflow of backwater streams rather than from overflow of the mainstem river. Backwater stream levees are lower in elevation and are easily breached by rising waters. Minor drainage within the floodplain may, therefore, significantly affect flooding and drainage patterns. In the Raritan River watershed, average monthly precipitation is greatest in summer, but despite this, floods reach their yearly low in June and August. At this time, less water is available for runoff due to high evapotranspiration and to interception of rainfall by plant leaves. In the fall, the hurricane season normally brings heavy rains which increase flood heights and duration (Wistendahl 1958).

Water table fluctuations follow a similar pattern (Figure 17). From winter to mid-spring or early summer, the water table is at or near the surface in most wetlands. During this time, water may pond or flood the wetland surface for variable periods. In May or June, the water table may begin to drop, reaching its low point in September or October. Most of the fluctuation relates to rainfall patterns, yet longer days, increasing air temperatures, increasing evapotranspiration and other factors are responsible for the consistent lowering of the water table from spring through summer.

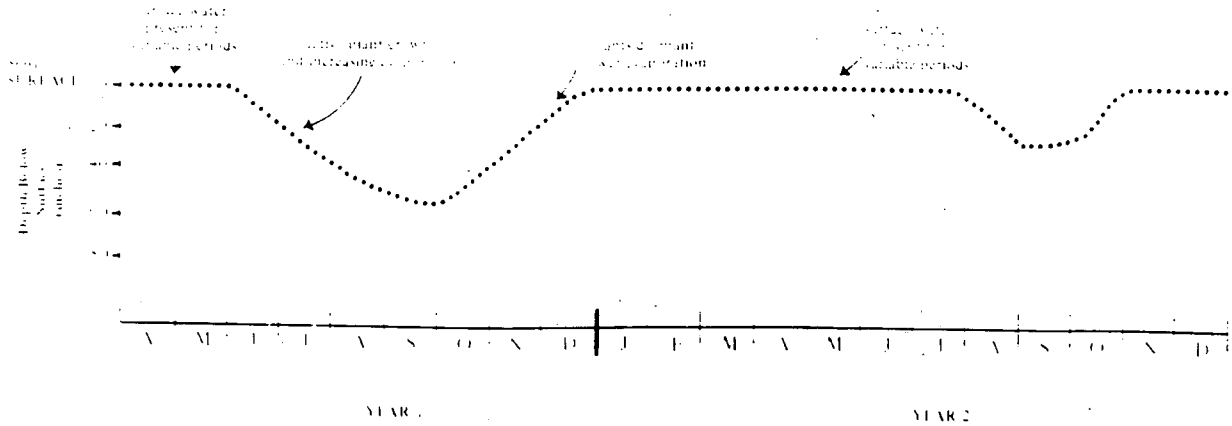


Figure 17. Example of water table fluctuations in a seasonally flooded wetland (adapted from Lyford 1964). In general, the water table is at or near the surface through the winter and spring, drops markedly in summer, and begins to rise in the fall. As shown, the water table fluctuates seasonally and annually.

Standing water may be present in depressional, streamside or lakefront wetlands for variable periods during the growing season. When flooding or ponding is brief (usually 2 weeks or less), the wetland is considered temporarily flooded. During the summer, the water table may drop to 3 feet or more below the surface in these wetlands. This situation is prevalent along floodplains. It also occurs in the Pine Barrens where wetlands are directly connected to the underlying ground-water aquifer (Rhodehamel 1979). Flooding for longer periods is described by three common water regimes: (1) seasonally flooded, (2) semipermanently flooded, and (3) permanently flooded. A seasonally flooded wetland typically has standing water visible for more than 1 month, but usually by late summer, such water is absent. At this time, however, the water table remains within 1.5 feet of the surface. By contrast, a semipermanently flooded wetland remains flooded throughout the growing season in most years. Only during dry spells does the surface of these wetlands become exposed to air. Even then, the water table lies at or very near the surface. The wettest wetlands are permanently flooded, yet they also may be exposed during extreme droughts. These areas include open water bodies where depth is less than 6.6 feet, e.g., ponds and shallow portions of lakes, rivers and streams.

Other wetlands are rarely flooded and are almost entirely influenced by ground-water discharge or surface water runoff. Some of these wetlands occur on considerable slopes in association with springs (i.e., points of active ground-water discharge), where they are commonly called "seeps". Their soils are saturated to the surface for most of the growing season and the water regime is, therefore, classified as saturated. Other saturated wetlands exist in isolated depressions. In these situations, soil saturation may come from both surface water runoff and ground-water discharge.

Common indicator plants of nontidal water regimes are presented in Table 10. Hydrologic conditions, e.g., water table fluctuation, flooding, and soil saturation, for each of New Jersey's hydric soils are generally discussed in the following chapter. For more detailed information on wetland hydrology, the reader is referred to the following sources.

Table 10. Examples of plant indicators of nontidal water regimes for New Jersey's palustrine wetlands.

Water Regime	Indicator Plants
Permanently Flooded	White Water Lily Pondweeds Water Shield Spatterdock
Semipermanently Flooded	Buttonbush Wild Rice Burreeds Pickerelweed
Seasonally Flooded	Atlantic White Cedar Alders Highbush Blueberry Broad-leaved Cattail Tussock Sedge
Temporarily Flooded	Silver Maple Pin Oak Sycamore Goldenrods
Saturated	Steeplebush Black Spruce Leatherleaf Sheep Laurel

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CHAPTER 6.

Vegetation and Plant Communities of New Jersey's Wetlands

Introduction

The vast majority of New Jersey's wetlands are characterized by dense growths of plants adapted to existing hydrologic, water chemistry and soil conditions, although some wetlands have little or no apparent vegetation. Most wetland definitions have relied heavily on dominant vegetation for identification and classification purposes. The presence of "hydrophytes" or wetland plants is one of the three key attributes of the Service's wetland definition (Cowardin, *et al.* 1979). Vegetation is the most conspicuous feature of wetlands and one that can be readily identified in the field. Other wetland characteristics, i.e., hydric soil and hydrology, are not as easily recognized and often require considerable scientific expertise or long term study for accurate identification. In this chapter, after discussing the concept of "hydrophyte," attention will focus on the major plant communities of New Jersey's wetlands. In addition, rare and endangered wetland plants will be briefly covered in the last section.

Hydrophyte Definition and Concept

Wetland plants are technically referred to as "hydrophytes." The Service defines a "hydrophyte" as "any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content" (Cowardin, *et al.* 1979). Thus, hydrophytes are not restricted to true aquatic plants growing in water, but also include plants morphologically and/or physiologically adapted to periodic flooding or saturated soil conditions of marshes, swamps, bogs and bottomland forests. Teskey and Hinckley (1977) have reviewed physiological responses and tolerance mechanisms of woody vegetation to flooding.

The Service has prepared a comprehensive preliminary list of the Nation's hydrophytes to help clarify its wetland definition and facilitate wetland identification. This national wetland plant list has been divided into regional lists, including one for the Northeast (U.S. Fish and Wildlife Service 1982). Currently the preliminary Northeast list is undergoing technical review by the scientific community. The Service recognizes four types of hydrophytes: (1) obligate, (2) facultative wet, (3) facultative, and (4) facultative upland. Obligate hydrophytes are those plants which nearly always occur in wetlands (at least 99% of the time). They are the best vegetative indicators of wetland. The facultative types can be found in both wetlands and uplands to varying degrees. Facultative wet plants are usually associated with wetlands (from 66% to 99% of the time) and are generally good indicators of wetland, while purely facultative hydrophytes show no affinity to wetlands or uplands and are found in wetlands with a frequency of occurrence between 33-66%. By contrast, facultative upland plants are more typical of uplands, but do, on occasion (less than 33% of the time), occur in wetlands. When present in wetlands, they are usually in drier wetlands or at higher elevations in wetter areas. In addition to these four types, the Service's list of hydrophytes also identifies drawdown plants which invade normally unvegetated wetlands (e.g., exposed shores) during extreme dry periods. These plants are often pioneer species with upland affinities. Examples of different types of hydrophytes for New Jersey are presented in Table 14.

New Jersey Hydrophytes

Since the Service's wetland plant list is not final, an interim list of New Jersey's wetland plants was compiled for this report. In preparing this list, field notes from wetlands inventory field surveys and the findings of more than 30 scientific publications on New Jersey's wetland vegetation were reviewed. Over 1,000 vascular plants were recorded: 50+ trees, 100+ shrubs, 20+ vines, 750+ emergents and 80+ aquatics (Appendix). Since this list is based on actual observations, it does not contain all of the plants that potentially exist in New Jersey's wetlands, yet it probably includes all of the common plants and the majority of minor species, such as cosmopolitan weeds that occur in both wetlands and uplands, and numerous rare plants. Scientific names of vascular plants referred to in this report conform with the **National List of Scientific Plant Names** (U.S.D.A. Soil Conservation Service 1982).

Factors Influencing Wetland Vegetation

Many factors influence wetland vegetation and community structure, including climate, hydrology, water chemistry, and human activities. Penfound (1952) identified the most important physical factors as: (1) water depth, (2) fluctuation of water levels, (3) soil moisture, and (4) salinity. Other important physical factors included soil type, aeration, nutrients, acidity, temperature, and light. Penfound also recognized the role of biotic factors,

Table 14. Examples of wetland plants types occurring in New Jersey. Obligate plants are nearly always found in wetlands (at least 99% of the time); Facultative Wet plants are usually associated with wetlands (66-99% of the time); Facultative plants have no affinity to wetlands or uplands and are found in wetlands between 33-66% of the time; Facultative Upland plants are occasionally present in wetlands (less than 33% of the time).

Hydrophyte Type	Plant Common Name	Scientific Name
Obligate	Royal Fern	*Osmunda regalis*
	Pondweeds	*Potamogeton* spp.
	Smooth Cordgrass	*Spartina alterniflora*
	Soft Rush	*Juncus effusus*
	Cattails	*Typha* spp.
	Boneset	*Eupatorium perfoliatum*
	Swamp Azalea	*Rhododendron viscosum*
	Big Cranberry	*Vaccinium macrocarpon*
	Buttonbush	*Cephalanthus occidentalis*
Facultative Wet	Atlantic White Cedar	*Chamaecyparis thyoides*
	Cinnamon Fern	*Osmunda cinnamomea*
	Salt Hay Grass	*Spartina patens*
	Common Reed	*Phragmites australis*
	Grass-leaved Goldenrod	*Euthamia graminifolia*
	Lowland Broomsedge	*Andropogon virginicus* var. *abbreviatus*
	Steeplebush	*Spiraea tomentosa*
	Dwarf Huckleberry	*Gaylussacia dumosa*
	Highbush Blueberry	*Vaccinium corymbosum*
	Sweet Pepperbush	*Clethra alnifolia*
	Silver Maple	*Acer saccharinum*
	Pin Oak	*Quercus palustris*
Facultative	Foxtail Grass	*Setaria geniculata*
	Wrinkled Goldenrod	*Solidago rugosa*
	Purple Joe-Pye-weed	*Eupatoriadelphus purpureum*
	Sheep Laurel	*Kalmia angustifolia*
	Southern Arrowwood	*Viburnum dentatum*
	Red Maple	*Acer rubrum*
	Black Gum	*Nyssa sylvatica*
Facultative Upland	Bracken Fern	*Pteridium aquilinum*
	May Apple	*Podophyllum peltatum*
	Snowberry	*Symphoricarpos albus*
	Black Huckleberry	*Gaylussacia baccata*
	Beech	*Fagus grandifolia*
	American Holly	*Ilex opaca*
	White Ash	*Fraxinus americana*
	White Oak	*Quercus alba*

i.e., plant competition, animal actions (e.g., grazing and beaver dam construction), and human activities. Many construction projects alter the hydrology of wetlands through channelization and drainage or by changing surface water runoff patterns. These activities often have a profound effect on plant composition. This is particularly evident in coastal marshes where mosquito ditching has increased the abundance of high-tide bush (*Iva frutescens*), especially on spoil mounds adjacent to ditches (Bourn and Cottam 1950). Sipple (1971) observed that salt marsh vegetation now occurs further upstream in the Hackensack River and attributed increased saltwater penetration to Ordell Reservoir's reduction of freshwater inflow into the estuary. Repeated timber cutting and severe fires have had a profound effect on wetland communities in the Pine Barrens (Little 1950, 1979; McCormick 1979). A recent study of the effects of regional land-use changes on Pine Barrens swamps found that urbanization has added nutrients to both surface and ground waters, resulting in floristic changes (Ehrenfeld 1983). Plants adapted to nutrient poor, acid conditions were replaced by non-Pine Barrens plants.

While New Jersey is relatively small in size, its location along the East Coast gives rise to high plant and landscape diversity. Five physiographic regions can be identified: (1) Ridge and Valley, (2) Highlands, (3) Piedmont, (4) Inner Coastal Plain, and (5) Outer Coastal Plain (Figure 1). Physical and biotic factors have interacted within each physiographic region to create a wealth of plant communities in New Jersey. Robichaud and Buell (1973) have reported on the predominant influences on the State's vegetation and on the variety of vegetation types, including wetlands.

Wetland Plant Communities

Wetlands occur in New Jersey in all five ecological systems inventoried by the Service's National Wetlands Inventory: Marine, Estuarine, Riverine, Lacustrine and Palustrine. In coastal areas, the estuarine marshes, which include salt and brackish tidal marshes and flats, are most abundant, with marine wetlands generally limited to intertidal beaches along the shoreline and bars at the mouths of tidal inlets. Overall, however, palustrine wetlands predominate, representing about two-thirds of the State's wetlands. They include the overwhelming majority of freshwater marshes, swamps, bogs and ponds. Riverine and lacustrine wetlands are largely restricted to aquatic beds and nonpersistent emergent wetlands along the shores of rivers and lakes. The following sections discuss major wetland types in each ecological system as defined by Cowardin and others (1979). Descriptions are based on field observations and a review of scientific literature.

Marine Wetlands

The Marine System includes the open ocean overlying the continental shelf and the associated coastline. Deep-water habitats predominate in this system, with wetlands generally limited to sandy intertidal beaches and bars at the mouths of coastal inlets. Largely due to heavy wave action, vegetation is sparse and scattered along the upper zones of beaches. Beach plants are so few that Martin (1959) did not consider the beach as a significant vegetation zone in his classic study of the vegetation of Island Beach State Park. Vascular plants like sea rocket (*Cakile edentula*) and saltwort (*Salsola kali*) may be common. Other beach plants include seaside spurge (*Euphorbia polygonifolia*), sandbur (*Cenchrus tribuloides*), beach grass (*Ammophila breviligulata*), beach orach (*Atriplex arenaria*), cocklebur (*Xanthium strumarium*), sea purslane (*Sesuvium maritimum*), and beach bean (*Strophostyles helvola*) (Harshberger 1900; Silberhorn 1982).

Estuarine Wetlands

The Estuarine System consists of tidal brackish waters and contiguous wetlands where ocean water is at least occasionally diluted by freshwater runoff from the land. It generally begins behind barrier islands and at the mouth of coastal rivers and extends upstream in rivers to fresh water where no measureable amounts of ocean-derived salts (less than 0.5 parts per thousand) can be detected. Estuarine wetlands are most extensive behind barrier islands and along Delaware Bay.

From a salinity standpoint, New Jersey estuaries can be divided into three distinct reaches: (1) polyhaline - strongly saline areas (18-30 parts per thousand), (2) mesohaline - moderate salinity areas (5-18 ppt), and (3) oligohaline - slightly brackish areas (0.5-5 ppt). Large coastal rivers, such as the Mullica, become increasingly fresher upstream from the river's mouth as salt water is diluted by the river's freshwater discharge. Since river discharge varies during the year, the salinity of coastal rivers varies accordingly. A variety of wetlands develop in estuaries largely because of differences in salinity and duration and frequency of flooding. Major wetland types include: (1) intertidal flats, (2) aquatic beds, (3) emergent wetlands and (4) scrub-shrub wetlands.

Estuarine Intertidal Flats

Intertidal flats of mud and/or sand are extremely common in estuaries, particularly between salt marshes and open coastal bays. They are typically flooded by tides and exposed to air twice daily, although some flats are only intermittently exposed by spring and storm tides. Tidal flats are generally devoid of macrophytes, although smooth cordgrass (*Spartina alterniflora*) may occur in isolated clumps at higher levels. Microscopic plants, especially diatoms, euglenoids, dinoflagellates and blue-green algae, are often extremely abundant, yet inconspicuous (Whitlatch 1982). Intertidal flats covered by macroalgae or vascular plants are classified as vegetated flats (Cowardin, *et al.* 1977). Plants of vegetated flats are similar to estuarine aquatic beds, with the alga sea lettuce (*Ulva lactuca*) being particularly common.

Estuarine Aquatic Beds

Macroalgae and vascular plants form extensive aquatic beds in shallow waters and irregularly exposed flats of estuaries. Aquatic beds are most abundant in the more saline parts of New Jersey's estuaries behind barrier islands where large bays exist. In these areas, common plants include three algae and two vascular plants: sea lettuce, spaghetti grass (*Codium fragile*), red algae (*Gracilaria* spp.), eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*), respectively (Good, *et al.* 1978; Sugihara, *et al.* 1979). Taylor (1970) reported 147 types of macroalgae from New Jersey estuaries.

The distribution of submerged aquatic vegetation in New Jersey has been mapped and described by Macomber and Allen (1979). In general, sea lettuce dominates estuarine areas from Cape May north to Great Bay and north of the Metedeconk River. Between these areas, little algae has been observed. Sea lettuce is also quite dense in shallow rivers and sounds north of Barnegat Bay. By contrast, the large bays from Great Bay (e.g., Little Egg Harbor and Barnegat Bay) to the Metedeconk River are largely dominated by vascular plants, especially eelgrass

and widgeon grass. Sago pondweed (*Potamogeton pectinatus*) and horned pondweed (*Zannichellia palustris*) replace eelgrass in bay areas of decreasing salinity.

In lower salinity (mesohaline and oligohaline) portions of coastal rivers such as the Mullica, aquatic beds are formed by other plants, including pondweeds (*Potamogeton perfoliatus, P. pusillus* and *P. epihydrus*), eastern lilaeopsis (*Lilaeopsis chinensis*), wild celery (*Vallisneria americana*), naiad (*Najas flexilis*) and submergent forms of Parker's pipewort (*Eriocaulon parkeri*) and hooded arrowhead (*Sagittaria calycina*) (Arsenault 1981; Ferren, *et al.* 1981). Wild celery, naiad, pipewort and ribbonleaf pondweed (*P. epihydrus*) may be oligohaline species, while the other two pondweeds and eastern lilaeopsis may be indicative of mesohaline waters. Horned pondweed and widgeon grass may also be found in these lower salinity waters, but are more abundant at higher salinities (Arsenault 1981).

Estuarine Emergent Wetlands

Differences in salinity and tidal flooding within estuaries have a profound effect on the emergent vegetation, which is visually apparent. Plant composition markedly changes from the more saline portions to the slightly brackish areas. Even within areas of similar salinity, vegetation differs largely due to frequency and duration of tidal flooding and locally to freshwater runoff. Examples of estuarine wetland plant communities are listed in Table 15. Estuarine emergent wetlands, as defined by Cowardin and others (1979), can be further subdivided for discussion purposes into (1) salt marshes, (2) brackish marshes, and (3) oligohaline marshes.

Salt marshes

The more saline (polyhaline) reaches of estuaries are dominated by salt marshes. These estuarine wetlands are most widespread along the coast from the Atlantic Highlands and Sandy Hook to Cape May and Delaware Bay. A distinct zonal pattern exists due to tidal flooding, with two general zones identified: (1) low marsh and (2) high marsh (Figure 21).

The low marsh is flooded at least once daily by the tides. A tall form of smooth cordgrass dominates this zone from approximately mean sea level to the mean high water mark. A recent study in Connecticut found that the tall form of smooth cordgrass was an accurate indicator of the landward extent of mean high tide (Kennard, *et al.* 1983).

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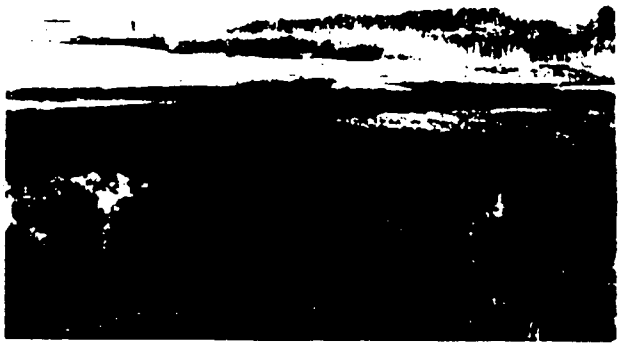

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Figure 21. Example of New Jersey salt marsh communities: (a) low marsh of smooth cordgrass (tall form) along creek and high marsh above and (b) high marsh panne (depression) dominated by glassworts.

Above this level is the high marsh which is flooded less often and is exposed for much greater periods. The high marsh may be divided into subzones based on flooding and vegetation differences (Figure 22). These zones often form a complex mosaic rather than a distinct zonal pattern (Good 1965). Plant diversity increases with several species being abundant, including a short form of smooth cordgrass, salt hay grass (*Spartina patêns*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardii*), switchgrass (*Panicum virgatum*), high-tide bush (*Iva frutescens*), and common reed (*Phragmites australis*). Other common marsh plants are sea lavender (*Limonium carolinianum* and *L. nashii*), glassworts (*Salicornia bigelovii, S. europaea* and *S. virginica*), marsh orach (*Atriplex patula*), salt marsh asters (*Aster subulatus* and *A. tenuifolius*), marsh pinks (*Sabatia dodecandra* and *S. stellaris*), sea blites (*Suaeda linearis* and *S. maritima*), spikerushes (*Eleocharis* spp.), salt marsh bulrush (*Scirpus robustus*), and seaside goldenrod (*Solidago sempervirens*). Pools and tidal creeks within the salt marshes may be vegetated with widgeon grass, sea lettuce or other algae.

The short form of smooth cordgrass forms extensive stands just above the low marsh. Within these areas, shallow depressions called pannes can be found. These pannes are subjected to extreme temperatures and salinity.

Table 15. Representative estuarine wetland plant communities in New Jersey.

Wetland Type (Halinity)	Dominance Type	Common Associates	Less Common Plants	Water Regime
Emergent (Polyhaline)	Smooth Cordgrass (tall form)	None	None	Regularly Flooded
Emergent (Polyhaline)	Smooth Cordgrass (short form)	Marsh Fleabane, Glassworts	Sea Lavender, Salt Hay Grass, Spike Grass, Marsh Orach, Perennial Salt Marsh Aster, Salt Marsh Bulrush	Irregularly Flooded
Emergent (Polyhaline)	Salt Hay Grass	Spike Grass, Smooth Cordgrass (short form)	Glasswort, Marsh Orach	Irregularly Flooded
Emergent (Polyhaline)	Switchgrass	Seaside Goldenrod, Poison Ivy	Sea Myrtle, Grass-leaved Goldenrod, Bayberry, Salt Hay Grass, Common Reed, Marsh Pink, Red Cedar	Irregularly Flooded
Scrub-Shrub (Polyhaline)	High-tide Bush	Black Grass, Spike Grass, Salt Hay Grass	Perennial Salt Marsh Aster, Seaside Goldenrod, Sea Lavender, Sea Myrtle	Irregularly Flooded
Emergent (Mesohaline)	Olney Three-square	Spike Grass, Salt Hay Grass, Marsh Fleabane	Seaside Gerardia, Rose Mallow, Perennial Salt Marsh Aster, Spikerush	Irregularly Flooded
Emergent (Mesohaline)	Smooth Cordgrass/ Big Cordgrass	None	Common Reed, High-tide Bush, Sea Myrtle	Irregularly Flooded
Emergent (Mesohaline)	Common Reed	None	Smooth Cordgrass, Spike Grass, Salt Hay Grass, Slough Grass, High-tide Bush, Goldenrods, Asters, Smartweeds, Sea Myrtle	Irregularly Flooded
Emergent (Oligohaline)	Narrow-leaved Cattail	Water Smartweed	Water Hemp, Water Parsnip, Big Cordgrass, Soft-stemmed Bulrush, Arrow Arum, Wild Rice	Irregularly Flooded
Emergent (Oligohaline)	Big Cordgrass	Bur Marigold, Common Three-square	Water Parsnip, St. John's-wort, Lowland White Aster, Royal Fern, Arrow Arum, Rice Cutgrass, Hedge Bindweed	Irregularly Flooded
Emergent (Oligohaline)	Common Three-square	Wild Rice	Smooth Cordgrass, Water Hemp, Water Smartweed, Arrow Arum, Spikerush	Regularly Flooded

Summer salinities may exceed 40 parts per thousand (Martin 1959). Although they may be devoid of plants, many pannes are colonized by the short form of smooth cordgrass, glassworts, marsh orach, salt marsh fleabane (*Pluchea purpurascens*) and saltwort (Good 1965; Martin 1959; personal observations). Blue-green algae may form dense mats in salt pannes. Pannes are particularly striking in late summer and fall, when the glassworts turn deep red in color.

Above the short cordgrass marsh, two grasses predominate: salt hay grass and spike grass. Salt hay grass often forms nearly pure stands and is probably the more abundant of the two, while spike grass is commonly intermixed. Spike grass appears to dominate in the more poorly drained areas of the high marsh. The short form of smooth cordgrass also frequently occurs in this zone. Extensive areas of salt hay grass have been diked for hay farming along Delaware Bay. Black grass, which is actually a rush, is typically found at slightly higher elevations and is often associated with high-tide bush. Many ditches and natural creeks throughout the high marsh are immediately bordered by tall or intermediate forms of smooth cordgrass, while old spoil mounds adjacent to the mosquito ditches are often colonized by high-tide bush. At the upland edge of salt marshes, switchgrass, common reed, sea myrtle (*Baccharis halimifolia*), high-tide bush, and red cedar (*Juniperus virginiana*)

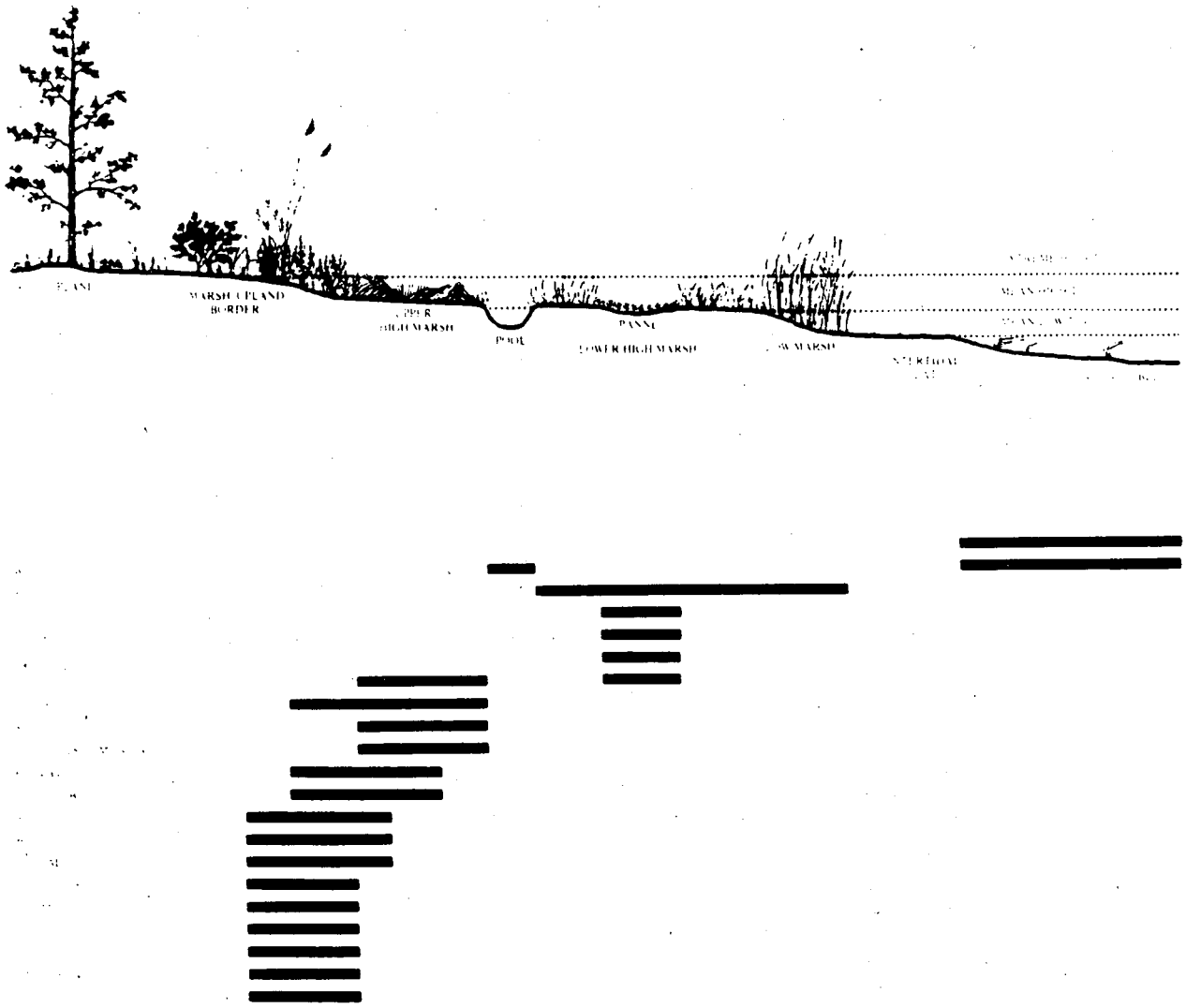

Figure 22. Generalized distribution of vegetation in New Jersey salt marsh. Note increased plant diversity along marsh-upland border.

may form the salt marsh border. Other plants have also been observed in border areas, including bayberry (*Myrica pensylvanica*), poison ivy (*Toxicodendron radicans*), seaside rose (*Rosa rugosa*), marsh fern (*Thelypteris thelypteroides*), seaside goldenrod, grass-leaved goldenrod (*Euthamia graminifolia*), foxtail grass (*Setaria geniculata*), slough grass (*Spartina pectinata*), spikerushes, marsh pink (*Sabatia stellaris*), and Canada rush (*Juncus canadensis*) (Martin 1959; Sugihara, *et al.* 1979; personal observations). Where freshwater influence from the upland is strong, narrow-leaved cattail (*Typha angustifolia*), salt marsh bulrush, three-squares (*Scirpus americanus* and *S. pungens*), marsh fern, rose mallow (*Hibiscus moscheutos*), and other brackish species may occur in abundance. In some areas along the coast (e.g., Barnegat Bay), salt marshes grade into freshwater forested wetlands.

Numerous scientific studies have been undertaken in New Jersey's salt marshes (Harshberger 1900, 1909; Martin 1959; Good 1965; Sugihara, *et al.* 1979; Ferren, *et al.* 1981 and others). In addition, the Service has reviewed the ecology of New England high salt marshes which is a useful reference (Nixon 1982).

Brackish marshes

The brackish marshes in the middle (mesohaline) reach of estuaries are exposed to the widest ranges in salinity (5 to 18 ppt), varying considerably with the seasons. In spring, these marshes are mildly brackish due to heavy river discharge, while in late summer during low freshwater flows, salt water penetrates farther upstream and the salinity of the brackish marshes approaches that of the

more saline marshes. From a vegetation standpoint, this area begins the large zone of transition where some of the common salt marsh plants like smooth cordgrass, salt hay grass, spike grass, salt marsh aster and salt marsh bulrush first mix with freshwater species, e.g., arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), jewelweed (*Impatiens capensis*), common three-square (*Scirpus pungens*), water smartweed (*Polygonum punctatum*), water parsnip (*Sium suave*), rice cutgrass (*Leersia oryzoides*), and soft-stemmed bulrush (*Scirpus validus*) (Ferren 1975; Ferren, *et al.* 1981; personal observations). Salt marsh plants are more common at downstream locations, while freshwater plants are more abundant upstream. For example, in the regularly flooded zone, smooth cordgrass is more important at higher salinities, whereas common three-square dominates at lower salinities (Ferren 1975).

At least four plants may reach their maximum abundance in New Jersey's estuarine marshes: (1) narrow-leaved cattail (Figure 23), (2) big cordgrass (*Spartina cynosuroides*), (3) common reed, and (4) Olney three-square (*Scirpus americanus* = *S. olneyi*). These plants represent the major dominance types of the mesohaline marshes and generally occupy the irregularly flooded areas. Narrow-leaved cattail and common reed also occur to a lesser extent along the banks at lower elevations. Other common brackish plants include water hemp (*Amaranthus cannabinus*), eastern lilaeopsis, salt marsh bulrush, rose mallow, salt marsh fleabane, seashore mallow (*Kosteletzkya virginica*), and mock bishopweed (*Ptilimnium capillaceum*). Mesohaline marshes are most common in southern New Jersey along large tidal rivers, such as the Maurice, the Mullica, the Great Egg Harbor and the Salem. Hog Island in the Mullica River represents an excellent example of the transition between brackish marshes and the oligohaline and salt marshes. Ferren and others (1981) commented that drastic periodic salinity changes have resulted in floristic instability on the island, particularly along the water's edge. By contrast, vegetative changes in the marsh interior are gradual, with smooth cordgrass replacing arrow arum.

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Figure 23. Mesohaline marsh in southern New Jersey. Narrow-leaved cattail predominates.

In northern New Jersey, mesohaline marshes are largely dominated by common reed and do not have the variety of plants common to the south. The Hackensack Meadowlands, for example, represents the largest mesohaline marsh complex in northern New Jersey. The salinity averages between 12 and 15 ppt, although concentrations as low as 0 to 3 ppt are not uncommon (Hackensack Meadowlands Development Commission 1975). Urban development in the New York metropolitan area has greatly stressed these wetlands through disturbances including drainage, landfills, toxic waste disposal, highway construction, industrial and residential development and air and water pollution (Figure 24). The majority of the Meadowlands is dominated by common reed which does particularly well in disturbed and degraded areas.

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Figure 24. The Hackensack Meadowlands are part of the largest estuarine wetland complex in northern New Jersey. This area has been subjected to intense urban development since the late 1800's.

In tracing the history of vegetation for the Hackensack Meadows, Sipple (1971) identified 5 estuarine marsh types: (1) common reed type, (2) smooth cordgrass-water hemp type, (3) salt hay grass-marsh orach-glasswort type, (4) narrow-leaved cattail type, and (5) salt marsh fleabane type. Common reed was ubiquitous in the area and represented the most common vegetation type. The other types were rather localized communities. Other plants found in the Meadows include big cordgrass, spike grass, salt hay grass, Olney three-square, rose mallow, annual salt marsh aster (*Aster subulatus*), seaside goldenrod, and common three-square. In low salinity tidal pools, dwarf spikerush (*Eleocharis parvula*) and soft-stemmed bulrush often occur. Smooth cordgrass dominates creek banks in higher salinity waters and is associated with big cordgrass and water hemp at lower salinities. Recent observations suggest an increase in smooth cordgrass as old dikes are breached by more saline tidal waters.

Oligohaline marshes

Only traces of ocean-derived salts characterize the uppermost (oligohaline) estuarine marshes. They are predominantly influenced by fresh water with saltwater intrusion generally restricted to late summer and most important within tidal channels. Oligohaline marshes may possess the highest diversity of all estuarine wetlands, since they lie between the strictly freshwater tidal marshes and the more brackish mesohaline wetlands. The regularly flooded zone is often dominated by nonpersistent emergents, such as arrow arum, wild rice (*Zizania aquatica*), spatterdock (*Nuphar luteum*), common three-square or pickerelweed (Ferren 1975; personal observations). Smooth cordgrass can still be found along the banks in decreasing amounts where it is intermixed with freshwater species or in monospecific clumps. Big cordgrass is common at higher elevations. Mixed plant communities typify the irregularly flooded areas. In the Mullica River, Ferren and others (1981) identified two mixed communities related to substrate differences. On peat, community dominants consisted of creeping spikerush (*Eleocharis fallax*), sedge (*Carex hormathodes*), salt hay grass, bulrushes (*Scirpus* spp.), rose mallow, and seashore mallow. Mud substrates contained a different assemblage of dominant plants: hooded arrowhead, spikerush (*Eleocharis olivacea*), umbrella sedges (*Cyperus* spp.) and marsh fleabane (*Pluchea odorata*). At the upper limits of the oligohaline reach, estuarine marshes are virtually indistinguishable from the freshwater tidal marshes with main differences being the abundance of wild rice and the absence of brackish plants like smooth cordgrass in these freshwater marshes.

Estuarine Scrub-Shrub Wetlands

Estuarine shrub wetlands are not extensive along the New Jersey coast, although some rather large stands exist in the high marsh zone of salt marshes. They are usually dominated by high-tide bush (Figure 25). This shrub is especially common along mosquito ditches where it has become established on mounds of deposited material and at higher elevations in salt marshes near the upland. Black grass and salt hay grass often grow beneath high-tide bush. Other common estuarine shrubs include sea myrtle and bayberry. These woody plants frequently grow along the upper edges of salt marshes in association with switchgrass.

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Figure 25. High-tide bush characterizes the majority of estuarine scrub-shrub wetlands in New Jersey. Red cedar trees are on higher ground.

Riverine Wetlands

The Riverine System encompasses all of New Jersey's freshwater rivers and their tributaries, including the freshwater tidal segments of the Delaware River (i.e., north of the Delaware Memorial Bridge) and other large coastal rivers where salinity is less than 0.5 ppt. This system is dominated by deepwater habitats, with wetlands occurring between the river banks and deep water (6.6 feet and greater in depth). By definition, riverine wetlands are restricted to nonpersistent emergent wetlands, aquatic beds and unvegetated shallow water or exposed areas. These wetlands are most extensive in tidal freshwater areas due to exposure of vast acreages of mudflats at low tide. The Delaware River and its tributaries contain the bulk of the State's riverine tidal marshes. Since the 1970's, these wetlands have received much attention by scientists (McCormick 1970a; McCormick and Ashbaugh 1972; Walton and Patrick 1973; Good and Good 1974; Good, *et al.* 1975; Ferren 1975; Whigham and Simpson 1975; Ferren and Schuyler 1980), while other riverine wetlands have been little studied. Recently, the vegetation of Pine Barrens streams has been investigated (Morgan, *et al.* 1983).

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Figure 26. Freshwater tidal marsh in Burlington County, New Jersey. Note flooding of spatterdock, a broad-leaved emergent plant, in the regularly flooded zone.

Riverine Tidal Wetlands

Freshwater tidal marshes exhibit a zonation pattern similar to their estuarine counterparts (Figure 26). Two

zones based on elevation and frequency of flooding are recognized: (1) low marsh and (2) high marsh. Low marsh areas are considered riverine tidal wetlands which also consist of intertidal mudflats. The low marsh is flooded at least once daily by the tides. High marsh areas are flooded less often by tides and are classified as palustrine wetlands by Cowardin and others (1979). The Service has recently reviewed the ecology of eastern tidal freshwater marshes (Odum, *et al.* 1984).

The dominant low marsh plants are nonpersistent emergents, including wild rice, spatterdock, water smartweed (*Polygonum punctatum*), bur marigold (*Bidens laevis*), broadleaf arrowhead (*Sagittaria latifolia*), water hemp, arrow arum and pickerelweed. These plants generally dominate the regularly flooded zones and intermix with persistent emergents at higher elevations to form large stands of palustrine tidal wetlands (Figure 27). Wild rice is widespread in these tidal marshes because it can germinate under a wide range of hydrologic regimes (Whigham and Simpson 1977). Pure and mixed stands of wild rice, spatterdock, and arrow arum usually characterize the majority of riverine tidal marshes (McCormick and Ashbaugh 1973; Good and Good 1974; personal observations). Pickerelweed, water smartweed, and water hemp are also dominant along tidal stream channels. Along the Mullica River, Parker's pipewort, quillwort (*Isoetes riparia*), dwarf St. John's-wort (*Hypericum mutilum*), bog rush (*Juncus pelocarpus*), and hedge hyssop (*Gratiola aurea*) have been observed on sand and gravel shores (Ferren, *et al.* 1981). Major freshwater tidal emergent wetland communities for the Hamilton Marshes in Trenton are listed in Table 16.

Vegetation is not always evident in these marshes due to the predominance of nonpersistent emergents. By definition, these plants readily decompose after the growing season and their remains are not found standing in the marshes in spring. Tidal riverine emergent wetlands, therefore, appear as mudflats during low tide in the winter and early spring. During the growing season, the visual picture or physiognomy of these wetlands changes drama-

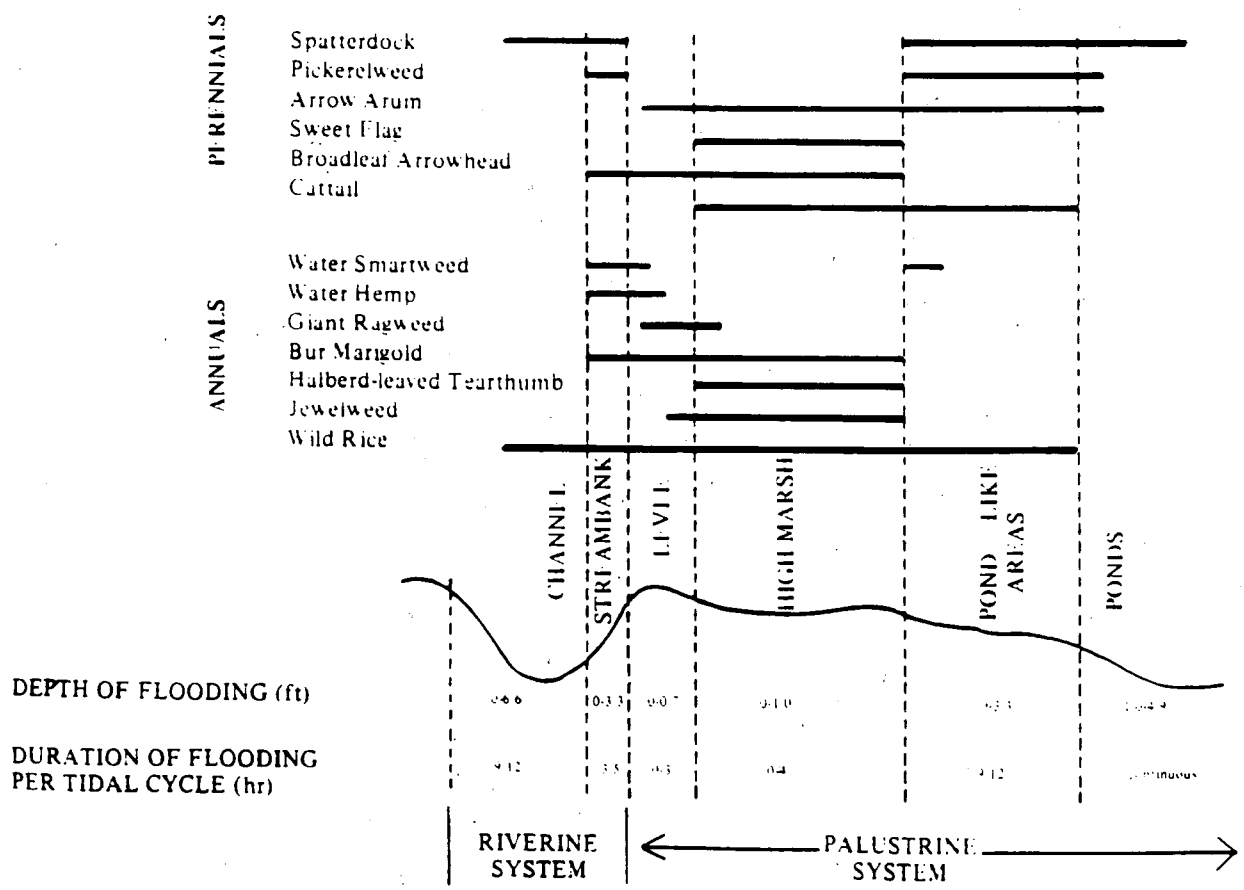

Figure 27. Generalized plant zonation in a freshwater tidal wetland (adapted from Simpson, *et al.* 1983). Note that wetland vegetation occurs in two systems - Riverine and Palustrine.

Table 16. Major freshwater tidal wetland communities in the Hamilton Marshes, Trenton, New Jersey (from Whigham and Simpson 1975). Communities have been arranged according to ecological system. Riverine communities are flooded daily by the tides, while palustrine communities are flooded less often, except for ponds that are continuously flooded.

System	Dominance Types	Associated Vegetation	Wetland Location
Riverine	Spatterdock/Wild Rice	Wild Celery, Broadleaf Arrowhead, Water Milfoil	Stream Channel
	Spatterdock/Water Hemp/ Broadleaf Arrowhead/Pickerelweed	Water Smartweed, Wild Rice	Stream Bank
	Spatterdock/Wild Rice/ Pickerelweed	Water Smartweed, Water Hemp	Stream Bank
Palustrine	Cattails/Arrow Arum/Sweet Flag	Jewelweed, Halberd-leaved Tearthumb, Arrow-leaved Tearthumb, Rose Mallow	High Marsh
	Purple Loosestrife/ Arrow Arum	Jewelweed, Rose Mallow, Tearthumbs	High Marsh
	Sweet Flag/Arrow Arum	Jewelweed, Tearthumbs	High Marsh
	Bur Marigold/Arrow Arum/Tearthumbs	Broadleaf Arrowhead, Water Hemp, Jewelweed	High Marsh
	Giant Ragweed/Arrow Arum	Jewelweed, Tearthumbs	High Marsh
	Reed Canary Grass	None specified	High Marsh
	Wild Rice/Bur Marigold/Sweet Flag/Broadleaf Arrowhead	None specified	High Marsh
	Spatterdock/Pickerelweed/Water Smartweed	Broadleaf Arrowhead, Wild Rice, Purple Loosestrife	Pond-like Area subject to tidal fluctuations (alternately flooded and exposed)
	Arrow Arum/Wild Rice	Broadleaf Arrowhead, Water Smartweed	Pond-like Area
	Purple Loosestrife	Arrow Arum, Spatterdock, Rose Mallow	Pond-like Area
	Cattails	Arrow Arum, Water Smartweed	Pond-like Area
	Rose Mallow	Purple Loosestrife, Arrow Arum, Spatterdock	Pond-like Area
	Spatterdock	Pickerelweed, Waterweed, Pondweed, Water Smartweed	Tidal Pond (permanently flooded)
	Purple Loosestrife	Spatterdock, Arrow Arum, Water Smartweed, Rose Mallow	Tidal Pond
	Rose Mallow	Spatterdock, Arrow Arum, Water Smartweed, Purple Loosestrife	Tidal Pond

tically. In mid to late April, annual seedlings cover the high marsh (R.L. Simpson, pers. comm.). By late spring and early summer, broad-leaved emergents, particularly spatterdock, arrow arum and arrowhead, dominate, since their leaves are among the first to emerge. As the season progresses, taller growing plants like water hemp, wild rice, smartweeds, jewelweed, and bur marigold become visually dominant. If, however, one looks closely a dense understory of spatterdock can often be seen (McCormick and Ashbaugh 1972). Bur marigold becomes evident in late September and early October when its large yellow flowers appear.

Riverine Nontidal Wetlands

Although the majority of the State's wetlands probably lie along nontidal rivers and streams, only a fraction of these are considered riverine wetlands according to the Service's classification system (Cowardin, *et al.* 1979). Riverine wetlands are largely restricted to fringes of nonpersistent emergent plants growing on river banks or in shallow water and to aquatic beds within the channels. Contiguous wetlands dominated by persistent vegetation (trees, shrubs, and robust emergents) are classified as palustrine wetlands (see following section for discussion).

Nontidal riverine wetlands are most visible along slow-flowing, meandering lower perennial rivers. Here nonpersistent emergent plants like burreeds, pickerelweed, arrowheads, arrow arum, cutgrasses and smartweeds colonize exposed banks or very shallow waters (Figure 28). Aquatic beds may also form in slightly deeper waters of clear rivers and streams. Important aquatic bed plants include submerged forms of burreeds and arrowheads, riverweeds and pondweeds (*Potamogeton* spp.), spatterdock and white water lily (*Nymphaea odorata*). A recent study of Pine Barrens streams (Morgan, *et al.* 1983) found these plants associated with others, such as bayonet rush (*Juncus militaris*), false loosestrife (*Ludwigia palustris*), larger water starwort (*Callitriche heterophylla*), three-way sedge (*Dulichium arundinaceum*), cardinal flower (*Lobelia cardinalis*), and Virginia meadow beauty (*Rhexia virginica*). Algae in these streams have been described by Moul and Buell (1979). In contrast, fast flowing upper perennial streams of northern New Jersey's mountains mainly support beds of aquatic weeds and mosses, e.g., *Podostemum, Fissidens, Fontinalis, and Hypnum* (Fairbrothers and Moul 1965). These plants grow on stones and boulders in the streambeds.

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Figure 28. Aquatic vegetation is present in many New Jersey streams. Here, riverine aquatic beds are bordered by palustrine wetland.

Palustrine Wetlands

The majority of New Jersey's wetlands, i.e., freshwater marshes, bogs, swamps and bottomland forests, are classified as palustrine wetlands. They represent the most floristically diverse group of wetlands in the State. Considerable vegetation change can be observed in palustrine wetlands from north to south and within regions due to differences in climate, hydrology, water chemistry (pH), soils and human disturbance. This collection of wetlands is subjected to a wider range of water regimes than wetlands of other systems. The more common water regimes include permanently flooded, semipermanently flooded, seasonally flooded, and temporarily flooded. Certain tidally influenced freshwater areas also represent palustrine wetlands. Many plants may be restricted to one or two sets of hydrologic regimes, but a great many like red maple (*Acer rubrum*), purple loosestrife (*Lythrum salicaria*) and cattails tolerate a wide range of flooding and soil saturation conditions. Woody plants as a group appear to have the widest range. Although their tolerances may be high, many wetland plants are usually more prevalent under particular water regimes and may, therefore, be used as good indicators of flooding duration and soil saturation. Examples of plant-water regime relationships are presented in Table 17. Palustrine wetland plant communities are discussed by class in the following subsections. The reader should recognize the diversity of these communities and that this discussion attempts to characterize only the major types.

Palustrine Aquatic Beds

Natural and man-made ponds are common throughout the State. These permanently flooded water bodies comprise the "wettest" of the palustrine wetlands. Many shallow ponds have aquatic beds covering all or part of their surfaces or bottoms. The aquatic beds are similar to those associated with the shallow water margins of lakes and reservoirs. Common dominance types include floating species like duckweeds; rooted vascular plants such as spatterdock, white water lily, water shield (*Brasenia schreberi*) and pondweeds; and green algae. For additional information, please refer to the discussion of lacustrine wetlands.

Palustrine Emergent Wetlands

Palustrine emergent wetlands are freshwater marshes dominated by persistent and nonpersistent grasses, rushes, sedges, forbs, and other herbaceous or grass-like plants. In general, they can be divided into two groups based on hydrology: (1) tidal emergent wetlands and (2) nontidal emergent wetlands.

Table 17. Examples of hydrophyte-water regime relationships in New Jersey's nontidal wetlands.

Water Regime	Scientific Name	Common Name	Plant Life Form
Permanently Flooded	*Vallisneria americana*	Wild Celery	Submergent
	Eriocaulon parkeri	Parker's Pipewort	Submergent and Emergent
	Nymphaea odorata	White Water Lily	Floating-leaved
	Spirodela polyrhiza	Big Duckweed	Floating
Semipermanently Flooded	*Sparganium americanum*	Burreed	Emergent
	Juncus militaris	Bayonet Rush	Emergent
	Decodon verticillatus	Water Willow	Shrubby Emergent
	Cephalanthus occidentalis	Buttonbush	Shrub
Seasonally Flooded	*Carex stricta*	Tussock Sedge	Emergent
	Symplocarpus foetidus	Skunk Cabbage	Emergent
	Typha latifolia	Broad-leaved Cattail	Emergent
	Vaccinium corymbosum	Highbush Blueberry	Shrub
	Chamaecyparis thyoides	Atlantic White Cedar	Tree
Temporarily Flooded	*Solidago* spp.	Goldenrods	Emergent
	Maianthemum canadense	Canada Mayflower	Emergent
	Kalmia angustifolia	Sheep Laurel	Shrub
	Smilax rotundifolia	Common Greenbriar	Vine
	Mitchella repens	Partridgeberry	Shrub
	Quercus palustris	Pin Oak	Tree
	Fagus grandifolia	Beech	Tree
	Carya ovata	Shagbark Hickory	Tree

Palustrine Tidal Emergent Wetlands

Palustrine emergent wetlands occur along tidal freshwater rivers and generally lie above the mean high tide mark. These emergent wetlands fall within the Palustrine System since they occur behind natural levees and often have a predominance of persistent vegetation, whereas adjacent streamside marshes of nonpersistent emergents are included in the Riverine System. Freshwater tidal wetlands are most abundant along the Delaware River and its tributaries, especially in Gloucester and Burlington Counties.

Plant diversity is greater in palustrine tidal emergent wetlands than in contiguous riverine tidal marshes. A mixed plant community usually predominates and includes narrow-leaved cattail, bur marigold, water smartweed, halberd-leaved tearthumb (*Polygonum arifolium*), arrow-leaved tearthumb (*P. sagittatum*), wild rice, broadleaf arrowhead, water hemp, sweet flag (*Acorus calamus*), and arrow arum. Wild rice also occurs in pure stands. Dodder (*Cuscuta* sp.), a plant parasite, is quite common in these wetlands (R.L. Simpson, pers. comm.). Common reed is especially abundant in disturbed areas such as near dredged material disposal sites and landfills. Giant ragweed (*Ambrosia trifida*) often grows on the natural levee between the high and low marsh and is also found on disturbed areas in and adjacent to these wetlands (McCormick 1970a; Simpson, *et al.* 1983; Sickels and Simpson 1984). Other common plants which may be locally dominant are pickerelweed, rose mallow, purple loosestrife, Walter's millet (*Echinochloa walteri*), reed canary grass (*Phalaris arundinacea*), soft-stemmed bulrush, and broad-leaved cattail (*Typha latifolia*) (McCormick and Ashbaugh 1972; Good, *et al.* 1975; Whigham and Simpson 1975; Ferren 1975; Simpson, *et al.* 1983; personal observations). In the high marsh, spatterdock and pickerelweed are dominants in ponds and pond-like areas which may be flooded from 9 to 12 hours during each tidal cycle (Simpson, *et al.* 1983). Scattered shrubs and trees, such as buttonbush (*Cephalanthus occidentalis*), willows (*Salix* spp.), swamp rose (*Rosa palustris*), and red maple, are often associated with palustrine tidal wetlands.

Palustrine Nontidal Emergent Wetlands

Freshwater emergent wetlands beyond tidal influence are about five times more abundant than the palustrine tidal marshes in New Jersey. While more common in northern areas than in the southern part of the State, freshwater marshes even occur in wet swales between dunes on coastal barrier islands.

Table 18 presents a list of dominant emergent plants in New Jersey's freshwater marshes. This list generally compares northern and southern marshes. Ubiquitous plants common to both regions include cattails, water willow (*Decodon verticillatus*), woolgrass, common reed, and purple loosestrife.

Table 18. Common dominance types for New Jersey's palustrine emergent wetlands. The asterisk (*) denotes species characteristic of the Pine Barrens.

Northern New Jersey	Southern New Jersey
Cattails	Cattails
Arrow Arum	Common Reed
Tussock Sedge	Water Willow
Rice Cutgrass	Purple Loosestrife
Water Willow	Rice Cutgrass
Reed Canary Grass	Burreeds
Spikerushes	Arrow Arum
Bluejoint	Goldenrods
Woolgrass	Woolgrass
Sedges	Soft Rush
Common Reed	Pickerelweed
Soft Rush	Smartweeds
Burreeds	Three-way Sedge
Pickerelweed	Sedges
Sweet Flag	*Twig Rush
Millet	*Bayonet Rush
Purple Loosestrife	*Canada Rush
Smartweeds	*Pipeworts
Arrowheads	*Bull Sedge
Bulrushes	*Cottongrass
Goldenrods	*Golden Club
	*Lowland Broomsedge
	*Manna Grasses
	*Beakrushes

In northern marshes, water willow, pickerelweed, arrowheads, burreeds, cattails, and soft-stemmed bulrush are common in semipermanently flooded areas. Seasonally flooded wetland dominants include cattails, tussock sedge, bluejoint, sweet flag, smartweeds, bulrushes, purple loosestrife, and arrow arum. Broad-leaved cattail and purple loosestrife are frequent co-dominants in northern New Jersey marshes. Sweet flag commonly forms nearly pure stands in depressions of wet pastures in the northern half of the State. Goldenrods (*Euthamia graminifolia* and *Solidago* spp.) and Joe-Pye-weeds (*Eupatoriadelphus purpureus* and others) often reflect drier situations of temporarily flooded emergent wetlands. Soft rush often occurs in a short form in temporarily flooded meadows, while a robust (taller) form grows in seasonally flooded areas. Reed canary grass can also be found in both temporarily flooded and seasonally flooded wetlands. Other common plants in northern emergent wetlands include jewelweed, blue flag (*Iris versicolor*), skunk cabbage (*Symplocarpus foetidus*), bugleweeds (*Lycopus* spp.), marsh fern, crowfoots (*Ranunculus* spp.), Angelica (*Angelica atropurpurea*), sensitive fern (*Onoclea sensibilis*), winter cress (*Barbarea vulgaris*), soft-stemmed bulrush, swamp milkweed (*Asclepias incarnata*), boneset (*Eupatorium perfoliatum*), asters (*Aster novae-angliae*, *A. novi-belgii*, and others), blue vervain (*Verbena hastata*), New York ironweed (*Vernonia noveboracensis*), false nettle (*Boehmeria cylindrica*), and mock bishopweed.

Shrubs are often scattered in clumps throughout marshes and found along the upland border. They include Allegheny blackberry (*Rubus allegheniensis*) and poison ivy in temporarily flooded situations and swamp rose, buttonbush, winterberry (*Ilex verticillata*), poison sumac (*Toxicodendron vernix*), highbush blueberry (*Vaccinium corymbosum*), alders (*Alnus* spp.), willows, and red maple saplings in seasonally flooded marshes. More wide ranging shrubs are meadowsweet (*Spiraea latifolia*), steeplebush (*Spiraea tomentosa*), silky dogwood (*Cornus amomum*), and southern arrowwood (*Viburnum dentatum*). Examples of northern marsh communities are shown in Figure 29.

Freshwater marshes in the Pine Barrens of southern New Jersey are quite different from marshes in the rest of the State (Figure 30). The acid waters of Pine Barrens streams create conditions that favor colonization by other plants. Here, dominant emergents consist of bayonet rush, wild rice, bull sedge (*Carex bullata*), pipeworts (*Eriocaulon* spp.), Canada rush, twig rush (*Cladium mariscoides*), cottongrass (*Eriophorum virginicum*), golden club (*Orontium aquaticum*), manna grass (*Glyceria obtusa*), coast sedge (*Carex exilis*), Virginia meadow beauty, three-way sedge, beakrushes (*Rhynchospora alba* and others), redroot (*Lachnanthes caroliniana*), lowland broomsedge (*Andropogon virginicus* var. *abbreviatus*), and twisted yellow-eyed grass (*Xyris torta*) (Olsson 1979; personal observations). Other common plants include sundews (*Drosera* spp.), panic grass (*Panicum* spp.), shortleaf milkwort (*Polygala brevifolia*), peat mosses (*Sphagnum* spp.), wild oat grass (*Danthonia sericea* var. *epilis*), bog aster (*Aster nemoralis*), toothleaf flatsedge (*Cyperus dentatus*), bog rush (*Juncus pelocarpus*), forked rush (*J. dichotomus*), rice cutgrass, eastern burreed (*Sparganium americanum*), woolgrass, pickerelweed, spikerushes, St. John's-worts (*Triadenum virginicum* and *Hypericum* spp.), bladderworts (*Utricularia* spp.), and orchids (e.g., *Platanthera blephariglottis*). Less common plants in seasonally flooded "savannas" include purple pitcher plant (*Sarracenia purpurea*), bog asphodel (*Narthecium americanum*), slender blue flag (*Iris prismatica*), gold-crest (*Lophiola americana*), false asphodel (*Tofieldia racemosa*), royal fern (*Osmunda regalis*), Bartonia (*Bartonia virginica*), twisted yellow-eyed grass, and ten-angled pipewort (*Eriocaulon decangulare*) (Harshberger 1916; Olsson 1979). Dense St. John's-wort (*Hypericum densiflorum*) is abundant in these areas, while big cranberry (*Vaccinium macrocarpon*) may be locally common. In temporarily flooded "savannas", scattered pitch pine (*Pinus rigida*) and clumps of inkberry (*Ilex glabra*), bayberry, sheep laurel (*Kalmia angustifolia*), fetterbush (*Leucothoe racemosa*), red chokeberry (*Aronia arbutifolia*), black chokeberry (*A. melanocarpa*), witherod (*Viburnum cassinoides*) and leatherleaf (*Chamaedaphne calyculata*) may be found (Harshberger 1916). According to McCormick (1979), Pine Barrens savannas are not as extensive as they were at the turn of the century,

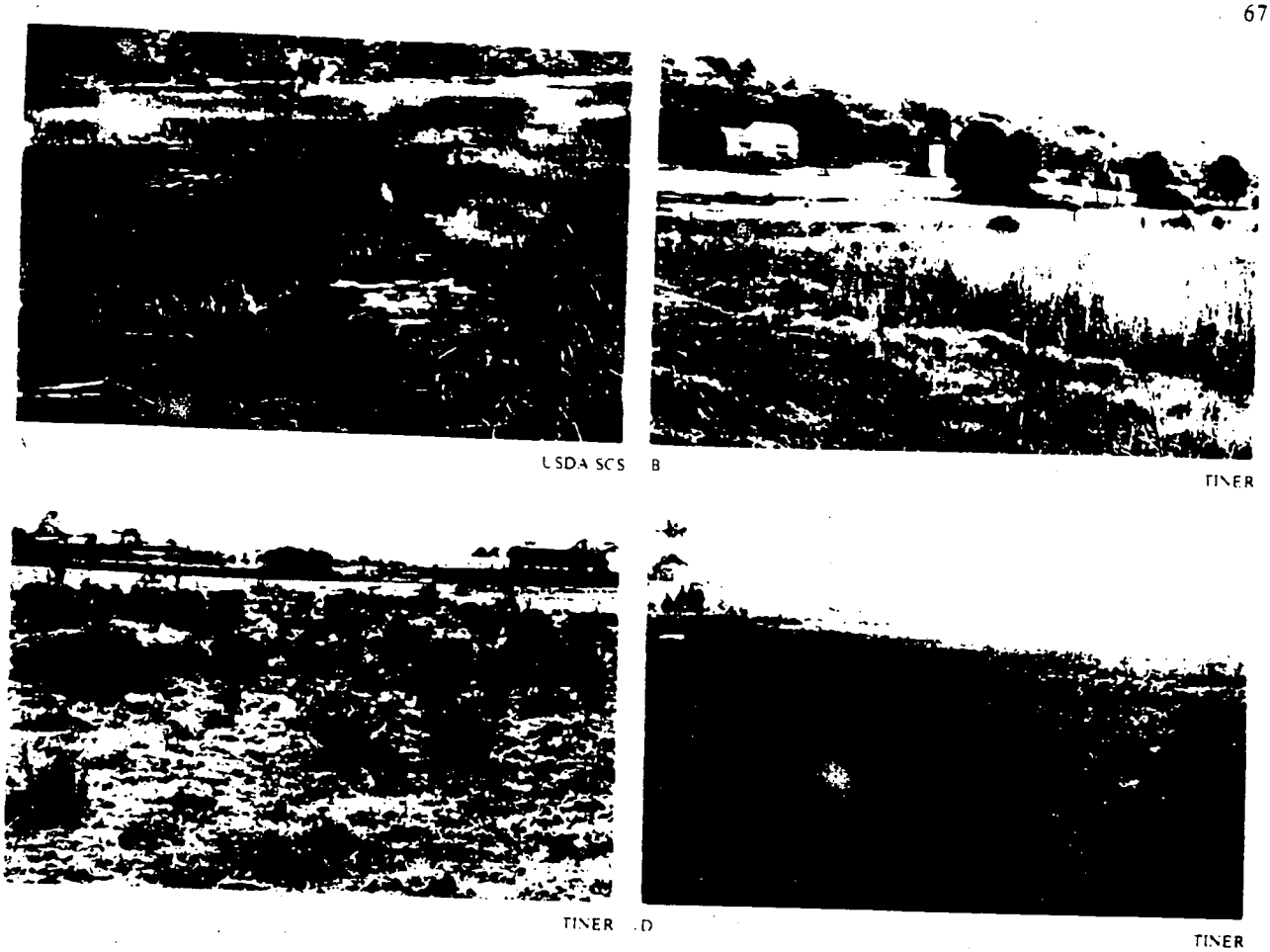

Figure 29. Examples of palustrine emergent wetlands in northern New Jersey: (a) burreed marsh, (b) broad-leaved cattail marsh, (c) soft rush-dominated wet meadow, and (d) tussock sedge meadow, with cattail marsh.

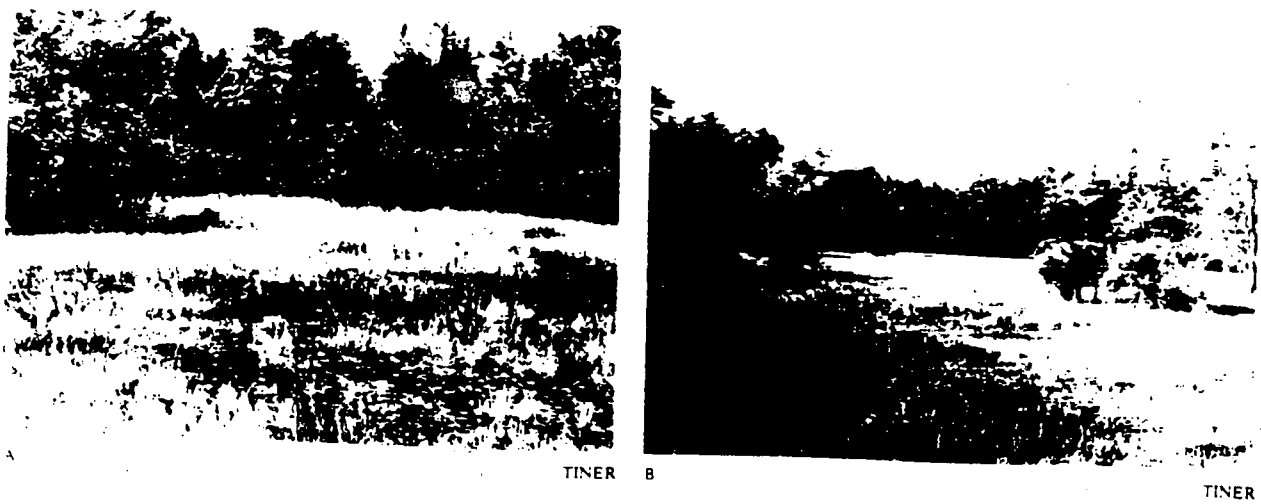

Figure 30. Examples of palustrine emergent wetlands in southern New Jersey: (a) mixed emergents with aquatic bed and (b) spikerush marsh, with grasses and highbush blueberry.

with less than 1000 acres remaining. Today, shrub thickets of leatherleaf and highbush blueberry and maple-gum or white cedar swamps have replaced many former savannas.

Outside of the Pine Barrens in southern New Jersey, emergent wetlands are dominated by rice cutgrass, cattails, soft rush, water willow, burreeds, purple loosestrife, common reed, woolgrass, and others. Common emergent plants include pickerelweed, arrow arum, St. John's-worts, bedstraw (*Galium* sp.), tussock sedge, other sedges, smartweeds, blue flag, foxtail grass, soft-stemmed bulrush, jewelweed, swamp milkweed, boneset, three-way sedge, arrowheads, tearthumbs, and beggar-ticks. Shrubs and low trees may also be present, such as buttonbush, arrowwood, common elderberry (*Sambucus canadensis*), sweet gum (*Liquidambar styraciflua*), and red maple.

On coastal islands, other types of palustrine emergent wetlands are found. Where natural primary and secondary dunes have survived development, freshwater marshes exist in wet swales between the dunes. Martin (1959) observed three major communities on Island Beach State Park: (1) broad-leaved cattail dominance type, (2) marsh fern dominance type, and (3) rose mallow dominance type. Minor communities were dominated by swamp milkweed, flat sedge, and salt marsh hay. Numerous mixed communities were also reported. Harshberger (1900) also noted the high variability between different interdunal wetlands. Other common plants included lowland broomsedge, sedges, umbrella sedges (*Cyperus filicinus* and *C. grayii*), spikerush (*Eleocharis erythropoda*), thoroughwort (*Eupatorium album*), marsh St. John's-wort (*Triadenum virginicum*), Canada rush, soft rush, evening primrose (*Oenothera perennis*), cinnamon fern, royal fern, reed, Pennsylvania smartweed (*Polygonum pensylvanicum*), and common three-square (Small and Martin 1958). Common reed-dominated marshes are extensive, particularly where former salt marshes were cut off from tidal influence by dikes and roadways. Many of them have evidence of relict salt marsh species such as salt marsh hay, black grass, sea myrtle, marsh orach, and switchgrass, yet strictly freshwater plants including common elderberry, red maple, willows, horsetails (*Equisetum* spp.), nightshade (*Solanum dulcamara*), poison ivy, swamp rose and water primrose (*Ludwigia decurrens*) may also occur.

Palustrine Scrub-Shrub Wetlands

Palustrine scrub-shrub wetlands are shrub swamps dominated by woody vegetation less than 20 feet (6m) in height. The dominant shrubs in northern New Jersey include speckled alder (*Alnus rugosa*), smooth alder (*A. serrulata*), willows (*Salix sericea* and others), buttonbush, silky dogwood, northern arrowwood (*Viburnum recognitum*), southern arrowwood, meadowsweet, steeplebush, highbush blueberry, swamp rose, Allegheny blackberry, and sapling red maple. Other important shrubs in this area are sweet pepperbush (*Clethra alnifolia*), swamp azalea (*Rhododendron viscosum*), winterberry (*Ilex verticillata*), poison sumac, red osier dogwood (*Cornus stolonifera*), poison ivy, and maleberry (*Lyonia ligustrina*). Sweet gale (*Myrica gale*) and mountain holly (*Nemopanthus mucronata*) may be common locally in the northwestern corner of the State as observed in High Point State Park by Niering (1953).

In the southern region, red maple, southern arrowwood and high bush blueberry are still common dominants, but other woody plants often predominate in shrub wetlands including bayberry (on barrier islands), leatherleaf, staggerbush (*Lyonia mariana*), sweet pepperbush, swamp azalea, shrubby St. John's-wort, sheep laurel, dangleberry (*Gaylussacia frondosa*), dwarf huckleberry (*Gaylussacia dumosa*), fetterbush, big cranberry, and sapling trees of pitch pine, Atlantic white cedar (*Chamaecyparis thyoides*), and gray birch (*Betula populifolia*). Other shrubs of local importance are inkberry, chokeberries, withe-rod, possum haw (*Viburnum nudum*), and smooth alder. Examples of the community structure of scrub-shrub wetlands are shown in Table 19.

The wettest shrub wetlands may be dominated by buttonbush in the north and by leatherleaf and dense St. John's-wort in the south. Buttonbush is characteristic of semipermanently flooded wetlands and the wettest seasonally flooded ones. It is also found in freshwater tidal wetlands along the coastal plain, where it is often intermixed with emergent vegetation. Leatherleaf tends to predominate in southern shrub bogs which are seasonally flooded and saturated throughout the year, while it is much less common in northern New Jersey (Figure 31). It also grows along the margins of many ponds in the Pine Barrens and occurs with sedges in savannas (McCormick 1970b). Dense St. John's-wort is also common in these wet savannas (Harshberger 1916).

Other seasonally flooded shrub swamps throughout the State may be characterized by highbush blueberry (Figure 32) and sapling red maple or by alders and willows in northern New Jersey or by Atlantic white cedar, staggerbush, big cranberry and others in the south. Common associates in northern areas include bluejoint, purple loosestrife, soft rush, tussock sedge and other sedges, broad-leaved cattail, marsh fern, arrow arum, rice cutgrass, rose mallow, reed canary grass, arrow-leaved tearthumb, and peat mosses. Further south, sedges, soft rush, arrow arum, peat mosses and marsh fern remain common, but other plants become increasingly important in shrub swamps. They include woolgrass, chain ferns (*Woodwardia* spp.), lowland broomsedge, spikerushes, cinnamon fern (*Osmunda cinnamomea*), royal fern, bayonet rush, three-way sedge, cottongrass, sundews (*Drosera* spp.),

Table 19. Examples of palustrine scrub-shrub wetland communities in New Jersey.

Dominance Type (Water Regime)	Associated Vegetation		Location
Buttonbush (Semipermanently Flooded)	Shrubs:	Steeplebush, Red Maple	Morris County
	Herbs:	Arrow Arum, Soft Rush, Woolgrass, Blue Flag, St. John's-wort, Tussock Sedge, False Nettle, Arrow-leaved Tearthumb	
	Others:	Duckweed	
Red Maple (Seasonally Flooded)	Shrubs:	Steeplebush, Highbush Blueberry, Smooth Alder, Poison Sumac, Gray Birch, Maleberry, Black Chokeberry, Southern Arrowwood	Passaic County
	Herbs:	Marsh Fern, Cinnamon Fern, Tussock Sedge, Boneset, Sweet Flag, Marsh St. John's-wort, Sweet White Violet, Sensitive Fern	
	Others:	Peat Moss and other mosses	
Highbush Blueberry/ Swamp Azalea/ Sweet Pepperbush (Seasonally Flooded)	Shrubs:	Red Maple	Morris County
	Herbs:	Arrow Arum, St. John's-wort, Tussock Sedge	
	Others:	Peat Moss	
Smooth Alder (Seasonally Flooded)	Shrubs:	Red Maple, Swamp Rose, Willow, American Elm, Silky Dogwood, Cherry, Arrowwood	Sussex County
	Herbs:	Sweet Flag, Skunk Cabbage, Sensitive Fern, Manna Grass, Spikerush, Blue Flag, Mint	
Silky Dogwood (Seasonally Flooded)	Herbs:	Rice Cutgrass, Arrow-leaved Tearthumb, Thoroughwort	Union County
Red Maple (Seasonally Flooded)	Shrubs:	Southern Arrowwood, Silky Dogwood, Alder, Willow, Highbush Blueberry, Poison Sumac	Monmouth County
	Herbs:	Jewelweed, Boneset, Sensitive Fern, Tussock Sedge, Broad-leaved Cattail, Woolgrass, Seed-box, Spotted Joe-Pye-weed, Smartweed, Marsh Fern, Goldenrod, Arrow-leaved Tearthumb	
	Others:	Climbing Hempweed	
Red Maple (Seasonally Flooded)	Shrubs:	Dangleberry, Sheep Laurel, Leatherleaf, Big Cranberry, Sweet Bay, Bayberry, Serviceberry	Burlington County
	Herbs:	Cinnamon Fern, Sedges, Virginia Cottongrass, Soft Rush, Thoroughwort, Spikerush, Arethusa	
	Others:	White Water Lily, Bladderwort	
Highbush Blueberry/ Sheep Laurel (Seasonally Flooded)	Trees:	Red Maple	Burlington County
	Shrubs:	Pitch Pine, Inkberry, Wintergreen, Big Cranberry	
	Herbs:	Woolgrass, Bracken Fern, Aster	
	Others:	Peat Moss, Haircap Moss	
Leatherleaf (Saturated)	Trees:	Pitch Pine, Red Maple	Burlington County
	Shrubs:	Highbush Blueberry, Inkberry	
	Herbs:	Virginia Chain Fern	
	Others:	Peat Moss	
Pitch Pine/Sheep Laurel/ Atlantic White Cedar (Saturated)	Shrubs:	Highbush Blueberry, Swamp Azalea	Ocean County
	Others:	Greenbriar	

TINER

Figure 31. Leatherleaf wetland in southern New Jersey. Saplings of Atlantic white cedar are growing along the edge of this scrub-shrub wetland.

FWS

Figure 32. Highbush blueberry is abundant throughout the State.

and St. John's-worts. These plants, which may dominate emergent wetlands, are especially abundant in mixed shrub-emergent wetlands.

Jervis (1963) described a mixed wetland type in northern New Jersey as the "sedge-shrub community." Here, shrubs like red maple, alder, buttonbush, swamp rose, steeplebush and silky dogwood had colonized the tussocks of the tussock sedge. Tiner (1980) also observed mixed emergent and shrub wetlands in the Passaic River Basin. Composition of these communities was quite variable, although red maple saplings with tussock sedge, purple loosestrife or bluejoint were most common. Other communities were well-mixed with numerous shrubs and herbs, including alders, dogwoods, willows, common elderberry, swamp rose, red maple, steeplebush, meadowsweet, poison sumac, southern arrowwood, tussock sedge, cattail, marsh fern, tearthumbs, sensitive fern, asters, St. John's-worts, cinnamon fern, soft rush, goldenrods, bluejoint, woolgrass, New York ironweed, fringed loosestrife (*Lysimachia ciliata*), blue flag, reed canary grass, purple loosestrife, horsetail, sedges, crowfoots, mints (*Mentha* spp.), wild millet (*Echinochloa* spp.) and blue vervain.

Olsson (1979) described several shrub wetland communities of the Pine Barrens, while Montgomery and Fairbrothers (1963) compared a northern New Jersey

sphagnum bog with one from the Pine Barrens. The southern bog (Bennett Bog, 149 species) had much higher plant diversity than the northern bog (Utterton Bog, 43 species). Interestingly, only 9 plants, including sweet pepperbush, swamp azalea, red maple, highbush blueberry and big cranberry, were common to both areas. These data confirmed claims that boreal plants near their southern range limit may be restricted to northern New Jersey bogs, while Pine Barrens bogs possessed southern species which have reached their northern limit.

Niering (1953) studied a leatherleaf-dominated northern bog in Sussex County. Associated shrubs included bog rosemary (*Andromeda glaucophylla*), bog laurel (*Kalmia polifolia*), sheep laurel, and big cranberry. Small trees of black spruce (*Picea mariana*) and larch (*Larix laricina*) were scattered on the bog mat. Rigg (1940) compared New Jersey shrub bogs with others in the United States.

In the northern half of the State, silky dogwood, meadowsweet, steeplebush, and Allegheny blackberry may reach their maximum abundance in temporarily flooded wetlands. Their southern counterparts are sheep laurel and pitch pine saplings.

Van Wechten and Buell (1959) found Allegheny blackberry, common elderberry, multiflora rose (*Rosa multiflora*) and silky dogwood on temporarily flooded floodplains of the Millstone River. Jervis (1963) reported a similar shrub wetland having a mixture of meadowsweet, steeplebush, Allegheny blackberry, silky dogwood, and goldenrods from Troy Meadows in Morris County.

Shrub wetlands are also present on barrier islands. Here, common shrubs are highbush blueberry, bayberry, big cranberry, and sea myrtle. Representative plant communities have been described by Martin (1959). All of these communities lie in depressions between sand dunes where the water table is near the surface. The highbush blueberry and bayberry communities are probably the most common types. Common associates within blueberry wetlands are poison ivy, sheep laurel, and common greenbriar (*Smilax rotundifolia*), while less abundant plants include bayberry, Canada serviceberry (*Amelanchier canadensis*), swamp rose, marsh fern, cinnamon fern, and royal fern.

Palustrine Forested Wetlands

Palustrine forested wetland is the most abundant and widely distributed wetland type in the State. Most swamps lie along rivers and streams and in upland depressions, while some border salt marshes in coastal areas. Forested wetlands are characterized by the presence of woody vegetation taller than 20 feet (6m). Figure 33 shows examples of these wetlands.

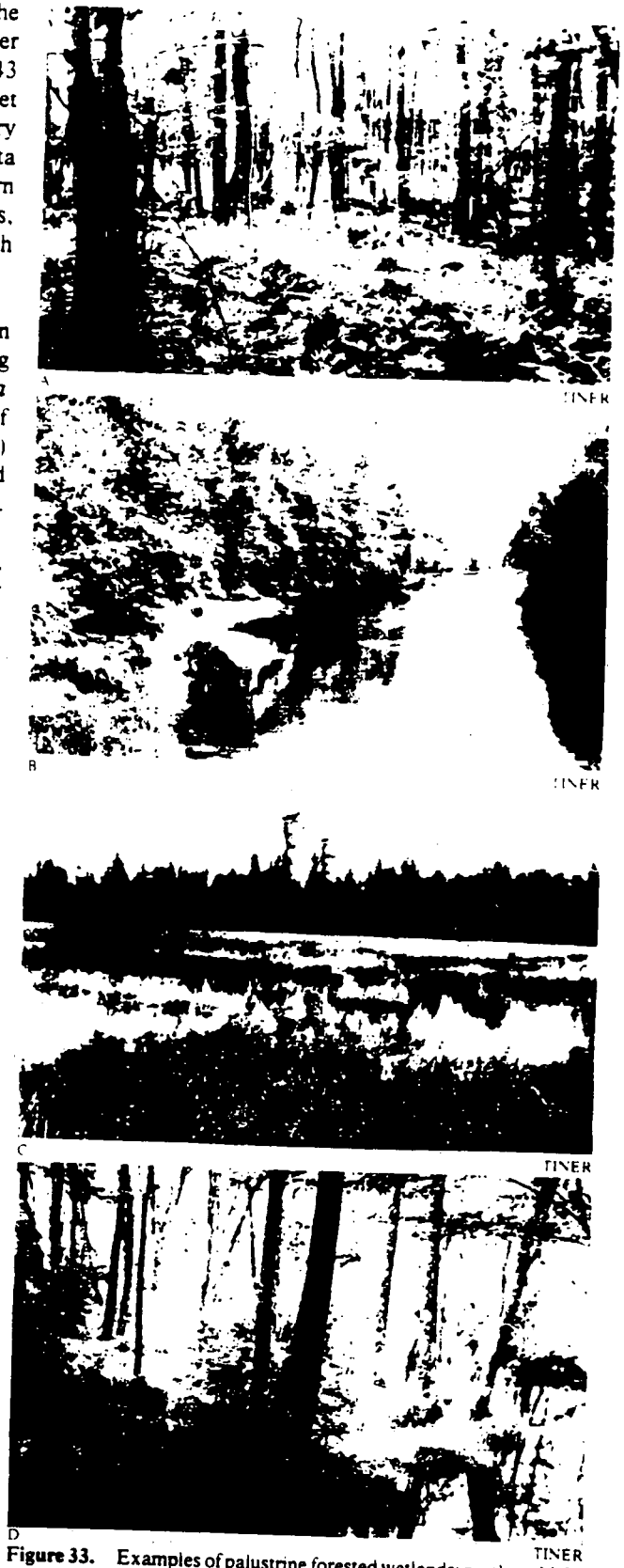

Figure 33. Examples of palustrine forested wetlands: northern N.J. (a) red maple swamp and (b) silver maple floodplain wetland: southern N.J. (c) Atlantic white cedar swamp (background) and (d) red maple swamp.

New Jersey's forested wetlands have received much attention from botanists and ecologists. Most studies have been conducted in the Pine Barrens (Stone 1911; Harshberger 1916; Little 1950, 1951; Bernard 1963; McCormick 1955, 1970b, 1979; Givnish 1971; Olsson 1979; Ehrenfeld and Gulick 1981; Ehrenfeld 1983). Considerable work has also centered on the floodplains of central and northern New Jersey (Buell and Wistendahl 1955; Wistendahl 1958; Van Vechten and Buell 1959; Jervis 1963; Buchholz 1981). Few studies, however, relate to northern forested wetlands (Heusser 1949; Niering 1953; Tiner 1980). General differences between northern and southern forested wetlands were reported by Robichaud and Buell (1973). Wetland communities are extremely diverse and complex and vary widely with changes in local characteristics.

Forested Wetlands of Northern New Jersey

The vast majority of wooded swamps in northern New Jersey are deciduous forested wetlands, with evergreen forested wetlands generally restricted to the northernmost areas, especially Sussex County. Red maple swamps are the predominant wetland type in this part of the State. In many instances, other trees are often intermixed and may appear as co-dominants in certain wetlands. These trees include white ash (*Fraxinus americana*), silver maple (*Acer saccharinum*), pin oak (*Quercus palustris*), black willow (*Salix nigra*), sycamore (*Platanus accidentalis*) and sweet gum. Less dominant trees which may be locally abundant are slippery elm (*Ulmus rubra*), American elm (*Ulmus americana*), black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), swamp white oak (*Querus bicolor*), ironwood (*Carpinus caroliniana*), gray birch, and yellow birch (*Betula alleghaniensis*). Conifers like larch, black spruce, hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*) are rather limited in their distribution and abundance.

Although red maple dominates the majority of forested wetlands, differences in plant community structure exist between individual wetlands due to factors such as soil type, water regime and historical land-use practices (Table 20). In most wetlands, other trees are found in varying numbers with red maple, often near the edges of the swamp. Robichaud and Buell (1973) observed that yellow birch was the prime associate of red maple in northern New Jersey swamps, while in central New Jersey, yellow birch was generally replaced by elm, pin oak, swamp white oak, and silver maple. These trees join black gum, ash, and red maple as the most common wetland trees. A shrub understory characterizes red maple swamps, with several species important: highbush blueberry, swamp azalea, winterberry, spicebush (*Lindera benzoin*), silky dogwood, and alders. Spicebush is very abundant in forested wetlands of the Piedmont region (Robichaud and Buell 1973) and its yellow blossoms are evident in early spring. Snowberry (*Symphoricarpos albus*) appears to be associated with the drier (temporarily flooded) red maple swamps. Numerous emergents form the herbaceous stratum of forested wetlands. Some of the more common emergents are skunk cabbage, jewelweed, marsh marigold (*Caltha palustris*), clearweed (*Pilea pumila*), false hellebore (*Veratrum viride*), tussock sedge, other sedges, asters, bugleweeds, beggar-ticks, smartweeds and tearthumbs, jack-in-the-pulpit (*Arisaema triphyllum*), goldenrods, false nettle, spring beauty (*Claytonia virginica*), cinnamon fern, royal fern, and sensitive fern. With long periods of soil saturation and surface water ponding, peat mosses often form dense mats on the forest floor. In general, many red maple swamps are flooded for long periods early in the growing season, while the soil remains saturated for most of the year. They represent the wettest of the forested wetlands in northern New Jersey.

Niering (1953) described a red maple-yellow birch swamp in Sussex County. Associated trees included black ash (*Fraxinus nigra*), white ash, basswood (*Tilia americana*), tulip tree (*Liriodendron tulipifera*), ironwood and hop-hornbean (*Ostrya virginiana*). Important shrubs were highbush blueberry, southern arrowwood, and nannyberry (*Viburnum lentago*). Cinnamon fern, tussock sedge and skunk cabbage were abundant, as was peat moss in wetter depressions. Other swamps were dominated by red maple and black gum, with white pine or hemlock sparsely intermixed. Common shrubs included highbush blueberry, swamp azalea, alders, and gray birch.

The driest (temporarily flooded) of the forested wetlands are represented by red maple, pin oak, sweet gum, white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), swamp white oak, ironwood and beech (*Fagus grandifolia*, probably var. *caroliniana*). Several shrubs forming the shrub understory include spicebush, highbush blueberry, southern arrowwood, snowberry, Japanese honeysuckle (*Lonicera japonica*), and brambles (*Rubus* sp.). Greenbriar (*Smilax* sp.) is also common. Canada mayflower (*Maianthemum canadense*) and trout lily (*Erythronium umbilicatum*) are locally abundant in these wetlands, while other emergents include may apple (*Podophyllum peltatum*), false nettle, sedges, wild garlic (*Allium* spp.), avens (*Geum* spp.), spinulose shield fern (*Dryopteris spinulosa*), and clubmosses (*Lycopodium* spp.). Haircap moss (*Polytrichum* spp.) and partridgeberry (*Mitchella repens*) may occur in scattered patches on the ground. These wetlands have a seasonal high water table and may be flooded annually for short periods early in the growing season. Infrequent flooding or surface water ponding may be observed after snow melt, spring rains, heavy summer storms or during the winter.

Forested wetlands often border major rivers and streams. They occur on the low-lying inner floodplain behind natural levees. Microrelief determines the duration of

flooding which affects plant community composition. The lowest areas are seasonally flooded, while slightly higher levels are only temporarily flooded. A mixed forest community characterizes these wetlands. Important trees include silver maple, white ash, sycamore, red maple, pin oak, swamp white oak, black willow, elms, black gum, box elder (*Acer negundo*), basswood, ironwood, and river birch (*Betula nigra*). Wistendahl (1958) found 17 tree species in Raritan River floodplain wetlands. Bitternut (*Carya cordiformis*), beech, and red oak (*Quercus rubra*) were among these trees. He described the inner floodplain as a series of shallow sloughs forming a network of low areas and noticed that trees did not grow in the slough itself, with the exception of box elder and river birch. Numerous shrubs comprised a shrub understory, with spicebush, snowberry, meadowsweet, alder, silky dogwood, barberry (*Berberis thunbergii*), and poison ivy being common. Spicebush was the dominant shrub along the Raritan River (Buell and Wistendahl 1955; Wistendahl 1958). Typical floodplain emergents on the wetland floor included avens, goldenrods, asters, rice cutgrass, reed canary grass, wood nettle (*Laportea canadensis*), wood reed (*Cinna arundinacea*), clearweed, jewelweed, violets (*Viola* spp.), Virginia smartweed (*Polygonum virginianum*), false nettle, smartweeds, and beggar-ticks. Common vines were poison ivy, Japanese honeysuckle, wild grape (*Vitis* spp.), Virginia creeper (*Parthenocissus quinquefolia*), and bittersweet (*Celastrus scandens*).

Evergreen forested wetlands are of minor importance in northern New Jersey being limited to the northernmost areas. Sussex County possesses most of these wetlands. Niering (1953) described a mixed hemlock-red maple swamp. Other important trees were Atlantic white cedar, yellow birch, black spruce and black gum. He noted that the oldest hemlocks and cedars were 90 and 140 years old, respectively. Rose bay (*Rhododendron maximum*) formed dense thickets in heavily shaded areas. Other shrubs were smooth winterberry (*Ilex laevigata*), winterberry, mountain holly, highbush blueberry, and smooth alder. In more open areas, swamp azalea, speckled alder and spicebush occurred. Herbs were widely scattered, with cinnamon fern, wild calla (*Calla palustris*) and skunk cabbage being most common. Belling (1977) found white pine, hemlock, black gum, red maple, and larch associated with Atlantic white cedar in southeastern New York.

Forested Wetlands of Southern New Jersey

Three types of forested wetlands are prevalent in southern New Jersey: (1) hardwood swamps, (2) Atlantic white cedar swamps, and (3) pitch pine lowland forests. Forested floodplain wetlands also occur along Inner Coastal Plain rivers. Soil type and water regime were reported by Bernard (1963) as the most important factors influencing vegetation in southern New Jersey. Human activities, particularly timber cutting, and natural events such as fire have played an important role in shaping the vegetation of the Pine Barrens (McCormick 1979). Table 21 presents examples of forested wetland communities in southern New Jersey.

Hardwood swamps are the most abundant forested wetland type. As in the north, red maple dominates most of these wetlands. Black gum and sweet gum are frequent co-dominants or locally dominant. Common associate trees in wetter swamps include sweet bay (*Magnolia virginiana*), Atlantic white cedar, and ash. Tulip tree, American holly (*Ilex opaca*), sassafras (*Sassafras albidum*), gray birch and willow oak (*Quercus phellos*) are frequently found at drier sites. Pitch pine is widely distributed ranging from seasonally flooded to temporarily flooded swamps (Ledig and Little 1979). Robichaud and Buell (1973) noted that sweet gum and tulip trees become more dominant in southernmost areas. Loblolly pine (*Pinus taeda*) was found in a Cape May County wetland by Bernard (1963). This may represent the northernmost location for this species. The shrub understory of hardwood swamps is often a dense thicket of sweet pepperbush, highbush blueberry, swamp azalea, fetterbush, black huckleberry (*Gaylussacia baccata*), dangleberry, and southern arrowwood. Other important shrubs are leatherleaf, inkberry, spicebush, smooth alder, other blueberries (*Vaccinium pallidum*), winterberry, staggerbush, maleberry, serviceberries (*Amelanchier* spp.), chokeberries, and sheep laurel. Mountain laurel (*Kalmia latifolia*) and bayberry are infrequently associated with drier forested wetlands. When a dense shrub understory exists, emergent plants are scarce. In most wetter swamps, emergents include tussock sedge, rice cutgrass, skunk cabbage, beggar-ticks, cinnamon fern, royal fern, arrow-leaved tearthumb, St. John's-worts, and three-way sedge. Peat mosses are scattered in patches on the forest floor in these wetlands. Drier swamps have goldenrods, Joe-Pye-weeds, white grass (*Leersia virginica*), meadow rue (*Thalictrum* sp.), and bracken fern (*Pteridium aquilinum*). Sensitive fern, chain ferns, jewelweed, bedstraws, and false nettle occur under variable water regimes. Common greenbriar is particulary common in the drier wetlands. It is also generally limited to the edges of wetter swamps, while bamboo-vine (*Smilax laurifolia*) occurs frequently in the swamp interior. Other important vines in forested wetlands are poison ivy, Virginia creeper, Japanese honeysuckle, wild grape, and trumpet creeper (*Campsis radicans*). Bernard (1963) described several hardwood swamp communities for Cape May County, while Ehrenfeld and Gulick (1981) examined tree and shrub strata in Pine Barrens swamps. Plant community differences between swamps in disturbed and undisturbed areas are discussed by Ehrenfeld (1983). Minor vegetation associated with Pine Barrens swamps has also been described (Little 1951). Other significant studies include Harshberger (1916), McCormick (1955, 1970b, 1979) and Olsson (1979).

Table 21. Examples of palustrine forested wetlands in southern New Jersey.

Dominance Type (Water Regime)	Associated Vegetation	Location
Red Maple (Seasonally Flooded)	Trees: Sweet Bay, Black Gum Shrubs: Southern Arrowwood, Brambles, Serviceberry, Winterberry Herbs: Cinnamon Fern, Thoroughwort, Grasses	Mercer County
Red Maple/Sweet Gum (Seasonally Flooded)	Trees: River Birch, American Holly Shrubs: Southern Arrowwood, Sweet Pepperbush Herbs: Sensitive Fern, Arrow-leaved Tearthumb, Smartweeds, Rice Cutgrass, Bedstraw, Jewelweed, St. John's-wort, Arrow Arum, Spotted Joe-Pye-weed, False Nettle	Cumberland County
Atlantic White Cedar (Seasonally Flooded)	Trees: Black Gum Shrubs: Fetterbush, Highbush Blueberry, Swamp Azalea, Red Maple, Alder, Sweet Pepperbush, Dangleberry, Big Cranberry Herbs: Smartweed, Arrow Arum, Virginia Cottongrass, Sedges, Spatulate-leaved Sundew Others: Peat Moss and other mosses	Ocean County
Atlantic White Cedar/ Red Maple (Seasonally Flooded)	Trees: None Shrubs: Southern Arrowwood, Swamp Rose, Sweet Pepperbush, Bayberry, Winterberry, Swamp Azalea Others: Poison Ivy	Burlington County
Pitch Pine (Seasonally Flooded)	Trees: Red Maple, Atlantic White Cedar, Sweet Bay Shrubs: Maleberry, Swamp Azalea, Sweet Pepperbush, Highbush Blueberry Herbs: Cinnamon Fern Others: Peat Moss	Atlantic County
Red Maple (Temporarily Flooded)	Trees: Black Gum Shrubs: Sweet Pepperbush, Southern Arrowwood, Spicebush, Japanese Honeysuckle, Swamp Azalea, Elderberry Herbs: Jewelweed, Spotted Joe-Pye-weed, Sensitive Fern, New York Fern, Smartweed, White Grass, Royal Fern, Cinnamon Fern Others: Greenbriar, Poison Ivy	Camden County
Red Maple (Temporarily Flooded)	Trees: Sweet Bay, Sweet Gum, White Oak, Red Oak Shrubs: American Holly, Sweet Pepperbush, Southern Arrowwood Herbs: Cinnamon Fern Others: Poison Ivy, Greenbriar	Cape May County
White Oak Sweet Gum (Temporarily Flooded)	Trees: Red Maple, Black Cherry, Beech, Sassafras, Ironwood, Swamp White Oak, Pin Oak, Shagbark Hickory Shrubs: Highbush Blueberry, Southern Arrowwood, Huckleberry Herbs: Sedges, Wrinkled Goldenrod, Canada Mayflower	Mercer County
Pitch Pine (Temporarily Flooded)	Trees: Sassafras, Gray Birch, Red Maple Shrubs: Highbush Blueberry, Sweet Pepperbush Herbs: Virginia Chain Fern Others: Common Greenbriar	Gloucester County
Pitch Pine/Black Gum/ Red Maple (Temporarily Flooded)	Trees: Sweet Bay, Gray Birch Shrubs: Sweet Pepperbush, Highbush Blueberry, Sheep Laurel, Swamp Azalea, Inkberry, Common Winterberry Herbs: Cinnamon Fern, Bracken Fern Others: Greenbriar	Atlantic County
Red Maple/Sweet Gum/ Pitch Pine (Temporarily Flooded)	Trees: American Holly, Sassafras, Black Gum, Sweet Bay, Red Oak Shrubs: Highbush Blueberry, Sweet Pepperbush, Swamp Azalea, Wintergreen, Partridgeberry, Mountain Laurel Herbs: Bracken Fern Others: Greenbriar	Cumberland County

Atlantic white cedar dominates many forested wetlands along Pine Barrens watercourses. In general, they form a band less than 1,000 feet wide, but some stands exceed one mile in width (McCormick 1979). These cedar swamps represent only 2% (or 21,450 acres) of the Pinelands National Reserve (Roman and Good 1983). While the hardwood swamps are largely represented by a mixture of co-dominant trees, many cedar swamps have a nearly solid canopy of Atlantic white cedar. This dense canopy precludes establishment of a thick shrub layer, typical of hardwood swamps. Instead, scattered trees and shrubs are found including red maple, sweet bay, black gum, sweet pepperbush, fetterbush, highbush blueberry, dangleberry, inkberry, and swamp azalea. In more open canopies, these plants and others are more abundant and red maple can co-dominate. Herbaceous species are not prevalent, but those present include chain ferns, cinnamon fern, sedge (*Carex collinsii*), bladderworts (*Utricularia* spp.), purple pitcher plant, sundews, swamp pink (*Helonias bullata*), and partridgeberry (McCormick 1979; Olsson 1979). Orchids occur in cedar swamps, including dragon's mouth (*Arethusa bulbosa*), swamp pink (*Calopogon pulchellus*), green rein orchid (*Platanthera clavellata*), white fringed orchid (*P. blephariglottis*), and rose pogonia (*Pogonia ophioglossoides*) (Harshberger 1916). Little (1951) found some emergent plants that were not found in hardwood swamps: rose pogonia, purple pitcher plant, round-leaved sundew (*Drosera rotundifolia*), starflower (*Trientalis borealis*) and twining bartonia (*Bartonia paniculata*). In addition, he reported that the rare curly grass fern (*Schizaea pusilla*) is restricted to cedar swamps. McCormick (1979) observed that this fern is widely distributed throughout cedar forests. Wintergreen (*Gaultheria procumbens*) occurs on the cedar hummocks (Roman and Good 1983). Peat mosses cover much of the ground, while liverworts and reindeer moss (*Cladonia incrassata*) are found on logs and tree bases (Olsson 1979). Forman (1979) noted that bryophyte cover increased with soil moisture and that cedar swamps had the greatest moss coverage of all Pine Barrens habitats. Harshberger (1916), Little (1950), and Givnish (1971) have examined the ecology of Pine Barrens cedar swamps.

Pitch pine lowlands are among the driest wetlands in southern New Jersey. Although pitch pine dominates some seasonally flooded wetlands, it is most abundant in temporarily flooded situations associated with the seasonally high water table of the Pine Barrens (Figure 34). Pitch pine lowlands typically represent transitional areas between the white cedar and hardwood swamps and the dry upland. They comprise about 10% of the Pinelands National Reserve (Roman and Good 1983). While pitch pine forms almost the entire forest canopy, red maple and black gum may often be intermixed and sometimes co-dominant forming mixed deciduous-evergreen forested wetlands. In southernmost areas, sweet gum becomes an important community component. Other trees are scattered throughout this lowland complex including Atlantic white cedar, sassafras, gray birch, American holly, and willow oak. Other oaks, such as scrub oak (*Quercus ilicifolia*), may be common at drier sites (McCormick 1979). A shrub understory may be well developed in pitch pine wetlands. McCormick (1979) reported more than 20 species of shrubs and woody vines. Important shrubs are dangleberry, sweet pepperbush, highbush blueberry, swamp azalea, sheep laurel, leatherleaf, wintergreen, fetterbush, winterberry, black huckleberry, dwarf huckleberry, and inkberry. Leatherleaf forms a dense low thicket in the wetter areas. Less common shrubs include staggerbush, mountain laurel, alder, serviceberry, southern arrowwood, chokeberry, bayberry, and partridgeberry. Common vines are greenbriars (*Smilax glauca* and *S. rotundifolia*). Herbaceous vegetation is variable and may cover 30% of the ground (McCormick 1979). Numerous ferns can be found, i.e., bracken, chain, cinnamon, royal and sensitive ferns. Other significant emergents include turkeybeard (*Xerophyllum asphodeloides*), lowland broomsedge, sundews, cowwheat (*Melampyrum lineare*), sedges and orchids (McCormick 1979; Olsson 1979). Peat mosses may exist in wetter depressions. Olsson (1979) noted several plants associated with recent disturbance: sand myrtle (*Leiophyllum buxifolium*) with drainage, turkeybeard with fire, and bracken and cinnamon ferns with clearing or burning.

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Figure 34. Pitch pine occurs in a wide variety of habitats both wet and dry. Here it is growing in a seasonally flooded wetland.

Lacustrine Wetlands

The Lacustrine System is principally a deepwater habitat system of lakes, reservoirs and deep ponds. Wetlands are generally limited to shallow waters and exposed shorelines like in the Riverine System. While algae are probably more abundant in these waters, the vascular macrophytes are usually more readily observed. A variety of life forms can be recognized, including: (1) free-floating plants, (2) rooted vascular floating-leaved plants, (3) submergent plants, and (4) emergent plants. The first three groups of vascular plants form aquatic beds, while the latter represents nonpersistent emergent wetlands. Fairbrothers and Moul (1965) have discussed the ecology of aquatic vegetation in New Jersey and a list of common aquatic plants is presented as Table 22.

Lacustrine Aquatic Beds

Floating-leaved and free-floating aquatic beds are common in lacustrine shallow waters. Dominant floating-leaved species include spatterdock, white water lily, and water shield. Duckweeds (*Lemna* spp., *Spirodela polyrhiza*, *Wolffia* spp. and *Wolffiella* spp.) comprise the free-floating beds. Bladderworts (*Utricularia* spp.) are also free-floating, but are typically submerged. Submergent aquatic beds are less conspicuous. Lacustrine submergent plants include pondweeds, naiads (*Najas* spp.), wild celery, waterweeds (*Elodea* spp.), coontail (*Ceratophyllum demersum*), fanwort (*Cabomba caroliniana*), and the algal stoneworts (*Nitella* spp.).

Soft water lakes with a pH between 6.8 and 7.4 may be characterized by pondweeds, naiads, wild celery, and manna grasses (*Glyceria* spp.), with bladderworts, white water lilies and water milfoils (*Myriophyllum* spp.) also abundant. By contrast, hard water lakes (pH 8-8.8) frequently have a border of emergent plants, e.g., cattails, burreeds, bulrushes and common reed (Fairbrothers and Moul 1965). Renlund (1953) noted that many plants such as muskgrass (*Chara* spp.), water shield, quillwort (*Isoetes* spp.) and purple loosestrife may be limited to northern and central New Jersey, while others are more frequent in southern and central lakes, e.g., yellow-eyed grass, arrowheads and bladderworts. Purple loosestrife, however, is now abundant in some southern New Jersey marshes (N. Good, pers. comm.).

Nonpersistent Emergent Wetlands

Emergent wetlands frequently form along the shorelines of lakes. Common nonpersistent plants include arrowheads, three-way sedge, spikerushes, pipeworts, burreeds, rushes, smartweeds, manna grasses, pickerelweeds and arrow arum. In addition to these species, persistent plants like cattails, water willow, buttonbush, and leatherleaf may comprise all or part of the lacustrine boundaries. These persistent wetlands, however, fall within the Palustrine System according to Cowardin and others (1979) as discussed earlier.

Rare and Endangered Wetland Plants

New Jersey is located in a rather unique position along the East Coast which greatly affects its plant associations and diversity. The State includes both the southern limit of the Northern Hardwoods Forest and the northern tip of the Southeastern Mixed Forest (Bailey 1978). As a result, a large number of plants occur at the limit of their natural range, with many plants having a quite restricted distribution in New Jersey. In the Pine Barrens alone, 15% of the flora is composed of plants reaching their northern or southern range limit (McCormick 1970b). Fifty-four species have been identified as threatened or endangered plants of the Pinelands in the Comprehensive Management Plan (N.J. Pinelands Commission 1980).

Although New Jersey does not have an official state list of endangered and threatened plants, a total of 338 rare plants were identified for the State in a recent Fish and Wildlife Service sponsored survey (Snyder and Vivian 1981). Of these plants, 249 species (or 64%) grow in wetland or aquatic habitats. Another 7 species may be associated with wetlands, but available habitat information was inconclusive. For additional information, the reader is referred to Snyder and Vivian (1981).

To date, only one New Jersey plant has been officially listed by the Service as an endangered species, under protection of the Federal Endangered Species Act. The small-whorled pogonia (*Isotria medeoloides*) is in danger of extinction throughout all or a significant portion of its range. It is typically associated with mixed deciduous upland forest, but is found occasionally in wetlands along freshwater streams.

Interestingly, 23 of the 25 plants currently under review as being Federally endangered or threatened (likely to become endangered within the foreseeable future) throughout all or a significant part of their range in the United States occur in New Jersey wetlands (Table 23). Of these, 15 species are associated with the Pine Barrens.

Summary

Plant composition of New Jersey's wetlands is diverse and complex. The State's geographic position with several physiographic regions found within its borders adds to this natural diversity. At a broad level, major differences can be seen between the estuarine wetlands where salt and brackish emergent marshes predominate and the palustrine

Table 22. Plants of freshwater lakes, ponds and slow moving rivers and streams (from Fairbrothers and Moul 1965). Scientific names are listed as they appeared in this reference.

Scientific Name	Common Name
Acorus calamus	Sweet Flag
Alisma subcordatum	Water Plantain
Anacharis canadensis	Waterweed
Anacharis nuttallii	Waterweed
Bidens beckii	Water Marigold
Bidens bidentoides	
Brasenia schreberi	Water Shield
Cabomba caroliniana	Fanwort
Calamagrostis canadensis	Bluejoint
Callitriche heterophylla	Water Starwort
Callitriche terrestris	Water Starwort
Callitriche verna	Water Starwort
Carex langinosa	Woolly Sedge
Ceratophyllum demersum	Coontail
Cicuta maculata	Water Hemlock
Cladium mariscoides	Twig Rush
Eleocharis obtusa	Spike Rush
Glyceria striata	Manna Grass
Heteranthera dubia	Water Star Grass
Juncus marginatus	Rush
Juncus militaris	Bayonet Rush
Juncus repens	Rush
Juncus subtilis	Rush
Juncus pelocarpus	Rush
Lemna minor	Duckweed
Lemna perpusilla	Duckweed
Lemna trisulca	Duckweed
Lemna valdiviana	Duckweed
Lobelia cardinalis	Cardinal Flower
Myosotis laxa	Forget-me-not
Myriophyllum humile	Water Milfoil
Myriophyllum heterophyllum	Water Milfoil
Myriophyllum spicatum	Water Milfoil
Najas flexilis	Bushy Pondweed
Najas gracillima	Bushy Pondweed
Najas guadalupensis	Bushy Pondweed
Nuphar advena	Spatterdock
Nuphar microphyllum	Yellow Pond Lily
Nuphar variegatum	Yellow Pond Lily
Nymphaea odorata	White Water Lily
Nymphaea tuberosa	White Water Lily
Nymphoides cordata	Floating Heart
Orontium aquaticum	Golden Club
Peltandra virginica	Arrow Arum
Pontederia cordata	Pickerelweed
Potamogeton crispus	Crimped-leaf Pondweed
Potamogeton diversifolius	Pondweed
Potamogeton nodosus	Riverweed
Potamogeton perfoliatus	Pondweed
Potamogeton pusillus	Small Pondweed
Potamogeton robbinsii	Pondweed
Potamogeton spp.	Pondweeds
Proserpinaca palustris	Mermaid Weed
Proserpinaca pectinata	Mermaid Weed
Ranunculus aquatilis	White Water Crowfoot
Ranunculus circinatus	Water Crowfoot
Ranunculus longirostris	White Water Crowfoot
Sagittaria australis	Arrowhead
Sagittaria eatoni	Arrowhead
Sagittaria engelmanniana	Arrowhead
Sagittaria latifolia	Broad-leaved Arrowhead
Sagittaria graminea	Arrowhead
Sagittaria rigida	Arrowhead
Sagittaria subulata	Arrowhead
Sagittaria teres	Arrowhead
Saururus cernuus	Lizard's Tail
Scirpus acutus	Hard-stemmed Bulrush
Scirpus americanus	Three-square
Scirpus fluviatilis	River Bulrush
Scirpus olneyi	Three-square
Scirpus paludosus	Bulrush
Scirpus smithii	Bulrush
Scirpus subterminalis	Swaying Rush
Scirpus torreyi	Bulrush
Scirpus validus	Soft-stemmed Bulrush
Sium suave	Water Parsnip
Sparganium americanum	Burreed
Sparganium eurycarpum	Large Burreed
Spirodela polyrhiza	Big Duckweed
Utricularia biflora	Bladderwort
Utricularia cornuta	Bladderwort
Utricularia fibrosa	Bladderwort
Utricularia geminiscapa	Bladderwort
Utricularia gibba	Bladderwort
Utricularia inflata	Bladderwort
Utricularia intermedia	Bladderwort
Utricularia juncea	Bladderwort
Utricularia minor	Bladderwort
Utricularia purpurea	Purple Bladderwort
Utricularia resupinata	Bladderwort
Utricularia vulgaris	Bladderwort
Vallisneria americana	Wild Celery
Wolffia spp.	Duckweeds
Wolffiella spp.	Duckweeds
Xyris caroliniana	Yellow-eyed Grass
Zizania aquatica	Wild Rice

wetlands where forested swamps abound. Even within major vegetative classes of wetlands, significant differences in community structure are observed. These variations are largely due to several factors including water regime (hydrology), soil type, human activities (e.g., drainage, timber harvest, filling and water pollution) and natural events like fire. Consequently, a wide variety of wetland plant communities exist within the State and they represent an essential part of its landscape diversity and natural heritage.

Table 23. List of New Jersey plants under review for Federal listing as endangered species. Wetland habitats have been identified where applicable.

Scientific Name	Common Name	Occurs in Wetland	Pine Barrens Associate	Wetland Habitats
Aeschynomene virginica	Sensitive Joint Vetch	X	X	Tidal flats and marshes
Amaranthus pumilus	Sea-beach Pigweed	X	X	Sea beaches
Calamovilfa breviplis	Sand Grass	X	X	Freshwater wetlands
Cardamine longii	Long's Bitter Cress	X		Salt marshes
Carex barrattii	Barrett's Sedge	X	?	Freshwater wetlands
Carex polymorpha	Variable Sedge			N/A
Eriocaulon parkeri	Parker's Pipewort	X		Shallow water and freshwater tidal flats
Eupatorium resinosum	Pine Barrens Boneset	X	X	Freshwater wetlands
Euphorbia purpurea	Darlington's Spurge	X		Freshwater forested wetlands
Gentiana autumnalis	Pine Barren Gentian	X	X	Freshwater wetlands
Helonias bullata	Swamp Pink	X	X	Freshwater wetlands
Isoetes eatonii	Eaton's Quillwort	X		Freshwater ponds and lakes
Juncus caesariensis	New Jersey Rush	X	X	Freshwater wetlands
Lobelia boykinii	Boykin's Lobelia	X		Freshwater ponds and forested wetlands
Micranthemum micranthemoides	Nuttall's Micranthemum	X		Freshwater tidal wetlands
Muhlenbergia torreyana	Torrey's Muhly	X	X	Freshwater forested wetlands
Narthecium americanum	Bog Asphodel	X	X	Freshwater wetlands
Panicum hirstii	Hirst's Panic Grass	X	X	Freshwater wetlands
Polemonium vani-bruntiae	Jacob's Ladder	X		Freshwater wetlands
Rhexia aristosa	Awned Meadow Beauty	X	X	Freshwater ponds and acid bogs
Rhynchospora knieskernii	Knieskern's Beaked Rush	X	X	Freshwater wetlands
Schizaea pusilla	Curly Grass Fern	X	X	Freshwater wetlands
Schwalbea americana	Chaffseed		X	N/A
Scirpus longii	Long's Bulrush	X	X	Freshwater marshes
Trollius laxus subspecies *laxus*	Spreading Globe-flower	X		Freshwater wetlands

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CHAPTER 8.

New Jersey Wetland Trends

Introduction

Although conservation-minded government agencies, private groups and individuals have recognized the importance of wetlands to fish and wildlife. New Jersey's wetlands have been largely viewed as natural lands best suited for conversion to other uses such as agriculture, industrial sites and residential housing. Many of the alternative uses require the physical destruction of wetlands and the public values they naturally provide. Other uses alter the character or quality of a wetland, but do not destroy all of its natural values. For example, diking of coastal marshes along Delaware Bay for salt hay production has disrupted their ecology and estuarine productivity, yet these wetlands still provide wildlife habitat and function as wetland in other ways. The following discussion addresses factors causing wetland changes and presents available information on the amount of wetland change in New Jersey. For information on national wetland trends, the reader is referred to **Wetlands of the United States: Current Status and Recent Trends** (Tiner 1984).

Forces Changing Wetlands

Wetlands are a dynamic environment subject to change by both natural processes and human actions. These forces interact to cause wetland gains and losses as well as to degrade and improve their quality. In general, the overall effect in New Jersey has been a loss and degradation of wetlands. Table 25 outlines major causes of wetland loss and degradation in the State.

Table 25. Major causes of wetland loss and degradation in New Jersey (adapted from Zinn and Copeland 1982; Gosselink and Baumann 1980).

Human Threats

Direct:

1. Discharges of materials (e.g., pesticides, herbicides, other pollutants, nutrient loading from domestic sewage, urban runoff, agricultural runoff, and sediments from dredging and filling, agricultural and other land development) into waters and wetlands.
2. Filling for dredged spoil and other solid waste disposal, roads and highways, and commercial, residential and industrial development.
3. Dredging and stream channelization for navigation channels, flood protection, coastal housing developments, and reservoir maintenance.
4. Construction of dikes, dams, levees and seawalls for flood control, cranberry production, water supply, irrigation and storm protection.
5. Drainage for crop production, timber production and mosquito control.
6. Flooding wetlands for creating reservoirs and lakes.
7. Mining of wetland soils for sand, gravel, and other materials.

Indirect:

1. Sediment diversion by dams, deep channels and other structures.
2. Hydrologic alterations by canals, spoil banks, roads and other structures.
3. Subsidence due to extraction of ground water.

Natural Threats:

1. Subsidence (including natural rise of sea level).
2. Droughts.
3. Hurricanes and other storms.
4. Erosion.
5. Biotic effects, e.g., muskrat and snow goose "eat-outs".

Natural Processes

Natural events influencing wetlands include rising sea level, natural succession, the hydrologic cycle, sedimentation, erosion, beaver dam construction and fire. The rise in sea level (roughly one foot per century) has the potential to both increase wetland acreage by flooding low-lying uplands and decrease wetlands through permanent flooding. Along the New Jersey coastline, it is allowing estuarine wetlands to invade former forested wetlands. Natural succession and fire typically change the vegetation of a wetland, usually with no net loss or gain in wetland acreage. The hydrologic cycle represents the natural cycle of wet and dry periods over time. During dry periods, wetlands are particularly vulnerable to drainage and filling. Deposition of water-borne sediments along rivers and streams often leads to formation of new wetlands, while erosion removes wetland acreage. The activities of beavers create or alter wetlands by damming stream channels. Thus, natural forces act in a variety of ways to create, modify and destroy wetlands.

Human Actions

Human actions have a significant impact on wetlands. Unfortunately, many human activities are destructive to natural wetlands, either by converting them to agricultural or other lands or by degrading their quality. Key human impacts in New Jersey include drainage for agriculture;

channelization for flood control; filling for housing, highway, industry and sanitary landfills; dredging for navigation channels, harbors and marinas; reservoir construction; timber harvest; ground-water extraction; and various forms of water pollution and waste disposal. A few human actions do, however, create and preserve wetlands. Construction of farm ponds and in some cases reservoirs may increase wetland acreage, although valuable natural wetlands may be destroyed in the process. Marsh creation and restoration of previously altered wetlands can also be beneficial. Federal and State fish and wildlife agencies have traditionally managed wetlands in New Jersey to improve their value to waterfowl. Wetland protection efforts, such as Federal and State wetland regulation programs, serve to help maintain and enhance our Nation's wetland resources, despite mounting pressures to convert them to other uses.

Wetland Trends

Changes in New Jersey's wetlands can be generally divided into two categories: (1) quantitative changes and (2) qualitative changes. The former represent actual increases or decreases in the amount of wetland, while the latter relate to quality changes.

Quantitative Changes

While some wetlands are created by reservoir, impoundment, and pond construction, beaver activities or other projects, the net effect of these gains is minimal due to the extensive conversion of wetlands to other uses. These other uses include cropland, residential housing, commercial and industrial development, and highways.

Drainage of wetlands for pasturage or crop production has altered many of the State's wetlands. Muckland farming (e.g., onions, cabbage and lettuce) in northern New Jersey and blueberry and cranberry cultivation in the Pine Barrens have been particularly significant uses of wetlands. Other important crops grown in drained wetlands include corn, soybeans, hay, small grains, summer vegetables and sod. Agricultural drainage has affected many types of wetlands, e.g., freshwater tidal marshes (Good, *et al* 1976; Ferrigno, *et al.* 1973), forested wetlands (McCormick 1970; Markley 1979), and freshwater marshes (Jervis 1963; Robichaud and Buell 1973). Counties experiencing significant wetland conversions to agriculture may include Atlantic, Burlington, Hunterdon, Mercer, Middlesex, Monmouth, Ocean, Somerset, Sussex and Warren. Agriculture has been abandoned in many drained wetlands and these areas have potential for wetland rehabilitation. Many areas are naturally reverting to woodland and whether they will become forested wetland depends on how permanent the drainage is and on restoration efforts. It is quite possible that many of these areas could once again become forested wetlands. In the future, agricultural impacts may be limited to abandoned farmed wetlands, although blueberry cultivation in the Pine Barrens may utilize additional wetland acreage.

Filling of wetlands is probably the greatest threat to New Jersey's wetlands. Many municipalities outside of the Pinelands Natural Reserve encourage wetland filling by zoning wetlands for residential, commercial or industrial development. Although filling has recently accelerated throughout the State, it is not a new threat to New Jersey wetlands. For example, in the late 1800's large tracts of the Hackensack Meadowlands were drained and then filled for railroad terminals and factories (Harshberger and Burns 1919). More recently, the Meadowlands have been partly filled for a sports complex and a section of the New Jersey Turnpike. At one point, filling in this area was occurring at a rate of 30,000 tons per week (Robichaud and Buell 1973). In general, filling of wetland for industrial and residential uses increased after World War II. Increasing population raised demand for land for housing and businesses particularly in northern New Jersey and along the Atlantic coast. Urbanization probably took its greatest toll of wetlands in coastal counties and Morris and Middlesex Counties since the 1950's. By contrast, northeastern counties, i.e., Bergen, Essex, Hudson, Passaic and Union, probably experienced heaviest losses prior to that time. Interstate highway development, such as Routes 80, 287, and 280, directly impacted many acres of wetlands by filling and by fragmenting large wetland complexes in northern New Jersey. This transportation network also spawned accelerated urban development of wetlands in affected areas. Significant wetland losses within the Passaic River Basin have been partly responsible for escalating flood damages (Figure 42). In the central basin alone, nearly half of the wetlands were destroyed between 1940 and 1978 (Photographic Interpretation Corporation 1978). During this period, Passaic County lost 14.5% of its wetland acreage to housing, reservoir construction, and industrial and commercial development (Tiner, *et al.* 1984).

Although the Pine Barrens generally have not experienced heavy urbanization like more northern areas, residential developments east of the Garden State Parkway are impacting wetlands (Andropogon Associates 1980). Lagoonal housing developments in estuarine wetlands often extend into adjacent hardwood swamps. In addition, scattered small-scale developments within the Pine Barrens are having an adverse impact on its wilderness quality. Fragmentation of large wetland complexes and other ecosystems jeopardizes wildlife populations dependent on these large areas. This situation has been occurring throughout New Jersey.

Other significant adverse direct impacts on wetlands include reservoir and recreational lake construction, and

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Figure 42. Increased urban development of wetlands has heightened flood damages, especially in northern New Jersey communities.

channel dredging and associated material disposal (e.g., Atlantic intracoastal waterway and Delaware River). Man-made lakes and reservoirs throughout the State have been created from wetlands and adjacent upland. Examples of former wetlands include Lake Mohawk and Steeny Kill Lake in northern New Jersey (Waksman, *et al.* 1943; Niering 1953). In southern areas, abandoned cranberry bogs have been cleared and flooded, creating residential lakes like Presidential Lakes, Lebanon Lakes, and Fawn Lake (McCormick 1970).

Qualitative Changes

Qualitative changes are often more subtle and more difficult to detect at first glance than the effects of filling, drainage, and impoundment. These quality-related actions include logging operations, direct (point source) discharges of industrial wastes and municipal sewage, and indirect (non-point source) discharges such as urban and agricultural runoff.

Logging operations in forested wetlands in New Jersey may alter the character or plant composition of utilized wetlands. Historically, Atlantic white cedar swamps were the most extensive forested wetland type in the Pine Barrens, but recent logging practices have substantially reduced cedar acreage between 1970 and 1979 (N.J. Pinelands Commission 1980). Select or small-tract cutting practices have converted many cedar swamps to hardwood swamps.

Water pollution and disposal of hazardous and other wastes have degraded many wetlands. Urbanization has often increased sedimentation and nutrient levels in streams, thereby affecting wetland and aquatic plants and animals as well as water quality. In numerous instances, less desirable plants, like common reed and purple loosestrife have invaded urban wetlands, replacing native species. Robichaud and Buell (1973) observed less plants growing along the polluted Whippany River than were found on the edge of Troy Brook in northern New Jersey. Ehrenfeld (1983) documented the loss of sensitive Pine Barrens plants in developed drainages in southern New Jersey. About 25% of the species observed in pristine areas disappeared in developed basins. Elevated hydrogen ion concentration (pH), resulting from increased nutrients, and increased flooding associated with urbanization were particular problems for these native species.

Coastal Wetland Losses

Coastal wetland losses were tremendous prior to the establishment of the Wetlands Act of 1970 which provided strong control of uses of tidal wetlands. Although most of the State's remaining tidal marshes are in the southern region, northern New Jersey once possessed vast acreages of estuarine marshes. These wetlands were probably the first of the coastal wetlands to be subjected to extensive filling. Their location within the New York City metropolitan area, proximity to harbor waters, and the relative ease of filling these wetlands made them especially vulnerable to development. As previously mentioned, large areas of the Hackensack Meadowlands were filled in the late 1800's. Available 1925 soil survey information for northern New Jersey (Lee, *et al.* 1925) identified 31,296 acres of tidal marsh. Approximately 50 years later, less than 8,000 acres remained, amounting to a loss of about 75% of these coastal wetlands. Extensive filling has eliminated most of northern New Jersey's estuarine marshes, especially in Newark, Elizabeth, and Jersey City.

More recently, development focused on coastal marshes in southern New Jersey. Between 1953 and 1973, nearly 25% of the State's tidal marshes were filled or diked, with heaviest losses in Cumberland, Ocean, Salem, Atlantic, and Cape May Counties (Table 26; Ferrigno, *et al.* 1973). Filling for houses, roads, industry and sanitary landfills had the greatest impact, resulting in a loss of 28,386 acres or 11% of the tidal marshes. Dredge and fill developments converted thousands of acres of coastal wetlands to finger canal residential areas (Figure 43). Examples of these developments can be found in Beach Haven West, Forked River, Tuckerton and elsewhere along large coastal bays and barrier islands. Filling of freshwater tidal wetlands along the Delaware River and other rivers has extirpated or seriously reduced populations of several plants (Ferren and Schuyler 1980). Since the early 1970's, coastal wetland losses have been greatly reduced by the Wetlands Act of 1970 and the Federal Clean Water Act. Prior to 1970, annual losses averaged 3,200 acres, but since then losses have been reduced to about 50 acres per year (JACA Corporation 1982).

Statewide Wetland Losses

Information on statewide wetland losses does not exist, although good data are available on coastal marsh losses (Ferrigno, *et al.* 1973). Shaw (1982) has reported losses and proposed developments for some of the larger wetlands in northern New Jersey, while Tiner and others (1984) identified wetland changes in Passaic County between 1940 and the mid-1970's. A comparison between the results of the National Wetlands Inventory (NWI) and the Soil Conservation Service's (SCS) soil surveys provides an interesting perspective on the State's wetland losses. Such comparison does, however, have limitations due to differences in mapping techniques, but it is nonetheless useful for showing trends.

Comparing the NWI data with the SCS data for hydric soils, a tremendous difference, amounting to a potential loss of 200,000 wetland acres, was detected. This figure equates to roughly 20% of the State's wetland resources. Moreover, the figure is probably conservative for at least two reasons: (1) Essex and Hudson Counties are not included in this number and (2) the soil surveys are relatively recent and do not reflect the original extent of hydric soils or wetlands. On a county basis, losses were even more startling. Twelve counties may have lost more than 25% of their wetlands (Table 27), with five losing

Table 26. Losses of tidal marshes between 1953 and 1973 (Ferrigno, *et al.* 1973). These figures include losses by filling and impoundment construction.

County	1953 Marsh Acreage	1973 Marsh Acreage	Marsh Acreage Lost	% Lost
Atlantic	48,141	43,157	4,984	10.4
Bergen	4,986	2,438	2,548	51.1
Burlington	8,980	8,428	552	6.1
Camden	553	29	257	46.5
Cape May	50,204	41,921	8,283	16.5
Cumberland	54,018	43,018	11,000	20.4
Essex	613	0	613	100.0
Gloucester	7,118	3,674	3,444	48.4
Hudson	4,171	1,623	2,548	61.1
Mercer	796	796	0	0.0
Middlesex	5,355	3,374	1,981	37.0
Monmouth	3,811	2,021	1,790	47.0
Ocean	37,007	26,078	10,929	29.5
Salem	34,877	24,549	10,328	29.6
Union	2,420	0	2,420	100.0

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Figure 43. Prior to the 1970's, many estuarine wetlands were filled for residential housing and other development. Since passage of the Wetlands Act in 1970, losses of tidal marshes have been greatly reduced.

Table 27. Comparison between NWI results and SCS hydric soil statistics for 19 counties in New Jersey, excluding Essex and Hudson Counties. Note: NWI statistics do not include flats, aquatic beds, open water, or beach/bars because such areas were not mapped as a soil type by SCS soil surveys.

County	SCS Hydric Soils (acres)	NWI Wetlands (acres)	Difference (acres)	Change
Atlantic	132,920	127,930	− 4,990	− 4%
Bergen	8,930	8,882	− 48	− 1%
Burlington	114,470	132,804	+ 18,334	+ 16%*
Camden	24,595	19,727	− 4,868	− 20%
Cape May	70,800	74,071	+ 3,271	+ 5%*
Cumberland	98,400	88,180	− 10,220	− 10%
Gloucester	45,420	33,569	− 11,851	− 26%
Hunterdon	15,650	4,537	− 11,113	− 71%
Mercer	25,883	11,291	− 14,592	− 56%
Middlesex	34,160	21,488	− 12,672	− 37%
Monmouth	56,290	24,676	− 31,614	− 56%
Morris	54,069	38,481	− 15,587	− 29%
Ocean	104,630	96,428	− 8,202	− 8%
Passaic	13,490	4,639	− 8,851	− 66%
Salem	77,760	56,140	− 21,620	− 28%
Somerset	15,109	10,558	− 4,551	− 30%
Sussex	67,670	28,764	− 38,906	− 57%
Union	3,530	2,627	− 903	− 26%
Warren	21,760	11,680	− 10,080	− 46%

* Increase in wetland highly unlikely, the positive difference is probably related to better resolution (increased detail) of NWI and not to a gain in wetland acreage.

more than half: Hunterdon, Passaic, Mercer, Sussex, and Monmouth. Comparative data suggest a 16% and 5% increase in wetland acreage for Burlington and Cape May Counties, respectively. The positive differences, however, probably reflect differences in mapping techniques (i.e., increased mapping resolution for the wetlands inventory), since there was no reason for such an increase. Despite limitations in comparing actual numbers of NWI findings with SCS statistics, significant wetland losses undoubtedly took place. Inland wetlands probably accounted for at least 80% of all losses, with coastal marshes representing the remainder.

Future Outlook

While substantial wetland losses have occurred, wetlands remain abundant, particularly in southern New Jersey. This may be related to the fact that population growth has focused on a few areas, i.e., New York metropolitan area, Camden, Trenton and more recently in Ocean County (Robichaud and Buell 1973). This growth pattern left many areas in a natural state.

Future losses in coastal wetlands and in inland wetlands of Pinelands should be significantly reduced through existing laws and regulations, i.e., Wetlands Act of 1970 and the Pinelands Comprehensive Management Plan (N.J. Pinelands Commission 1980). The Pinelands alone contain about half of the State's inland wetlands. The fate of the Hackensack Meadowlands lies in the hands of the Hackensack Meadowlands Development Commission, whose prime objective is promoting economic growth. The Commission's master plan includes filling 1,196 acres of Hackensack wetlands during the next 20 years (JACA Corporation 1982).

Many uses of inland wetlands outside of these areas are regulated by the U.S. Army Corps of Engineers through the Clean Water Act of 1977 or in rare instances by local municipalities through wetland protection ordinances. Yet, many inland wetlands outside of the Pinelands are not receiving adequate protection (Figure 44). A bill to regulate uses of these freshwater wetlands has been introduced into the State legislature in 1983 and 1984. If this bill or a similar version is passed, tools to better manage New Jersey's inland wetlands will be in place. If not, then wetland filling can be expected to continue, with numerous northern New Jersey wetlands destroyed within the next 10 years. Proposed developments already have been planned for all or part of Lee Meadows, Bog and Vly Meadows, Long Meadows, Black Meadows and numerous other wetlands (Shaw 1982).

Water quality problems will also continue to affect the quality of the State's remaining wetlands. Although control of point sources of water pollution, such as industrial effluents and municipal wastewater treatment plants, is improving the quality of many of New Jersey's waterways, urban and agricultural runoff (non-point sources) continues to degrade water quality. Soil erosion from upland development causes sedimentation and water quality problems for streams and adjacent wetlands. Perhaps establishing a buffer zone around wetlands would help better maintain the ecological integrity of the State's waters and wetlands. Roman and Good (1983) have proposed a buffer zone delineation model to accomplish this in the Pinelands and the buffer zone concept has been incorporated into the State's freshwater wetlands protection bill.

USDA SCS

Figure 44. Many freshwater wetlands remain vulnerable to development pressures.

Summary

Available information on wetland trends for the State suggest that New Jersey may have lost at least 20% of its wetland resources since the mid-1900's. While agriculture may have played the primary role in wetland alteration in in the distant past, the most significant recent cause is urbanization. Filling wetlands for houses, industry, and business offices has been accelerating since the 1950's. The Wetlands Act of 1970 in combination with the Federal regulations under Section 10 of the River and Harbor Act and Section 404 of the Clean Water Act have served to protect coastal wetlands, yet inland wetland losses have continued despite Federal jurisdiction (see following chapter for further discussion). In order to protect inland wetlands (outside of the Pinelands) and their public values, new initiatives must be taken. Strengthened Federal regulations and a New Jersey bill to regulate uses of these wetlands are first steps toward accomplishing this goal.

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CHAPTER 9.

Wetland Protection

Introduction

A variety of techniques are available to protect our remaining wetlands, including land-use regulations, direct acquisition, conservation easements, tax incentives, and public education. Kusler (1983) describes these techniques in great detail in **Our National Wetland Heritage - A Protection Guidebook**. Tabachnik (1980) specifically addresses protection of New Jersey's inland wetlands. Opportunities also exist for private initiatives by individual landowners, groups, and corporations to help in conserving our Nation's wetlands. Private options for land preservation are reviewed by Rusmore and others (1982).

Wetland Regulation

Several Federal and State laws regulate certain uses of many New Jersey wetlands. The more significant ones include the River and Harbor Act of 1899 and the Clean Water Act of 1977 at the Federal level. At the State level, the Wetlands Act of 1970, the Waterfront Development Law of 1914, the Coastal Area Facility Review Act of 1973, the Pinelands Protection Act of 1979 and the Flood Hazard Area Control Act of 1979 all contribute to wetland protection. In addition, Executive Order 11990 - "Protection of Wetlands" - requires Federal agencies to develop guidelines to minimize destruction and degradation of wetlands and to preserve and enhance wetland values. Key points of these laws are outlined in Table 28.

The foundation of Federal wetland regulation is Section 10 of the River and Harbor Act and Section 404 of the Clean Water Act. Federal permits for many types of construction in wetlands are required from the U.S. Army Corps of Engineers, but normal agricultural and silvicultural activities are exempt from permit requirements. The Service plays an active role in the permit process by reviewing permit applications and making recommendations based on environmental considerations, under authority of the Fish and Wildlife Coordination Act. Although the Federal laws in combination apply to virtually all of the State's wetlands, the U.S. Army Corps of Engineers' 1982 regulations for Section 404 of the Clean Water Act reduced its effectiveness for protecting wetlands. In particular, the widespread use of "nationwide permits" and the lack of strong enforcement were major weak points (U.S. Fish and Wildlife Service 1984). Under the nationwide permit system, there is no required reporting or monitoring system, consequently there is no record of wetland loss and no effort to promote environmental or other public interest concerns. In New Jersey, many wetlands lie above designated headwaters or exist in isolated basins and were, therefore, not protected under the 1982 regulations. Numerous lawsuits were filed nationwide against the Corps by concerned environmental organizations over the 1982 regulatory changes. Under a recent out-of-court settlement agreement (National Wildlife Federation v. Marsh), the Corps issued new regulations in October 1984 requiring closer Federal and State review of proposals to fill wetlands. Implementation of these new regulations needs to be monitored to assess their effectiveness of protecting wetlands.

State laws have generally worked well to protect wetlands in certain areas of the State, especially in tidal waters and the Pinelands (Figure 45). Since its passage in 1970, the Wetlands Act has reduced annual losses of tidal wetlands from about 3,200 acres to about 50 acres (JACA Corporation 1982). Approximately 3,800 acres of tidal wetlands in northern New Jersey are regulated under the Waterfront Development Act (M. Hochman, pers. comm.). The Coastal Area Facility Review Act protects wetlands in the designated coastal zone from large facilities such as housing developments of 25 or more units. Approximately 300,000 acres of freshwater wetlands are regulated through the Pinelands Comprehensive Management Plan. The Flood Hazard Area Control Act has a high potential for protecting wetlands from residential and commercial developments. Presently, increased attention is given in project reviews to environmental and flood storage values of wetlands. The real test of this Act's effectiveness will be seen in the future

In addition to these major laws, other governmental authorities have a role in wetland protection. The Hackensack Meadowlands Development Commission controls the use of approximately 5,000 acres of wetland in Hudson and Bergen Counties. The Delaware River Basin Commission has authority over wetlands generally 25 acres or greater in size within the Basin. A comprehensive plan for water resources development and uses has been prepared which specifies an environmental impact statement requirement for wetland alterations in these areas and a public interest determination. The N.J. Department of Environmental Protection has a number of policies and programs that help conserve wetlands besides the regulatory programs mentioned. One of particular importance is the 201 Water Quality Construction Grants Program. This program has recently become quite effective at deterring construction of houses and other buildings in wetlands. Proposed developments are not approved to tie into existing Federally-financed sewer lines if wetlands are adversely impacted.

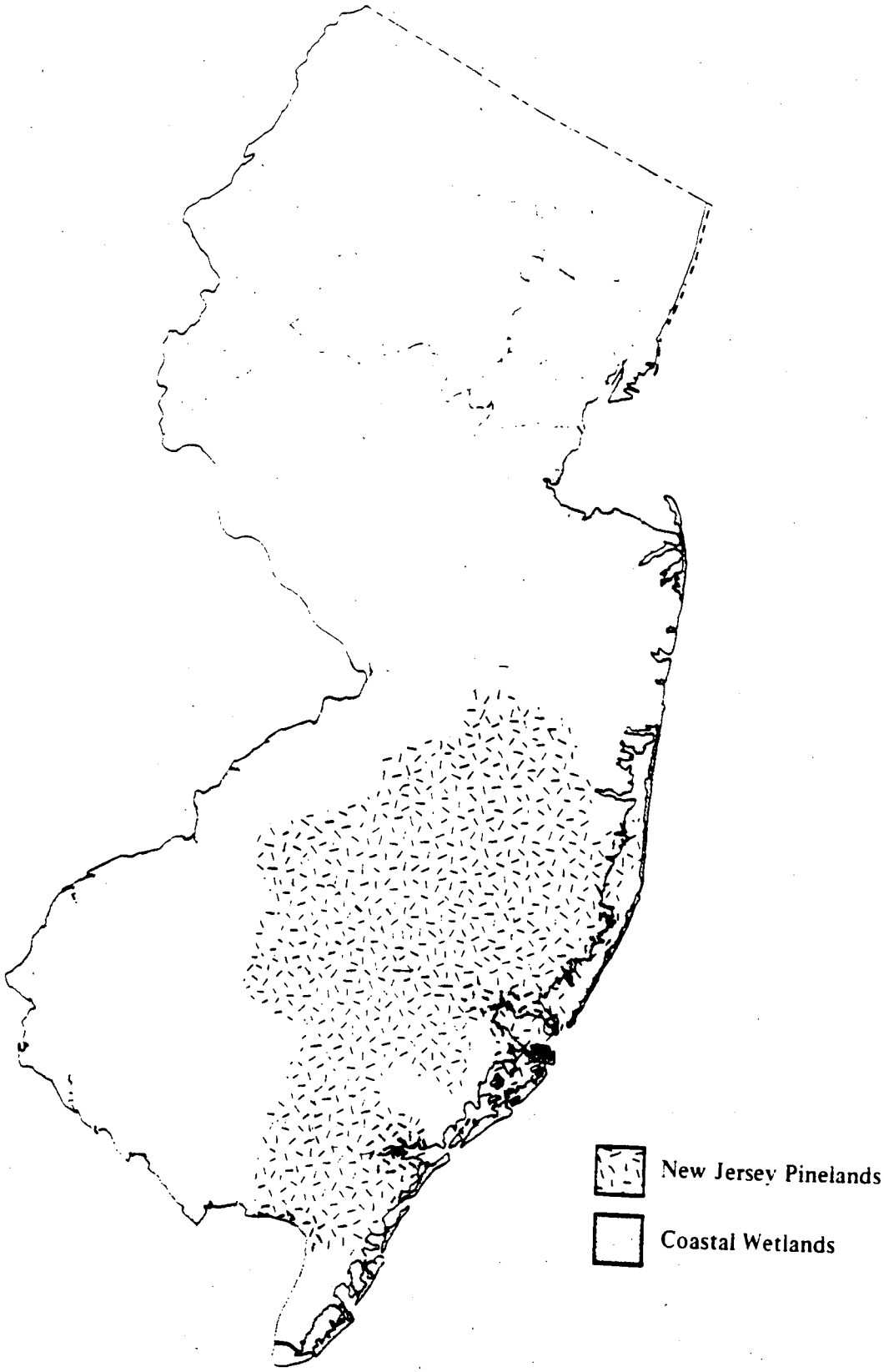

Figure 45. General extent of major State wetland protection efforts. Coastal wetlands are protected under the Wetlands Act of 1970, while wetlands within the Pinelands are regulated through the Pinelands Comprehensive Management Plan.

Table 28. Summary of primary Federal and State laws relating to wetlands protection in New Jersey.

Name of Law	Administering Agency	Types of Wetlands Regulated	Regulated Activities
River and Harbor Act of 1899 (Section 10)	U.S. Army Corps of Engineers	Tidal wetlands below the mean high water mark; nontidal wetlands below the ordinary high water mark	Structures and/or work in or affecting navigable waters of the U.S., including dredging and filling
Clean Water Act of 1977 (Section 404)	U.S. Army Corps of Engineers under their regulations and 404(b)(1) guidelines developed by the U.S. Environmental Protection Agency	Wetlands that are considered all waters of the U.S.	Discharge of dredged or fill material
Wetlands Act of 1970	N.J. Department of Environmental Protection	Coastal wetlands, excluding those within jurisdiction of Hackensack Meadowlands Development Commission (must appear on filed wetlands maps)	Draining, dredging, excavation or removal of materials; depositing, dumping or discharging of materials; erection of structures, or placing of obstructions
Coastal Area Facility Review Act of 1973	N.J. Department of Environmental Protection	Wetlands within the defined coastal region and where major facilities are proposed	Construction of designated "facilities" for the following purposes: electric power generation, food and food byproduct, waste incineration, paper production, public facilities and housing developments (25 or more units), agrichemical production, inorganic acids and salt manufacture, mineral products, chemical processes, storage, metallurgial processes and miscellaneous purposes (specified in the law)
Pinelands Protection Act of 1979	N.J. Pinelands Commission or municipal and county governments (upon certification of master plan and land use ordinances)	All wetlands (coastal and inland) and submerged lands within the designated Pinelands	All development in wetlands is prohibited, except as specified in Part I - Wetlands - of the Pinelands Comprehensive Management Plan
Waterfront Development Law of 1914	N.J. Department of Environmental Protection	Current or former tidal wetlands north of the Raritan Basin, (excluding the Meadowlands District) and all coastal wetlands in the Delaware and Raritan River Basins not regulated by the Wetlands Act	Dredging; erection of structures; landfills
Flood Hazard Control Act of 1979	N.J. Department of Environmental Protection	Wetlands within designated floodways and flood fringe	Construction, rebuilding or repair of structure or alteration within 100 yr. floodplain

Exemptions	Comments
None specified	July 22, 1982 Regulations: U.S. Fish and Wildlife Service and State wildlife agency review permit applications for environmental impacts by authority of the Fish and Wildlife Coordination Act.
Normal farming, silviculture, and ranching activities (including minor drainage); maintenance of existing structures; construction or maintenance of farm ponds, irrigation ditches or maintenance of irrigation ditches; construction of temporary sedimentation basins; construction or maintenance of farm roads, forest roads or temporary mining roads (within certain specifications)	July 22, 1982 Regulations: U.S. Environmental Protection Agency oversight; U.S. Fish and Wildlife Service and State wildlife agency review proposed work for environmental impacts by authority of the Fish and Wildlife Coordination Act. Permits cannot be issued without State certification that proposed discharge meets State water quality standards. Individual permits are required for specific work in many wetlands; regional permits for certain categories of activities in specified geographic areas; nationwide permits for 25 specific activities and for discharges into wetlands above headwaters or not part of surface tributary system to interstate or navigable waters of U.S. State takeover of permit program is encouraged. New regulations were issued in October 1984.
Continuance of commercial production of salt hay or agricultural crops; activities authorized by Dept. of Environmental Protection, Natural Resource Council, Mosquito Control Commission, Dept. of Health, or any mosquito control or other project authorized by provisions of Chap. 9 Title 26 of the Revised Statutes	Regulated wetlands are mapped. These regulations do not pertain to the Hackensack Meadowlands. DEP issues wetland order to establish wetland protection in each county.
Projects not meeting the definition of "facility"	Relates only to major facilities or developments within the defined coastal area. Requires preparation of an environmental impact statement. DEP must prepare an inventory of environmental resources in the coastal area, develop management strategies and select an appropriate environmental design.
Horticulture of native species and berry agriculture; beekeeping; forestry (subject to forestry requirements); fish and wildlife management (provided no significant adverse impact); hunting, fishing, trapping, hiking, boating, swimming or similar recreational uses; private docks, piers, moorings and boat launches (demonstrated need, no significant impact, conforms w/ all State and Fed. regs); bridges, roads, trails and utility transmission/distribution facilities (subject to specified conditions)	Public hearings held prior to finalizing master plans and land use ordinances. Landowners must request approval for developments in or within 300' of wetlands from Pinelands Commission, unless local authority is certified.
Construction of single family dwelling beyond 100' from mean high water line; expansion of existing structure beyond 100' from MHW line; minor changes in existing structures; navigation dredging, installation of aids to navigation, etc. by the U.S. government	Regulations amended in 1980; extends jurisdictions to adjacent upland areas within 500' of the waterway.
Recreation, agriculture, soil conservation projects or similar uses that do not obstruct or intensify flooding	Prohibits: dumping solid wastes, processing, storage and disposal of pesticides, domestic, industrial or other hazardous waste materials; storage of materials and equipment; construction of individual septic systems; erection of structures for humans, livestock or other animals.

Recently, there has been much public concern over inland wetland losses, especially in northern New Jersey. Approximately 300,000 acres of freshwater wetlands remain largely unprotected by State laws and Federal regulation does not adequately protect these wetlands. Consequently, State legislators have submitted a bill which expands county government's authority to regulate inland wetlands. If this bill or a similar version is passed, the tools will be available to better manage and protect the State's freshwater wetlands.

Wetland Acquisition

Wetlands may also be protected by direct acquisition or by other techniques such as conservation easements. Many wetlands are owned by public agencies and private environmental organizations, but the majority are privately-owned.

The Service's National Wildlife Refuge (NWR) System was established to preserve important migratory bird wetlands at strategic locations across the country. Three National Wildlife Refuges (NWR) are located in New Jersey: Great Swamp NWR (3,088 wetland acres), Forsythe NWR (Brigantine Division - 18,026 wetland acres; Barnegat Division - 9,271 wetland acres), and Supawna Meadows NWR (1,390 wetland acres). Great Swamp NWR contains only freshwater wetlands (Figure 46), while the others are nearly all estuarine marshes. Military reservations like Fort Dix, Lakehurst and Picatinny Arsenal also encompass considerable wetland acreage. The U.S. Army Corps of Engineers, New York District is considering acquisition of numerous wetlands in the Passaic River Basin for flood protection.

The State of New Jersey possesses much more wetland acreage than the Federal government. Its wildlife management areas, State parks and State forests contain

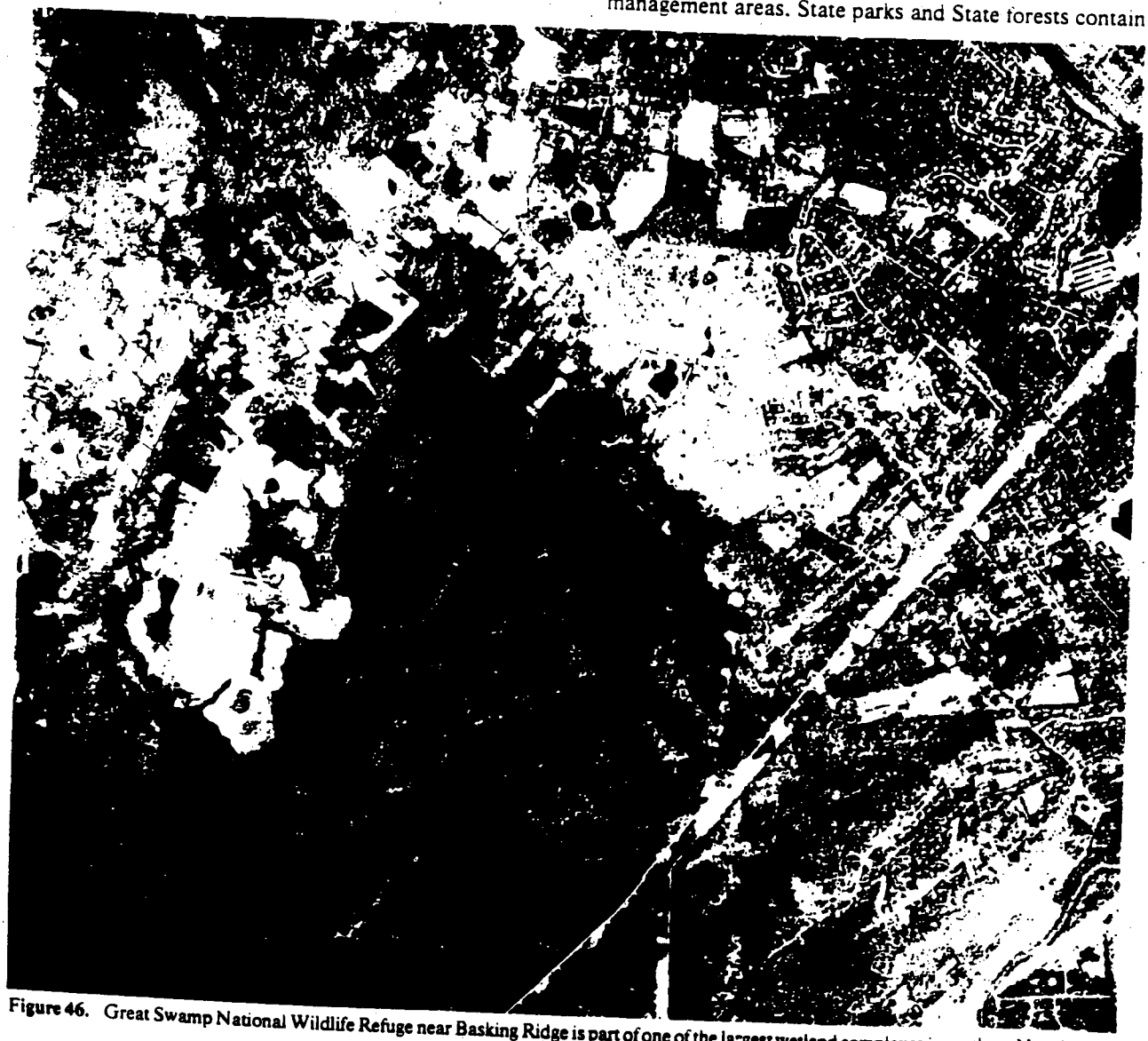

Figure 46. Great Swamp National Wildlife Refuge near Basking Ridge is part of one of the largest wetland complexes in northern New Jersey.

numerous wetlands, ponds, lakes, and streams. The N.J. Department of Environmental Protection is actively acquiring wetlands in the Pinelands National Reserve, using Federal and State funds. Acquisition efforts have focused on several watersheds including Cedar Creek, Oswego River, and Bass River. The Comprehensive Management Plan for the Pinelands recommends acquisition of 100,000 acres of land (i.e., upland and wetland). Through the Green Acres Program, additional wetland and upland habitats are acquired for conservation and recreation purposes. This program also permits acquisition of conservation easements. County and municipal parks may hold wetlands in public ownership as well.

Future Actions

Many opportunities are available to both government and the private sector to halt or slow wetland losses and enhance the quality of the remaining wetlands. Their joint efforts will determine the future course of our Nation's wetlands. Major options have been outlined below. For a more detailed discussion, the reader is referred to Kusler (1978; 1983), Tabachnick (1980), and Rusmore, *et al.* (1982).

Government Options:

1. Develop a consistent public policy to protect wetlands of national and state significance.
2. Strengthen Federal, State and local wetland protection.
3. Ensure proper implementation of existing laws and policies through adequate staffing, surveillance and enforcement.
4. Increase wetland acquisition in selected areas.
5. Remove government subsidies that encourage wetland drainage.
6. Provide tax and other incentives to private landowners and industry to encourage wetland preservation and remove existing tax benefits that encourage wetland destruction.
7. Scrutinize cost-benefit analyses and justifications for flood control projects that involve channelization of wetlands and watercourses.
8. Improve wetland management on publicly owned lands.
9. Increase the number of marsh creation and restoration projects, especially related to mitigation for unavoidable wetland losses by government-sponsored water resource projects. This should include enhancing existing wetlands by improving local water quality and providing buffer zones.
10. Monitor wetland changes especially with reference to effectiveness of State and Federal wetland protection efforts and periodically update the National Wetlands Inventory in problem areas.
11. Increase public awareness of wetland values and the status of wetlands through various media.
12. Conduct research to increase our knowledge of wetland values and to identify ways of using wetlands that are least disruptive to their ecology and public values.

Private Options:

1. Rather than drain or fill wetlands, seek compatible uses of those areas, e.g., timber harvest, waterfowl production, fur harvest, hay and forage, wild rice production, hunting leases, etc.
2. Donate wetlands or funds to purchase wetlands to private or public conservation agencies.
3. Maintain wetlands as open space.
4. Work in concert with government agencies to inform the public about wetland values.
5. Construct ponds in uplands and manage for wetland and aquatic species.
6. Purchase Federal duck stamps to support wetland acquisition.

Robichaud and Buell (1973) raised four basic questions that are central to the fate of the natural environment:

> "(1) How much future population growth?
> (2) What future industrial growth?
> (3) How much and what kind of open space?
> (4) Who plans and controls land use?"

The eventual answers to these questions will determine the future quantity and quality of New Jersey's wetlands as well as its other natural resources. Robichaud and Buell also recognized that people must develop a land ethic - an appreciation for the value of land in its natural state. To reach this endpoint, the public must be informed of the impacts associated with various land uses. For example, they must understand that filling and development of wetlands and floodplains leads directly to downstream flooding problems and to other losses like fish and wildlife habitat. Public education is, therefore, vital to protecting

wetlands. Private nonprofit organizations like the Association of New Jersey Environmental Commissions, American Littoral Society, N.J. Conservation Foundation, N.J. Audubon Society and others have made major contributions to educating the public on wetlands and other natural resources.

Public and private cooperation is needed to secure a promising future for our remaining wetlands. Private corporations are often in a position to work with private nonprofit conservation organizations and government agencies to protect wetlands. In October 1983, the American Telephone and Telegraph Company of New Jersey (AT&T) granted a perpetual easement to the Federal government for over 2,400 acres of wetland, adjacent to Forsythe National Wildlife Refuge's Barnegat Division. The area will be managed by the Service for migratory birds. This is an excellent example of private and public cooperation to achieve wetland protection goals. Perhaps, private corporations in the State will now follow the AT&T example and begin to seriously consider donating wetland holdings to public agencies or nonprofit environmental organizations for conservation purposes. In New Jersey, competition for wetlands is particularly intense between developers and environmental organizations. Ways must be found to achieve economic growth, while minimizing adverse environmental impacts. This is vital to preserving wetland values for future generations.

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Appendix. List of New Jersey Wetland Plants.

List of plants occurring in New Jersey's wetlands. Scientific names conform with the **National List of Scientific Plant Names** (U.S.D.A. Soil Conservation Service 1982). Although this list is comprehensive, it is not exhaustive, yet the majority of plants occurring in wetlands are listed. Sources used to compile this list are cited.

Scientific Name	Plant Common Name
Lycopodiaceae	
Lycopodium alopecuroides	Clubmoss
Lycopodium carolinianum	Clubmoss
Lycopodium inundatum	Clubmoss
Lycopodium obscurum	Ground-Pine
Selaginellaceae	
Selaginella apoda	Spikemoss
Isoetales	
Isoetes echinospora	Quillwort
Isoetes riparia	Quillwort
Equisetaceae	
Equisetum arvense	Horsetail
Equisetum fluviatile	Horsetail
Equisetum hyemale	Horsetail
Equisetum palustre	Horsetail
Ophioglossaceae	
Botrychium dissectum	Grape Fern
Botrychium virginianum	Grape Fern
Osmundaceae	
Osmunda cinnamomea	Cinnamon Fern
Osmunda claytoniana	Interrupted Fern
Osmunda regalis	Royal Fern
Schizaeaceae	
Schizaea pusilla	Curly Grass Fern
Polypodiaceae	
Pteridium aquilinum	Bracken Fern
Adiantum pedatum	Maidenhair Fern
Matteuccia struthiopteris	Ostrich Fern
Onoclea sensibilis	Sensitive Fern
Woodwardia areolata	Netted Chain Fern
Woodwardia virginica	Virginia Chain Fern
Athyrium filix-femina	Lady Fern
Thelypteris noveboracensis	New York Fern
Thelypteris simulata	Massachusetts Fern
Thelypteris thelypteroides	Marsh Fern
Dryopteris cristata	Crested Shield Fern
Dryopteris marginalis	Marginal Shield Fern
Dryopteris spinulosa	Spinulose Shield Fern
Polystichum acrostichoides	Christmas Fern
Salviniaceae	
Azolla caroliniana	Mosquito Fern
Pinaceae	
Picea mariana	Black Spruce
Tsuga canadensis	Hemlock
Larix laricina	Larch
Pinus rigida	Pitch Pine
Pinus strobus	White Pine
Pinus taeda	Loblolly Pine
Cupressaceae	
Chamaecyparis thyoides	Atlantic White Cedar
Juniperus virginiana	Red Cedar
Typhaceae	
Typha angustifolia	Narrow-leaved Cattail
Typha latifolia	Broad-leaved Cattail
Sparganiaceae	
Sparganium americanum	Eastern Burreed
Sparganium androcladum	Branching Burreed
Sparganium chlorocarpum	Green-fruit Burreed
Sparganium eurycarpum	Giant Burreed
Sparganium minimum	Small Burreed
Potamogetonaceae	
Potamogeton amphlifolius	Pondweed
Potamogeton confervoides	Tuckerman's Pondweed
Potamogeton crispus	Curly Pondweed
Potamogeton diversifolius	Waterthread Pondweed
Potamogeton epihydrus	Ribbonleaf Pondweed
Potamogeton foliosus	Leafy Pondweed
Potamogeton natans	Floatingleaf Pondweed
Potamogeton nodosus	Longleaf Pondweed
Potamogeton obtusifolius	Bluntleaf Pondweed
Potamogeton pectinatus	Sago Pondweed
Potamogeton perfoliatus	Thorowort Pondweed
Potamogeton pusillus	Baby Pondweed
Potamogeton robbinsii	Robbins Pondweed
Potamogeton strictifolius	Narrowleaf Pondweed
Ruppia maritima	Widgeon Grass
Zannichellia palustris	Horned Pondweed
Zostera marina	Eelgrass
Najadaceae	
Najas flexilis	Naiad
Najas gracillima	Naiad
Najas guadalupensis	Naiad
Alismataceae	
Alisma plantago-aquatica	Common Waterplantain
Alisma subcordatum	Subcordate Waterplantain
Sagittaria calycina	Hooded Arrowhead
Sagittaria engelmanniana	Engelmann Arrowhead
Sagittaria graminea	Grassy Arrowhead

Scientific Name	Plant Common Name
Sagittaria isoetiformis	Arrowhead
Sagittaria latifolia	Broadleaf Arrowhead
Sagittaria rigida	Bur Arrowhead
Sagittaria subulata	Owlleaf Arrowhead
Hydrocharitaceae	
Elodea canadensis	Waterweed
Elodea nuttallii	Waterweed
Vallisneria americana	Wild Celery
Gramineae	
Puccinellia pallida	Pale Manna Grass
Glyceria canadensis	Rattlesnake Manna Grass
Glyceria obtusa	Blunt Manna Grass
Glyceria septentrionalis	Eastern Manna Grass
Glyceria striata	Fowl Manna Grass
Poa palustris	Meadow Grass
Poa pratensis	Kentucky Bluegrass
Poa trivialis	Meadow Grass
Distichlis spicata	Spike Grass
Chasmanthium laxum	
Dactylis glomerata	Orchard Grass
Phragmites australis	Common Reed
Agropyron repens	Wheat Grass
Elymus virginicus	Wild Rye
Holcus lanatus	Velvet Grass
Danthonia sericea v. epilis	Wild Oat Grass
Calamagrostis canadensis	Bluejoint
Calamagrostis cinnoides	Hairyseed Reedgrass
Agrostis alba	Redtop
Agrostis scabra	Rough Bent Grass
Cinna arundinacea	Wood Reedgrass
Alopecurus pratensis	Meadow Foxtail
Phleum pratense	Timothy
Muhlenbergia sylvatica	Woodland Muhly
Muhlenbergia torreyana	New Jersey Muhly
Spartina alterniflora	Smooth Cordgrass
Spartina cynosuroides	Big Cordgrass
Spartina patens	Salt Hay Grass
Spartina pectinata	Slough Grass
Anthoxanthum odoratum	Sweet Vernal Grass
Phalaris arundinacea	Reed Canary Grass
Leersia oryzoides	Rice Cutgrass
Leersia virginica	White Grass
Zizania aquatica	Wild Rice
Digitaria sanguinalis	Finger Grass
Paspalum laeve	Field Paspalum
Panicum agrostoides	Panic Grass
Panicum amarum	Beach Panic Grass
Panicum dichotomiflorum	Fall Panicum
Panicum longifolium	Longleaf Panicum
Panicum verrucosum	Warty Panicum
Panicum virgatum	Switchgrass
Dichanthelium acicularae	Needle Panicum
Dichanthelium acuminatum	Pacific Panicum
Dichanthelium clandestinum	Deertongue
Dichanthelium dichotonum	Forked Panicum
Dichanthelium latifolium	Broad-leaved Panicum
Dichanthelium oligosanthes	Scribner Panicum
Dichanthelium scoparium	Velvet Panicum
Echinochloa crusgalli	Barnyard Grass
Echinochloa muricata	Barnyard Grass
Echinochloa walteri	Walter's Millet

Scientific Name	Plant Common Name
Setaria geniculata	Foxtail Grass
Setaria glauca	Yellow Foxtail Grass
Cenchrus tribuloides	Sandspur
Andropogon gerardii	Big Bluestem
Andropogon virginicus v. abbreviatus	Lowland Broomsedge
Schizachyrium scoparium	Little Bluestem
Sorghastrum nutans	Indian Grass
Coelorachis rugosa	Joint Grass
Cyperaceae	
Cyperus dentatus	Toothleaf Flatsedge
Cyperus erythrorhizos	Redroot Cyperus
Cyperus filicinus	Nuttall's Cyperus
Cyperus filiculmis	Slender Cyperus
Cyperus odoratus	Fragrant Flatsedge
Cyperus ovularis	Pine Barren Cyperus
Cyperus polystachyos	Many-spiked Flatsedge
Cyperus retrofractus	Rough Cyperus
Cyperus retrorsus	Cylinder Flatsedge
Cyperus rivularis	Nutgrass
Cyperus strigosus	Straw-colored Cyperus
Dulichium arundinaceum	Three-way Sedge
Eleocharis acicularis	Slender Spikerush
Eleocharis engelmanni	Engelmann's Spikerush
Eleocharis erythropoda	Creeping Spikerush
Eleocharis fallax	Creeping Spikerush
Eleocharis microcarpa	Torrey's Spikerush
Eleocharis obtusa	Blunt Spikerush
Eleocharis olivacea	Spikerush
Eleocharis ovata	Ovate Spikerush
Eleocharis palustris	Common Spikerush
Eleocharis parvula	Dwarf Spikerush
Eleocharis quadrangulata	Squarestem Spikerush
Eleocharis robbinsii	Trianglestem Spikerush
Eleocharis rostellata	Beaked Spikerush
Eleocharis smallii	Small's Spikerush
Eleocharis tenuis	Slender Spikerush
Eleocharis tricostata	Three-ribbed Spikerush
Eleocharis tuberculosa	Large Tubercled Spikerush
Fimbristylis castanea	Salt Marsh Fimbristylis
Fimbristylis autumnalis	Slender Fimbristylis
Scirpus acutus	Hardstem Bulrush
Scirpus americanus	Olney Three-square Bulrush
Scirpus atrocinctus	Green Bulrush
Scirpus atrovirens	Swamp Bulrush
Scirpus cylindricus	Woolgrass
Scirpus cyperinus	River Bulrush
Scirpus fluviatilis	Salt Marsh Bulrush
Scirpus maritimus	Panicled Bulrush
Scirpus microcarpus	Peck's Bulrush
Scirpus peckii	Common Three-square
Scirpus pungens	Weak Bulrush
Scirpus purshianus	Salt Marsh Bulrush
Scirpus robustus	Bluntscale Bulrush
Scirpus smithii	Water Bulrush
Scirpus subterminalis	Soft-stemmed Bulrush
Scirpus validus	Cottongrass
Eriophorum tenellum	Virginia Cottongrass
Eriophorum virginicum	Umbrella-sedge
Fuirena pumila	Hairy Umbrella-sedge
Fuirena squarrosa	White Beakrush
Rhynchospora alba	

Scientific Name	Plant Common Name
Rhynchospora capitellata	False Bog Rush
Rhynchospora cephalantha	Capitate Beakrush
Rhynchospora chalarocephala	Loose-headed Beakrush
Rhynchospora filifolia	Bristle-leaved Beakrush
Rhynchospora fusca	Brown Beakrush
Rhynchospora glomerata	Clustered Beakrush
Rhynchospora gracilenta	Slender Beakrush
Rhynchospora macrostachya	Horned Rush
Rhynchospora microcephala	Small-headed Beakrush
Rhynchospora oligantha	Few-flowered Beakrush
Rhynchospora pallida	Pale Beakrush
Rhynchospora torreyana	Torrey's Beakrush
Cladium mariscoides	Twigrush
Scleria minor	Slender Nutrush
Scleria reticularis	Netted Razorsedge
Scleria triglomerata	Whip-grass
Scleria verticillata	Low Nutgrass
Carex alata	Wingseed Sedge
Carex albolutescens	Sedge
Carex amphibola	Sedge
Carex annectens	Sedge
Carex barrattii	Sedge
Carex bullata	Bullsedge
Carex buxbaumii	Buxbaum Sedge
Carex canescens	Silvery Sedge
Carex collinsii	Sedge
Carex comosa	Longhair Sedge
Carex exilis	Coast Sedge
Carex flaccosperma	Sedge
Carex hormathodes	Sedge
Carex howei	Howe Sedge
Carex hystricina	Bottlebrush Sedge
Carex interior	Inland Sedge
Carex intumescens	Sedge
Carex lacustris	River Sedge
Carex lanuginosa	Wooly Sedge
Carex livida	Livid Sedge
Carex lonchocarpa	Sedge
Carex lupuliformis	Hoplike Sedge
Carex lupulina	Hop Sedge
Carex normalis	Sedge
Carex paupercula	Little Sedge
Carex rostrata	Beaked Sedge
Carex scoparia	Broom Sedge
Carex squarrosa	Sedge
Carex stipata	Sawbeak Sedge
Carex straminea	Sedge
Carex stricta	Tussock Sedge
Carex trisperma	Threeseeded Sedge
Carex typhina	Sedge
Carex venusta	Sedge
Carex vesicaria	Inflated Sedge
Carex vulpinoidea	Fox Sedge
Carex walteriana	Sedge
Araceae	
Arisaema dracontium	Jack-in-the-pulpit
Arisaema triphyllum	Jack-in-the-pulpit
Peltandra virginica	Arrow Arum
Symplocarpus foetidus	Skunk Cabbage
Calla palustris	Wild Calla
Acorus calamus	Sweet Flag
Orontium aquaticum	Golden Club

Scientific Name	Plant Common Name
Lemnaceae	
Spirodela polyrhiza	Big Duckweed
Lemna minor	Duckweed
Lemna perpusilla	Duckweed
Lemna trisulca	Star Duckweed
Lemna valdiviana	Valdivia Duckweed
Wolffia columbiana	Watermeal
Wolffiella floridana	Eastern Wolffiella
Eriocaulaceae	
Eriocaulon compressum	Pipewort
Eriocaulon decangulare	Ten-angle Pipewort
Eriocaulon parkeri	Parker's Pipewort
Eriocaulon septangulare	Pipewort
Xyridaceae	
Xyris caroliniana	Carolina Yellow-eyed Grass
Xyris difformis	Southern Yellow-eyed Grass
Xyris fimuriata	Fringed Yellow-eyed Grass
Xyris montana	Northern Yellow-eyed Grass
Xyris smalliana	Small's Yellow-eyed Grass
Xyris torta	Twisted Yellow-eyed Grass
Commelinaceae	
Commelina communis	Dayflower
Commelina virginica	Dayflower
Pontederiaceae	
Pontederia cordata	Pickerelweed
Zosterella dubia	Water Star-grass
Heteranthera reniformis	Roundleaf Mud Plantain
Juncaceae	
Juncus acuminatus	Tapertip Rush
Juncus balticus	Baltic Rush
Juncus biflorus	Turnflower Rush
Juncus bufonius	Toad Rush
Juncus caesariensis	New Jersey Rush
Juncus canadensis	Canada Rush
Juncus dichotomus	Forked Rush
Juncus effusus	Soft Rush
Juncus gerardii	Black Grass
Juncus marginatus	Shore Rush
Juncus militaris	Bayonet Rush
Juncus nodosus	Knotted Rush
Juncus pelocarpus	Bog Rush
Juncus repens	Creeping Rush
Juncus scirpoides	Needlepod Rush
Juncus subtilis	Creeping Rush
Juncus tenuis	Poverty Rush
Liliaceae	
Narthecium americanum	Bog Asphodel
Tolfieldia racemosa	False Asphodel
Xerophyllum asphodeloides	Turkeybeard
Helonias bullata	Swamp Pink
Amianthium muscaetoxicum	Fly-poison
Zigadenus leimanthoides	Pine Barren Deathcamas
Veratrum viride	False Hellebore
Melanthium virginicum	Bunchflower
Allium canadense	Wild Garlic
Allium tricoccum	Wild Leek
Allium vineale	Field Garlic

Scientific Name	Plant Common Name
Lilium canadense	Turk's Cap Lily
Erythronium umbilicatum	Trout Lily
Asparagus officinalis	Asparagus
Smilacina racemosa	False Solomon's Seal
Smilacina stellata	False Solomon's Seal
Maianthemum canadense	Canada Mayflower
Polygonatum biflorum	Solomon's Seal
Medeola virginiana	Indian Cucumber-root
Smilax glauca	Greenbriar
Smilax herbacea	Greenbriar
Smilax laurifolia	Bamboo-vine
Smilax rotundifolia	Common Greenbriar
Smilax pseudochina	Greenbriar
Smilax walteri	Walter's Greenbriar
Haemodoraceae	
Lophiola americana	Gold-crest
Lachnanthes caroliniana	Redroot
Dioscoreaceae	
Dioscorea villosa	Wild Yam
Amaryllidaceae	
Hypoxis hirsuta	Star Grass
Iridaceae	
Iris prismatica	Slender Blue Flag
Iris pseudacorus	Yellow Flag
Iris versicolor	Blue Flag
Sisyrinchium angustifolium	Blue-eyed Grass
Sisyrinchium atlanticum	Blue-eyed Grass
Orchidaceae	
Cypripedium acaule	Moccassin Flower
Platanthera blephariglottis	White Fringed Orchid
Platanthera ciliaris	Yellow Fringed Orchid
Platanthera clavellata	Green Rein Orchid
Platanthera cristata	Crested Fringed Orchid
Platanthera lacera	Ragged Fringed Orchid
Platanthera nivea	Snowy Orchid
Pogonia ophioglossoides	Rose Pogonia
Calopogon tuberosus	Grass Pink
Arethusa bulbosa	Arethusa
Spiranthes cernua	Nodding Ladies' Tresses
Spiranthes praecox	Southern Ladies' Tresses
Saururaceae	
Saururus cernuus	Lizard's Tail
Salicaceae	
Populus deltoides	Cottonwood
Populus tremuloides	Quaking Aspen
Salix alba	White Willow
Salix babylonica	Weeping Willow
Salix cordata	Heart-leaved Willow
Salix discolor	Pussy Willow
Salix lucida	Shining Willow
Salix nigra	Black Willow
Salix petiolaris	Meadow Willow
Salix rigida	Heart-leaved Willow
Salix sericea	Silky Willow

Scientific Name	Plant Common Name
Myricaceae	
Myrica gale	Sweet Gale
Myrica pensylvanica	Bayberry
Juglandaceae	
Juglans cinerea	Butternut
Juglans nigra	Black Walnut
Carya cordiformis	Bitternut
Carya ovata	Shagbark Hickory
Betulaceae	
Ostrya virginiana	Hop-hornbeam
Carpinus caroliniana	Ironwood
Betula alleghaniensis	Yellow Birch
Betula lenta	Sweet Birch
Betula nigra	River Birch
Betula populifolia	Gray Birch
Alnus rugosa	Speckled Alder
Alnus serrulata	Smooth Alder
Fagaceae	
Fagus grandifolia	Beech
Quercus alba	White Oak
Quercus bicolor	Swamp White Oak
Quercus falcata	Southern Red Oak
Quercus ilicifolia	Scrub Oak
Quercus michauxii	Swamp Chestnut Oak
Quercus nigra	Water Oak
Quercus palustris	Pin Oak
Quercus phellos	Willow Oak
Quercus prinus	Chestnut Oak
Quercus rubra	Red Oak
Ulmaceae	
Ulmus americana	American Elm
Ulmus rubra	Slippery Elm
Celtis occidentalis	Hackberry
Moraceae	
Morus alba	White Mulberry
Urticaceae	
Urtica dioica	Stinging Nettle
Laportea canadensis	Wood Nettle
Boehmeria cylindrica	False Nettle
Pilea pumila	Clearweed
Loranthaceae	
Phoradendron flavescens	Mistletoe
Santalaceae	
Comandra umbellata	Bastard Toad-flax
Aristolochiaceae	
Asarum canadense	Wild Ginger
Polygonaceae	
Rumex crispus	Sour Dock
Rumex obtusifolius	Bitter Dock
Rumex orbiculatus	Great Water Dock
Rumex verticillatus	Swamp Dock
Polygonum amphibium	Water Knotweed
Polygonum arifolium	Halberd-leaved Tearthumb

Scientific Name	Plant Common Name
Polygonum carey	Carey's Smartweed
Polygonum convolvulus	Black Bindweed
Polygonum hydropiper	Common Smartweed
Polygonum hydropiperoides	Mild Waterpepper
Polygonum lapathifolium	Smartweed
Polygonum orientale	Princess-feather
Polygonum pensylvanicum	Pennsylvania Smartweed
Polygonum persicaria	Lady's-thumb
Polygonum punctatum	Water Smartweed
Polygonum ramosissimum	Bushy Knotweed
Polygonum sagittatum	Arrow-leaved Tearthumb
Polygonum scandens	False Buckwheat
Polygonum virginianum	Virginia Smartweed
Chenopodiaceae	
Chenopodium album	Lamb's Quarters
Chenopodium ambrosioides	Mexican Tea
Atriplex arenaria	Seabeach Orach
Atriplex patula	Marsh Orach
Salicornia bigelovii	Glasswort
Salicornia europaea	Glasswort
Salicornia virginica	Perennial Glasswort
Suaeda linearis	Sea-blite
Suaeda maritima	Sea-blite
Salsola kali	Saltwort
Amaranthaceae	
Amaranthus cannabinus	Water Hemp
Phytolaccaceae	
Phytolacca americana	Pokeweed
Aizoaceae	
Mollugo verticillata	Carpetweed
Sesuvium maritimum	Sea Purslane
Portulacaceae	
Claytonia virginica	Spring Beauty
Caryophyllaceae	
Stellaria longifolia	Chickweed
Honkenya peploides	Seabeach Sandwort
Sagina decumbens	Trailing Pearlwort
Ceratophyllaceae	
Ceratophyllum demersum	Coontail
Nymphaeaceae	
Cabomba caroliniana	Fanwort
Brasenia schreberi	Water Shield
Nuphar luteum	Spatterdock
Nymphaea odorata	White Water Lily
Nymphaea tuberosa	Water Lily
Magnoliaceae	
Magnolia virginiana	Sweet Bay
Liriodendron tulipifera	Tulip Tree
Ranunculaceae	
Trollius laxus	Spreading Globeflower
Coptis trifolia	Goldthread
Caltha palustris	Marsh Marigold
Ranunculus abortivus	Kidneyleaf Buttercup

Scientific Name	Plant Common Name
Ranunculus bulbosus	Bulbous Buttercup
Ranunculus cymbalaria	Seaside Crowfoot
Ranunculus flabellaris	Yellow Water Crowfoot
Ranunculus longirostris	White Water Crowfoot
Ranunculus pensylvanicus	Bristly Buttercup
Ranunculus pusillus	Dwarf Buttercup
Ranunculus repens	Creeping Buttercup
Ranunculus sceleratus	Cursed Crowfoot
Ranunculus septentrionalis	Swamp Buttercup
Ranunculus subrigidus	White Water Crowfoot
Ranunculus tricophyllus	White Water Crowfoot
Thalictrum dioicum	Early Meadow Rue
Thalictrum pubescens	Tall Meadow Rue
Clematis virginiana	Virgin's Bower
Berberidaceae	
Podophyllum peltatum	May Apple
Berberis thunbergii	Barberry
Menispermaceae	
Menispermum canadense	Moonseed
Lauraceae	
Sassafras albidum	Sassafras
Lindera benzoin	Spicebush
Cruciferae	
Cakile edentula	Sea Rocket
Cardamine bulbosa	Spring Cress
Cardamine pensylvanica	Bitter Cress
Cardamine pratensis	Cuckoo-flower
Nasturtium officinale	Water Cress
Rorippa prostrata	Water Cress
Barbarea verna	Early Winter Cress
Barbarea vulgaris	Winter Cress
Alliaria petiolata	Garlic-mustard
Sarraceniaceae	
Sarracenia purpurea	Pitcher Plant
Droseraceae	
Drosera filiformis	Dew-thread
Drosera intermedia	Spatulate-leaved Sundew
Drosera linearis	Slender-leaved Sundew
Drosera rotundifolia	Round-leaved Sundew
Podostemaceae	
Podostemum ceratophyllum	Riverweed
Crassulaceae	
Penthorum sedoides	Ditch Stonecrop
Crassula aquatica	Pygmy-weed
Saxifragaceae	
Saxifraga pensylvanica	Swamp Saxifrage
Chrysosplenium americanum	Golden Saxifrage
Itea virginica	Virginia Sweetspire
Ribes americanum	Wild Black Currant
Hamamelidaceae	
Hamamelis virginiana	Witch Hazel
Liquidambar styraciflua	Sweet Gum
Platanaceae	
Platanus occidentalis	Sycamore

Scientific Name	Plant Common Name
Rosaceae	
Spiraea alba	Meadowsweet
Spiraea latifolia	Meadowsweet
Spiraea tomentosa	Steeplebush
Fragaria vesca	Woodland Strawberry
Fragaria virginiana	Common Strawberry
Duchesnea indica	Indian Strawberry
Potentilla palustris	Marsh Cinquefoil
Geum aleppicum	Avens
Geum canadense	White Avens
Geum laciniatum	Avens
Rubus allegheniensis	Allegheny Blackberry
Rubus argutus	Tall Raspberry
Rubus hispidus	Running Dewberry
Rubus occidentalis	Black Raspberry
Agrimonia gryposepala	Agrimony
Agrimonia parviflora	Agrimony
Sanguisorba canadensis	American Burnet
Rosa multiflora	Rose
Rosa palustris	Swamp Rose
Rosa rugosa	Seaside Rose
Rosa virginiana	Rose
Prunus pensylvanica	Pin Cherry
Prunus serotina	Black Cherry
Prunus virginiana	Choke-cherry
Aronia arbutifolia	Red Chokeberry
Aronia melanocarpa	Black Chokeberry
Amelanchier arborea	Shadbush
Amelanchier bartramiana	Bartram's Serviceberry
Amelanchier canadensis	Canada Serviceberry
Amelanchier intermedia	Shadbush
Caesalpiniaceae	
Cassia fasciculata	Partridge Pea
Cassia marilandica	Wild Senna
Leguminosae	
Trifolium pratense	Red Clover
Melilotus alba	White Sweet Clover
Melilotus officinalis	Yellow Sweet Clover
Desmodium canadense	Tick-trifoil
Desmodium paniculatum	Tick-trifoil
Aeschynomene virginica	Sensitive Joint Vetch
Strophostyles helveola	Beach Pea
Amphicarpaea bracteata	Hog Peanut
Oxalidaceae	
Oxalis stricta	Wood Sorrel
Geraniaceae	
Geranium maculatum	Wild Geranium
Linaceae	
Linum striatum	Flax
Linum virginianum	Flax
Polygalaceae	
Polygala brevifolia	Short-leaved Milkwort
Polygala cruciata	Cross-leaved Milkwort
Polygala lutea	Yellow Milkwort
Polygala nuttallii	Nuttall's Milkwort
Polygala sanguinea	Purple Milkwort
Polygala verticillata	Whorled Milkwort
Euphorbiaceae	
Acalypha virginica	Copperleaf
Euphorbia polygonifolia	Beach Spurge
Callitrichaceae	
Callitriche deflexa	Water Starwort
Callitriche heterophylla	Larger Water Starwort
Callitriche stagnalis	Green Water Starwort
Limnanthaceae	
Floerka proserpinacoides	False Mermaid
Anacardiaceae	
Toxicodendron radicans	Poison Ivy
Toxicodendron vernix	Poison Sumac
Aquifoliaceae	
Ilex glabra	Inkberry
Ilex laevigata	Smooth Winterberry
Ilex opaca	American Holly
Ilex verticillata	Winterberry
Nemopanthus mucronatus	Mountain Holly
Celastraceae	
Celastrus scandens	Bittersweet
Staphyleaceae	
Staphylea trifolia	Bladdernut
Aceraceae	
Acer negundo	Box Elder
Acer rubrum	Red Maple
Acer saccharinum	Silver Maple
Balsaminaceae	
Impatiens capensis	Jewelweed
Impatiens pallida	Pale Touch-me-not
Vitaceae	
Vitis riparia	Riverbank Grape
Parthenocissus quinquefolia	Virginia Creeper
Tiliaceae	
Tilia americana	Basswood
Malvaceae	
Kosteletzkya virginica	Seaside Mallow
Hibiscus moscheutos	Rose Mallow
Hypericaceae	
Hypericum adpressum	Shore St. John's-wort
Hypericum boreale	Northern St. John's-wort
Hypericum canadense	Canada St. John's-wort
Hypericum densiflorum	Dense St. John's-wort
Hypericum denticulatum	Coppery St. John's-wort
Hypericum mutilum	Dwarf St. John's-wort
Hypericum punctatum	Spotted St. John's-wort
Triadenum virginicum	Marsh St. John's-wort
Elatinaceae	
Elatine minima	Waterwort

Scientific Name	Plant Common Name
Violaceae	
Viola blanda	Sweet White Violet
Viola conspersa	American Dog Violet
Viola cucullata	Marsh Blue Violet
Viola lanceolata	Lance-leaved Violet
Viola pallens	Northern Blue Violet
Viola papilionacea	Common Blue Violet
Viola primulifolia	Primrose-leaved Violet
Viola striata	Cream Violet
Lythraceae	
Rotala ramosior	Toothcup
Decodon verticillatus	Water Willow
Lythrum lineare	Loosestrife
Lythrum salicaria	Purple Loosestrife
Melastomataceae	
Rhexia mariana	Meadow Beauty
Rhexia virginica	Meadow Beauty
Onagraceae	
Ludwigia alternifolia	Seed-box
Ludwigia hirtella	Spindle-root
Ludwigia linearis	Narrowleaf Seed-box
Ludwigia palustris	Water Purslane
Ludwigia sphaerocarpa	Spherical-fruited Seed-box
Epilobium angustifolium	Fireweed
Epilobium ciliatum	Hairy Willowherb
Epilobium coloratum	Purpleleaf Willowherb
Epilobium hirsutum	Hairy Willowherb
Oenothera biennis	Evening Primrose
Oenothera fruticosa	Sundrops
Oenothera humifusa	Seabeach Evening Primrose
Oenothera perennis	Evening Primrose
Circaea lutetiana	Enchanter's Nightshade
Halorrhagidaceae	
Myriophyllum heterophyllum	Variableleaf Water Milfoil
Myriophyllum humile	Lowly Water Milfoil
Myriophyllum spicatum	Common Water Milfoil
Myriophyllum tenellum	Water Milfoil
Proserpinaca palustris	Marsh Mermaidweed
Proserpinaca pectinata	Cutleaf Mermaidweed
Araliaceae	
Aralia spinosa	Hercules' Club
Umbelliferae	
Hydrocotyle americana	Water Pennywort
Hydrocotyle umbellata	Water Pennywort
Sanicula gregaria	Sanicle
Sanicula marilandica	Black Snakeroot
Cryptotaenia canadensis	Honewort
Osmorhiza claytoni	Sweet Cicely
Zizia aurea	Golden Alexanders
Conium maculatum	Poison Hemlock
Sium suave	Water Parsnip
Cicuta bulbifera	Water Hemlock
Cicuta maculata	Water Hemlock
Lilaeopsis chinensis	Eastern Lilaeopsis
Ptilimnium capillaceum	Mock Bishopweed
Angelica atropurpurea	Angelica
Oxypolis rigidior	Stiff Cowbane
Eryngium aquaticum	Eryngium
Cornaceae	
Cornus amomum	Silky Dogwood
Cornus foemina	Gray Dogwood
Cornus stolonifera	Red Osier Dogwood
Nyssa sylvatica	Black Gum
Clethraceae	
Clethra alnifolia	Sweet Pepperbush
Ericaceae	
Monotropa uniflora	Indian Pipe
Rhododendron maximum	Rose Bay
Rhododendron periclymenoides	Pinkstertlower
Rhododendron viscosum	Swamp Azalea
Leiophyllum buxifolium	Sand Myrtle
Kalmia angustifolia	Sheep Laurel
Kalmia latifolia	Mountain Laurel
Kalmia polifolia	Bog Laurel
Leucothoe racemosa	Fetterbush
Andromeda glaucophylla	Bog Rosemary
Lyonia ligustrina	Maleberry
Lyonia mariana	Staggerbush
Chamaedaphne calyculata	Leatherleaf
Gautheria procumbens	Wintergreen
Gaylussacia baccata	Black Huckleberry
Gaylussacia dumosa	Dwarf Huckleberry
Gaylussacia frondosa	Dangleberry
Vaccinium caesariense	New Jersey Blueberry
Vaccinium cespitosum	Dwarf Bilberry
Vaccinium corymbosum	Highbush Blueberry
Vaccinium macrocarpon	Big Cranberry
Vaccinium oxycoccos	Small Cranberry
Vaccinium pallidum	Blueberry
Primulaceae	
Lysimachia ciliata	Fringed Loosestrife
Lysimachia hybrida	Loosestrife
Lysimachia nummularia	Moneywort
Lysimachia quadrifolia	Whorled Loosestrife
Lysimachia terrestris	Swamp Candles
Lysimachia thyrsiflora	Tufted Loosestrife
Lysimachia vulgaris	Garden Loosestrife
Trientalis borealis	Starflower
Plumbaginaceae	
Limonium carolinianum	Sea Lavender
Limonium nashii	Sea Lavender
Ebenaceae	
Diospyros virginiana	Persimmon
Oleaceae	
Fraxinus americana	White Ash
Fraxinus pennsylvanica	Green Ash
Ligustrum vulgare	Privet
Gentianaceae	
Sabatia difformis	Marsh Pink
Sabatia dodecandra	Marsh Pink

Scientific Name	Plant Common Name
Sabatia stellaris	Marsh Pink
Gentiana autumnalis	Pine Barren Gentian
Gentiana saponaria	Soapwort Gentian
Gentianopsis crinita	Fringed Gentian
Bartonia paniculata	Twining Bartonia
Bartonia virginica	Bartonia
Menyanthes trifoliata	Buckbean
Nymphoides aquatica	Big Floating Heart
Nymphoides cordata	Little Floating Heart
Apocynaceae	
Apocynum cannabinum	Indian Hemp Dogbane
Asclepiadaceae	
Asclepias incarnata	Swamp Milkweed
Asclepias lanceolata	Milkweed
Asclepias rubra	Milkweed
Asclepias syriaca	Milkweed
Convolvulaceae	
Convolvulus sepium	Hedge Bindweed
Cuscuta compacta	Dodder
Cuscuta gronovii	Swamp Dodder
Hydrophyllaceae	
Hydrophyllum virginianum	Virginia Waterleaf
Boraginaceae	
Myosotis laxa	Forget-me-not
Myosotis scorpioides	True Forget-me-not
Hackelia virginiana	Stickseed
Mertensia virginica	Bluebell
Verbenaceae	
Verbena hastata	Blue Vervain
Verbena urticifolia	White Vervain
Labiatae	
Teucrium canadense	Germander
Scutellaria galericulata	Common Skullcap
Scutellaria integrifolia	Hyssop Skullcap
Scutellaria lateriflora	Mad-dog Skullcap
Prunella vulgaris	Self-heal
Stachys palustris	Woundwort
Stachys tenuifolia	Hedge Nettle
Pycnanthemum muticum	Mountain Mint
Pycnanthemum virginianum	Virginia Basil
Lycopus americanus	Water Horehound
Lycopus amplectens	Water Horehound
Lycopus uniflorus	One-flower Bugleweed
Lycopus virginicus	Bugleweed
Mentha arvensis	Wild Mint
Collinsonia canadensis	Horse-balm
Solanaceae	
Solanum dulcamara	Nightshade
Scrophulariaceae	
Gratiola aurea	Hedge Hyssop
Gratiola neglecta	Hedge Hyssop
Gratiola virginiana	Hedge Hyssop
Mimulus ringens	Square-stemmed Monkeyflower

Scientific Name	Plant Common Name
Lindernia dubia	False Pimpernel
Hemianthus micranthemoides	Nuttall's Micranthemum
Limosella aquatica	Mud-wort
Limosella subulata	Mud-wort
Chelone glabra	Turtlehead
Penstemon digitalis	Beard-tongue
Veronicastrum virginicum	Culver's Root
Veronica scutellata	Marsh Speedwell
Agalinis maritima	Seaside Gerardia
Agalinis purpurea	Purple Gerardia
Schwalbea americana	Chaffseed
Melampyrum lineare	Cowwheat
Bignoniaceae	
Campsis radicans	Trumpet Creeper
Catalpa speciosa	Catalpa
Conopholis americana	Squaw-root
Lentibulariaceae	
Utricularia biflora	Bladderwort
Utricularia cornuta	Horned Bladderwort
Utricularia fibrosa	Fiberous Bladderwort
Utricularia geminiscapa	Hidden-flower Bladderwort
Utricularia gibba	Humped Bladderwort
Utricularia inflata	Floating Bladderwort
Utricularia intermedia	Flat-leaved Bladderwort
Utricularia juncea	Rush Bladderwort
Utricularia macrorhiza	Common Bladderwort
Utricularia minor	Lesser Bladderwort
Utricularia purpurea	Purple Bladderwort
Utricularia resupinata	Lavender Bladderwort
Utricularia subulata	Zigzag Bladderwort
Plantaginaceae	
Plantago lanceolata	Plantain
Rubiaceae	
Mitchella repens	Partridge-berry
Cephalanthus occidentalis	Buttonbush
Galium asprellum	Rough Bedstraw
Galium tinctorium	Dye Bedstraw
Caprifoliaceae	
Viburnum acerifolium	Dockmackie
Viburnum cassinoides	Withe-rod
Viburnum dentatum	Southern Arrowwood
Viburnum lentago	Nannyberry
Viburnum nudum	Possumhaw
Viburnum opulus	Highbush Cranberry
Viburnum prunifolium	Black Haw
Viburnum recognitum	Northern Arrowwood
Sambucus canadensis	Common Elderberry
Lonicera japonica	Japanese Honeysuckle
Symphoricarpos albus	Snowberry
Cucurbitaceae	
Echinocystis lobata	Prickly Cucumber
Sicyos angulatus	Bur Cucumber
Campanulaceae	
Campanula aparinoides	Marsh Bellflower

Scientific Name	Plant Common Name
Lobeliaceae	
Lobelia canbyi	Lobelia
Lobelia cardinalis	Cardinal-flower
Lobelia nuttallii	Lobelia
Lobelia puberula	Downy Lobelia
Lobelia siphilitica	Great Lobelia
Lobelia spicata	Pale Spike Lobelia
Compositae	
Helianthus angustifolius	Swamp Sunflower
Helianthus decapetalus	Sunflower
Helianthus giganteus	Giant Sunflower
Helianthus tuberosa	Jerusalem Artichoke
Eclipta alba	Yerba-de-tajo
Rudbeckia hirta	Rough Coneflower
Rudbeckia laciniata	Cutleaf Coneflower
Helenium autumnale	Sneezeweed
Helenium flexuosum	Sneezeweed
Bidens bidentoides	Swamp Beggar-ticks
Bidens cernua	Nodding Beggar-ticks
Bidens connata	Swamp Beggar-ticks
Bidens coronata	Tickseed Sunflower
Bidens discoidea	Discoid Beggar-ticks
Bidens frondosa	Beggar-ticks
Bidens laevis	Bur Marigold
Coreopsis rosea	Tickseed
Iva frutescens	High-tide Bush
Ambrosia artemisifolia	Common Ragweed
Ambrosia trifida	Giant Ragweed
Xanthium strumarium	Cockebur
Achillea millefolium	Yarrow
Chrysanthemum leucanthemum	Ox-eye Daisy
Erechtites hieracifolia	Fireweed
Tussilago farfara	Coltsfoot
Heterotheca mariana	Golden Aster
Solidago canadensis	Canada Goldenrod
Solidago elliottii	Elliott's Goldenrod
Solidago elongata	Creek Goldenrod
Solidago fistulosa	Pine Barren Goldenrod
Solidago gigantea	Late Goldenrod
Solidago patula	Downy Goldenrod
Solidago rugosa	Wrinkled Goldenrod
Solidago sempervirens	Seaside Goldenrod
Solidago uliginosa	Bog Goldenrod
Euthamia galetorum	Narrow-leaved Goldenrod
Euthamia graminifolia	Grass-leaved Goldenrod
Aster dumosus	Bushy Aster
Aster ericoides	Heath Aster
Aster lateriflorus	Calico Aster
Aster nemoralis	Bog Aster
Aster novae-angliae	New England Aster
Aster novi-belgii	New York Aster
Aster puniceus	Swamp Aster
Aster simplex	Lowland White Aster
Aster spectabilis	Aster
Aster subulatus	Annual Salt Marsh Aster
Aster tenuifolius	Perennial Salt Marsh Aster
Aster umbellatus	Flattop Aster
Aster vimineus	Fairy Aster
Boltonia asteroides	Boltonia
Erigeron annuus	Daisy Fleabane
Baccharis halimifolia	Sea Myrtle
Pluchea camphorata	Camphorweed
Pluchea odorata	Marsh Fleabane
Pluchea purpuracens	Marsh Fleabane
Sclerolepis uniflora	
Eupatoriadelphus dubius	Joe-Pye-weed
Eupatoriadelphus fistulosus	Joe-Pye-weed
Eupatoriadelphus maculatus	Spotted Joe-Pye-weed
Eupatoriadelphus purpureus	Purple Joe-Pye-weed
Eupatorium album	Thoroughwort
Eupatorium leucolepis	White-bracted Thoroughwort
Eupatorium perfoliatum	Boneset
Eupatorium pilosum	Hairy Thoroughwort
Eupatorium resinosum	Resin Boneset
Eupatorium rotundifolium	Roundleaf Joe-Pye-weed
Eupatorium serotinum	Late Eupatorium
Mikania scandens	Climbing Hempweed
Liatris spicata	Blazing Star
Vernonia noveboracensis	New York Ironweed
Cirsium arvense	Canadian Thistle
Cirsium discolor	Thistle
Cirsium horridulum	Plumeless Thistle
Prenanthes alba	Rattlesnake-root
Prenanthes trifoliolata	Gall-of-the-earth
Lactuca biennis	Wild Lettuce
Lactuca canadensis	Canada Lettuce
Tragopogon porrifolius	Salsify

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* see Chapter 6 for references.

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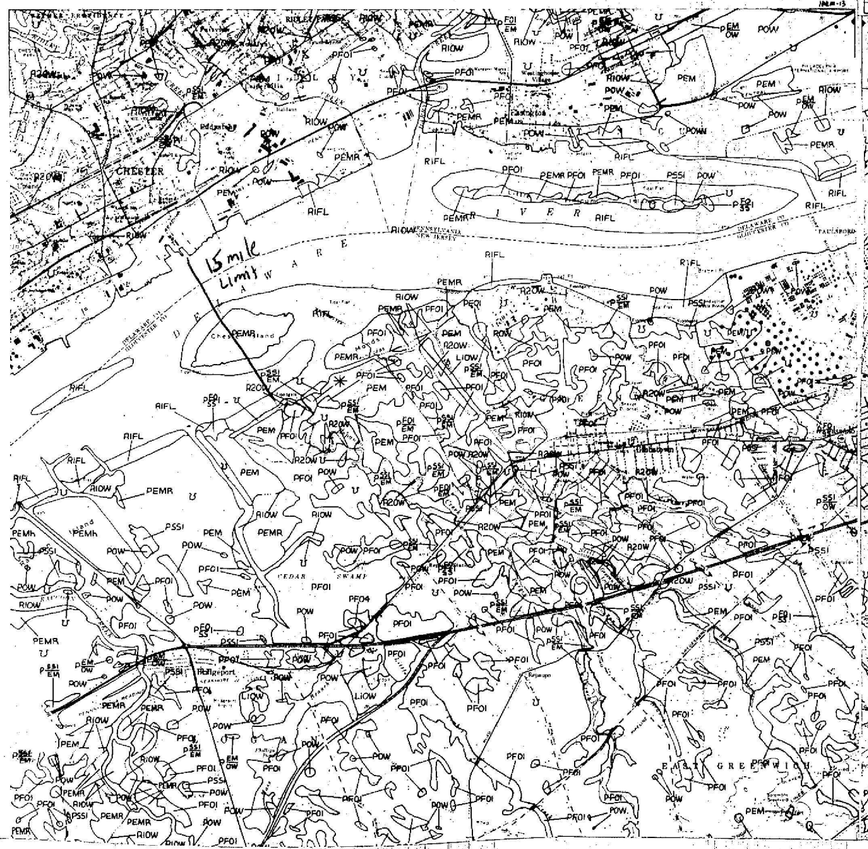

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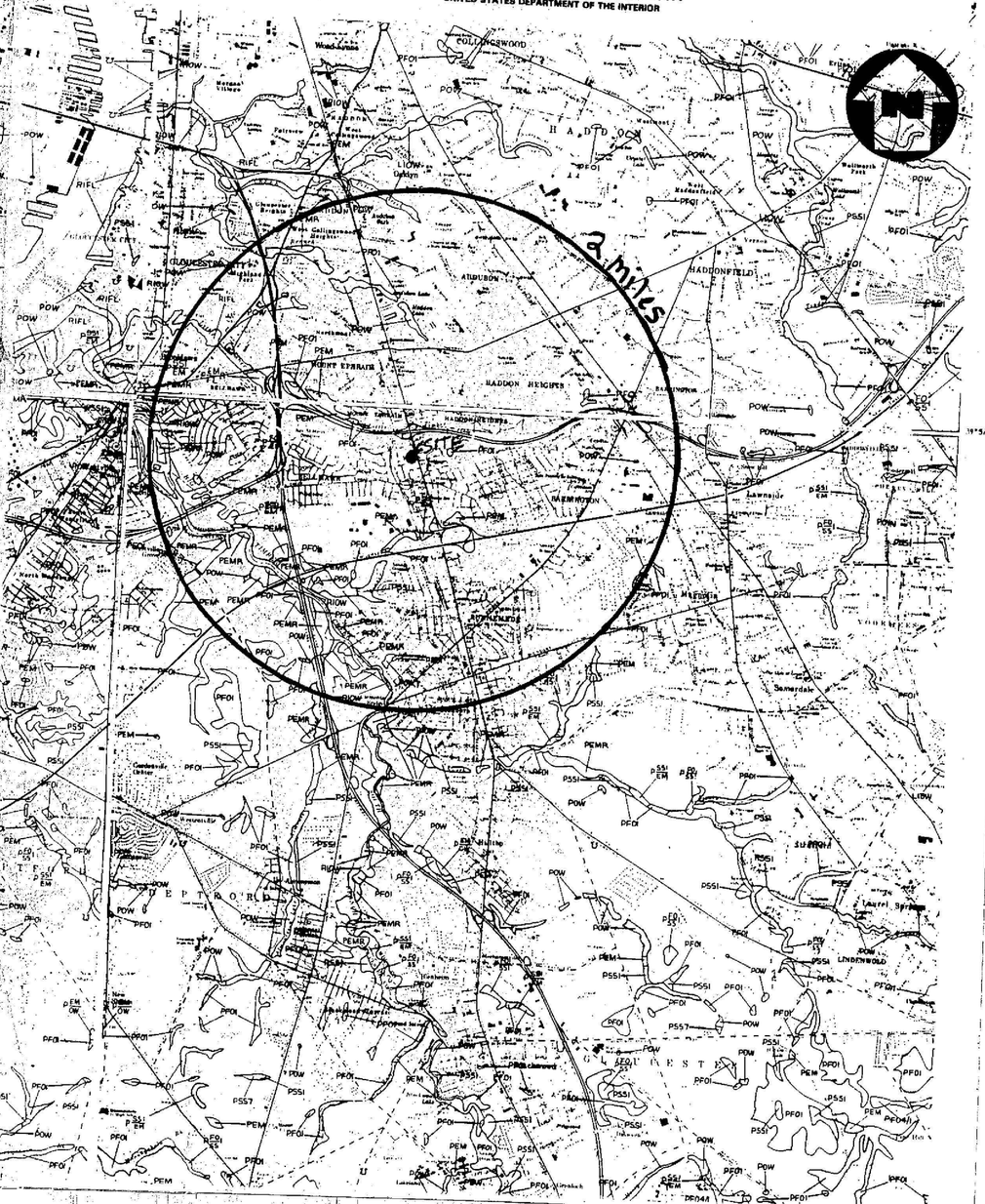
UNITED STATES DEPARTMENT OF THE INTERIOR



NUS CORPORATION

II

0706

FLAGS INCORPORATED
02-9011-22
TDD MANAGER-J. FILOSA
LOGBOOK #0706
JANUARY 9, 1991

Flags Incorporated

02-9011-22 1/22/91
2/27/91

Table of Contents

On-Site Reconnaissance 1/22/91 p4-6
Photo Log On-site Reconnaissance p. 7

Sampling Site Inspection 2/27/91 p8-14
Photo Log Sampling Site Inspection p 15-16

Sampling Information p 17-22

[signature] 1/22/91 [signature] 2-1-91

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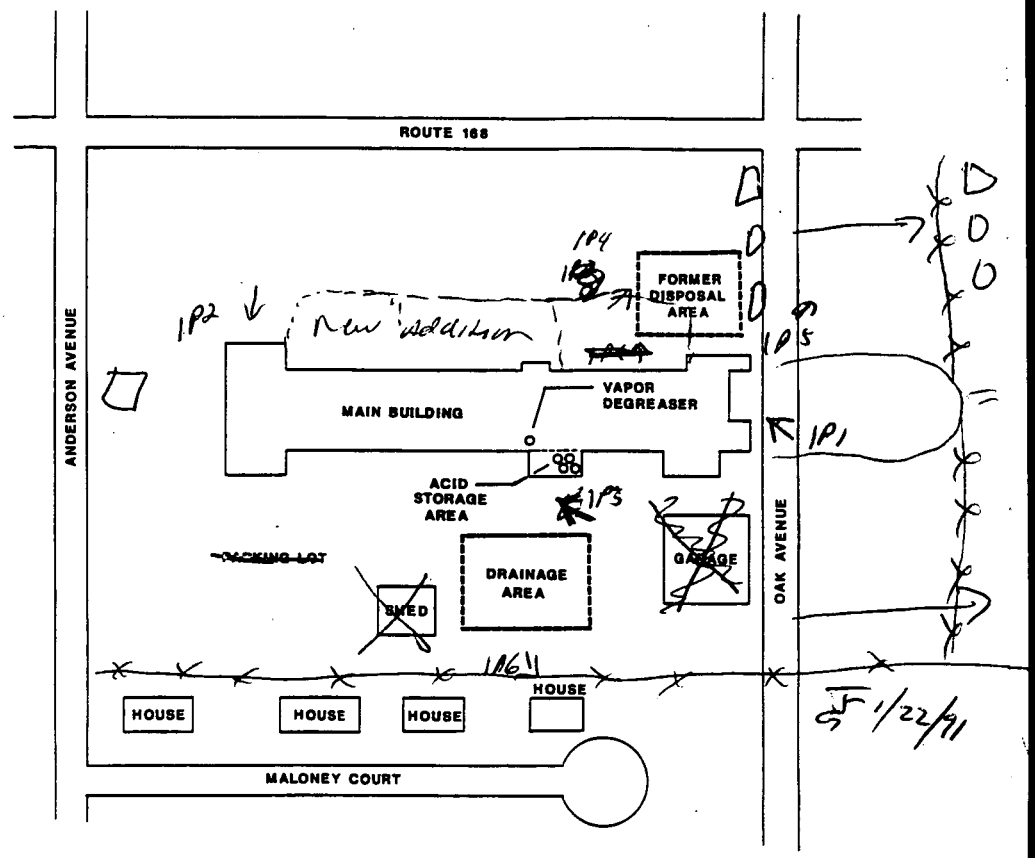


FIGURE 2

SITE MAP
FLAGS INC.,
BELLMAWR, N.J.
(NOT TO SCALE)

NUS CORPORATION

1/22/91 Laura Lefay 2-1-91

Flags Inc 02-9011-22

1/22/91

On-site Reconnaissance

~~Instrum~~ 1/22/91

Personell on site — Responsibility

Joe Filosa	JF	1/22/91	Site Manager
Kathy Indelicato	KI	1-22-91	Site Safety
Keith Billy	KB	1-22-91	Surveillance
Bill Foss	BF	1/22/91	Surveillance

The above personell have read + understand the work plan.

Instruments used on site	Background
OVA A 469759	0 ppm
HNU D 307144	0 ppm
mini RAD 469785	13 cpm
CAMERAS 428512/731692	—
compass 684179	—

Weather conditions:
Sunny Cold 15 °F winds 0-5 mph out of the NW

0930 Arrived on site

1/22/91

Laura Lilly 2-1-91

Flags Inc 02-9011-22 -
1/22/91

0931- met with mr purnell owner of Crucker barrel
he said they have been here for 5 years.
They are distributors of wooden displays for arts and crafts. There are 2 employees besides mr. purnell

0940 Begin setting up
15 houses within 200 feet of the site
No schools or Day care centers within 200 feet

1P1/151
0945 View of front of the building facing ~~NE~~ NW
1/22/91

0950 SSO Kathy Indelicato holds Tailgate Safety meeting Topics Discussed: Route to hospital Cold stress, site history
The following personell have read the Safety plan

Joe Filosa	[signature]	1/22/91
Kathy Indelicato	Kathy Indelicato	1-22-91
Bill Foss	[signature]	1/22/91
Keith Billy	Keith Billy	1-22-91

[signature] 1/22/91

Laura [signature] 2-1-91

Flags Inc 02-9011-22 1/22/91

0950 (cont'd) Fences surround southern + Eastern perimeters only
Access to the site is possible from the north + western sides.

0951 No evidence of stressed biota
or stained soil from the former degreaser sludge
dump area No readings from ova or Hnu

0955 observed New addition to building (metal prefab type)
No evidence of Air Discharge vents.

1P2/1S2
0955 View of building Facing SW

0958 Reconing Former NON Contact cooling H2O
discharge area. No signs of stressed biota No readings
on ova + Hnu. Area is covered with grass. The Dike has
1P3/ apparently been removed
1S3
0959 View of Former drainage area + Acid Storage
area Facing ~~NE~~ NW JE 1/22/91

1P4 1S4 / View of houses facing ~~SE~~ NE 1000

1P5/1S5 1001 View of former sludge Area Facing
NE

1004 1P6/1S6 View of houses facing ~~SW~~ SE JE 1/22/91
No Evidence of Hazardous Waste used by
Crackerbarrel Inc. No monitoring wells Anywhere on site.
No hazardous waste left
1010 Leaving the Site. by Flags anywhere on
site

[signature] 1/22/91 Laura Leibig 2-7-91

Flags Inc 02-9011-22 1/22/91

Photograph Log on-site Reconnaissance

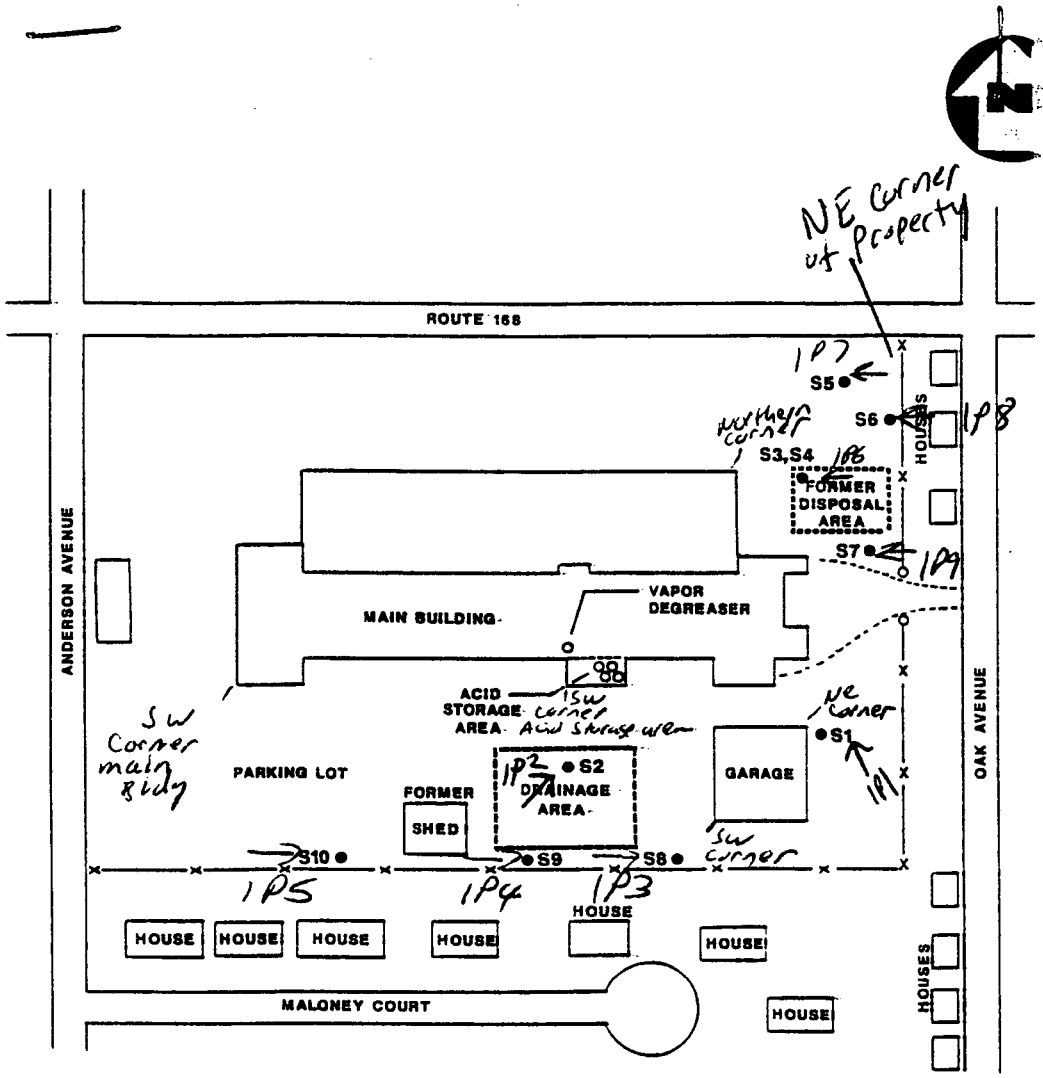
All Photos Taken by Joe Filosa

Picture/slide	Description	Time
1P1/1S1	View of Front of the building Facing Northwest.	0945
1P2/1S2	View of building facing Southwest	0955
1P3/1S3	View of former drainage area + Acid Storage Area facing Northwest	0959
1P4/1S4	View of nearby houses facing ~~Southeast~~ northeast 1/23/91	1000
1P5/1S5	View of former sludge area facing northeast.	1001
1P6/1S6	View of nearby Houses facing Southeast	1004

Joe Filosa 1/22/91

Laura Lutz 2-1-91

Flags Inc 92-9011-22
2/27/91



LEGEND

● SOIL SAMPLE LOCATION

FIGURE 2

PRE-SAMPLE LOCATION MAP

FLAGS INC.,

BELLMAWR, N.J.

(NOT TO SCALE)

NUS CORPORATION

2/27/91 2-28-91

Flags Inc 02-9011-22
Sampling Site Inspection 2/27/91

Personell on site		Responsibilities
Joe Filosa	2/27/91	Site Manager
Kathy Indelicato	2/27/91	Site Safety
Bill Foss	2/27/91	SMO
Keith Billy	KB 2-27-91	Sampler
Anthony Bonasera	2-27-91	Sampler

The Above personell have read and understood the workplan.

Equipment used on site		Background Readings
OVA L 469783		0 ppm
HNU J 469745		0 ppm
MINI-RAD 731691		0 mr/hr
CAMERAS 731695/ 469777		—
Compass 684177		—

Weather Conditions: Sunny cold, Temps 30-35°F winds 0-10 mph from the NW

0900 Arrived on site

2/27/91 2-27-91

Flags Inc 02-9011-22
2/27/91

0901 Begin setting up Decon area and Decon sampling equipment

1009 SSO Kathy Indelicato holds site safety meeting Topics Discussed Route to hospital Cold stress on site Hazards
personell present
Joe Filosa SM Joe Filosa 2/27/91
Kathy Indelicato SSO Kathy Indelicato 2-27-91
Bill Foss SMO [signature] 2/27/91
Anthony Bonasara Sampler [signature] 2/27/91
Keith Billy Sampler Keith Billy 2-27-91
All personell have read & understood the health & safety plan

1014 leaving Decon area + proceeding to location S1

1016 Arrived at location S1 surface soil sample collected at a bearing of 180° from northeastern corner of the garage NO readings on OVA or Hnu And 20 feet from the northern corner of the garage

1019 191/151 A Bonasara Collecting soil sample S1 facing NW

1023 leaving location S1 + proceeding to sampling location S2

1024 Arrived at sampling location S2 located in the former non contact cooling water discharge area

Joe Filosa 2/27/91 Laura Lafay 2-28-91

1040 Cont'd Met with local residence who lives along the southern perimeter of the site near sample location S8 I explained to her who we were what we were doing she remembered Flage Discharge area & even had made some complaints I gave her Larry Tannenbaum number.

[illegible] 2/27/91 Laura Lidy 2-28-91

Flags Inc 0d-SOIL-22
2/27/91

1025 A Bonasera begins collecting sample S2 0-6 inches beneath the surface sample location is at a bearing of 250° from the SW corner of the Acid Storage room and 14 feet from the same corner NO readings on OVA or HNU Soil is standard top soil

1028 1P2/1S2 A Bonasera collecting soil sample S2 from the former Drainage area facing NE

1031 leaving area S2 & returning to Decon area

1036 leaving Decon area & proceeding to sample location S8

1037 arrived at sample location S8 surface sample collected 0-6 inches beneath the surface at a bearing of 320° and 19 feet from the SW corner of the garage NO readings on ova or hnu Soil is standard top soil

1040 1P3/1S3 K Billy collecting surface sample S8 facing East

1048 Arrived at sample location S9 surface sample collected 0-6 inches beneath the surface at a bearing of 270° and 51 feet from the SW corner of the Acid Storage Room. NO readings on ova or hnu from either hole or bowl

1051 1P4/1S4 K Billy collecting soil sample S9 facing East.

[signature] 2/27/91 [signature] 2-28-91

Flugs Inc 02-9011-22
2/27/91

1057 Arrived At sampling location S10 ~~the~~ Surface sample 0-6 inches beneath the surface at a bearing of 240° and 49 feet from the SW corner of the main building No readings on OVA or HNU soil is Standard top soil

1100 IP5/155 K Billy collecting Soil sample S10 facing East

1102 returning to Decon area

1110 leaving Decon area + proceeding to sample location S3, S4

1111 arrived at sample S3, S4 in the former oil sludge disposal area subsurface sample collected by A Bonasera 4-6 feet beneath the surface at a bearing of 190° and 110 feet from the northern corner of the main building No readings on OVA or HNU from initial hole + 2 feet down soil is light (orange) colored and ~~sandy~~ & clayey with some rocks large rock was encountered so sample will be collected from 1½ to 3 feet beneath the surface NO readings on OVA or HNU No readings from the bowl on OVA or HNU

1125 IP6/156 A Bonasera collecting sub surface soil sample S3, and S4 facing west

1135 returning to Decon area

[signature] 2/27/91 Laura [signature] 2/28/91

Flags Inc 02-9011-22
2/27/91

1136 left Decon area + proceeded to sample location S5 Subsurface soil sample collected 4-6 feet beneath the surface by K billy at a bearing of 350° and 150 feet from the NE corner of the site property soil matrix is the same as samples S3+S4. NO readings on OVA or HNU from either hole or bowl

1145 1P7/1S7 K billy collecting sub surface soil sample S5 facing west

1153 returning to Decon area

1155 leaving Decon area + proceeding to sample location S6 surface soil sample collected by K Billy at a depth of 0-6 inches ~~beneath~~ at 2/27/91 the surface at a bearing of 340° and 65 feet from the North Eastern corner of the site NO readings from OVA or HNU. Soil is standard top soil

1159 K Billy collecting surface soil sample 1P8/1S8 S6 facing west no readings from the DINL on OVA or HNU

1201 returning to Decon area

1205 leaving decon area + proceeding to sample location S7

[signature] 2/27/91 [signature] 2-28-91

Flags Inc 02-9011-22
2/27/91

1207 Arrived at Sample location S7, a subsurface soil sample collected 4-6 feet beneath the surface by A Bonasara No readings on ova or hnu from initial hole. Sample taken at a bearing of 330° and 85 feet from the NE corner of the property Soil is same matrix as samples S3, S4, S5, No readings on ova or hnu at 4 feet beneath the surface

1215 IP9/ISG A Bonasara collecting subsurface soil sample S7 Facing west.

1220 Returning to Decon area begin deconing equipment, personell, and dismantling Decon area

1310 leaving site heading for Fed Express

1455 Arrived at Fed Express Edison
A total of 3 aqueous and 10 soil samples for organics analysis were shipped by NUS personell via Federal Express under Airbill No. 9802407075 to Ceimic CORP

A total of 3 aqueous and 10 soil samples for inorganics analysis were shipped by NUS personell via Federal Express under Airbill NO. 9802407101 to Natural Resources Labratory

1500 Returning to NUS Edison.

[signature] 2/27/91 [signature] 2-28-91

Flags Inc
02-9011-22 2/27/91

Photograph Log Site Inspection
All Photos taken by Joe FILOSA

Photo/Slide Number	Description	Time
1P1/1S1	View of A Bonasara collecting surface soil sample S1 facing northwest	1019
1P2/1S2	View of A Bonasara collecting surface soil sample S2 from the former Diked drainage area facing northeast	1028
1P3/1S3	View of K. Billy collecting surface soil sample S8 facing east	1040
1P4/1S4	View of K. Billy collecting surface soil sample S9 facing east	1051
1P5/1S5	View of K Billy collecting surface soil sample S10 facing East	1100
1P6/1S6	View of A Bonasara collecting subsurface soil samples S3, S4 from the former degreaser oil sludge disposal area facing west	1125
1P7/1S7	View of K Billy collecting subsurface soil sample S5 facing west	1145
1P8/1S8	View of K Billy collecting ~~[illegible]~~ surface soil sample S6 facing west	1159

2/27/91

Joe [illegible] 2/27/91 [illegible] 2-28-91

Flags Inc 02-9011-22 2/27/91

Photo Log Con'td

Photo / Slide Number	Description	Time
1P9/1S9/	View of A Bonastra collecting Subsurface Soil Sample S7 facing west	1215

[signature] 2/27/91 [signature] 2-28-91

United States Environmental Protection Agency
Contract Laboratory Program Sample Management Office
PO Box 818 Alexandria, VA 22313
703-557-2490 FTS 557-2490

EPA

Inorganic Traffic Report
(For CLP Use Only)

[redacted] Num[redacted] 15941

SAS [redacted] appl[redacted] ——

1. Type of Activity (Check one)
- [ ] ENF [ ] NPLD [ ] RA [X] SI [ ] STSI
- [ ] ER [ ] O&M [ ] RD [ ] ST [ ] Other *(Specify)*
- [ ] ESI [ ] PA [ ] RIFS [ ] STPA

Non-Superfund Program

Site Name: FLAGS INC.

City, State: BELLMAWR, NJ

Site Spill ID:

2. Region Number: 2

Sampling Co.: NUS-FIT

Sampler (Name): WILLIAM J. FOSS

3. Ship To: RICHARD SCHOTTLER
NATURAL RESOURCES LAB
409 CORPORATE CIRCLE
GOLDEN, CO 80401

4. Date Shipped: 2/27/91

Airbill Number: 9802407101

Carrier: FED-EX

Double volume required for matrix spike/duplicate aqueous sample.

Ship medium and high concentration samples in paint cans.

See reverse for additional instructions.

5. Sample Description *(Enter in Column A)*
1. Surface Water
2. Ground Water
3. Leachate
4. Rinsate
5. Soil/Sediment
6. Oil (SAS)
7. Waste (SAS)
8. Other (SAS) *(Specify)*

CLP Sample Number *(From labels)*	(A) Sample Description *(From box 1)*	(B) Concentration L=low M=med H=high	(C) RAS Analysis Total Metals	(C) RAS Analysis Cyanide	(D) Special Handling	(E) Station Location	(F) Date/Time of Sample Collection	(G) Corresponding Organic Sample Number
MBFQ01	5	L	X			NJHX-S1	2/27/91 1019	BHE 04
02	5	L	X		MS/MSD	S2	1028	05
03	5	L	X			S3	1125	06
04	5	L	X			S4	1125	07
05	5	L	X			S5	1145	08
06	5	L	X			S6	1159	09
07	5	L	X			S7	1215	10
08	5	L	X			S8	1040	11
09	5	L	X			S9	1051	12
10	5	L	X			S10	1100	13
11	4	L	X		BOWL	NJHXRIN1	1023	14
12	4	L	X		TROWEL	RIN2	1058	15
13	4	L	X		AUGER	RIN3	1200	16

EPA Form 9110-1 (8-88) Replaces EPA Form 2075-6, which may be used. Green - SMO Copy Pink - Region Copy White - Lab Copy for Return to SMO Yellow - Lab Copy

EPA

[redacted] Co[redacted] Labo[redacted] Progr[redacted] Sam[redacted]nage[redacted] Office[redacted]
PO Box 818 Alexandria, VA 22313
703-557-2490 FTS 557-2490

[redacted]rg[redacted]c T[redacted]c R[redacted]port [redacted]
(For CLP Use Only)

[redacted] 15941 [redacted]

1. Type of Activity (Check one)
- [ ] ENF [ ] NPLD [ ] RA [X] SI [ ] STSI
- [ ] ER [ ] O&M [ ] RD [ ] ST [ ] Other (Specify)
- [ ] ESI [ ] PA [ ] RIFS [ ] STPA

Non-Superfund Program

Site Name: FLAGS INC.

City, State: BELLMAWR, NJ

Site Spill ID:

2. Region Number: 2

Sampling Co.: NUSFIT

Sampler (Name): WILLIAM J. FOSS

3. Ship To:
VERONICA MORETTI
CEIMIC CORP.
100 DEAN KNAUSS DR.
S. TERRY IND. PARK
NARRAGANSETT, RI 02882

4. Date Shipped: 2/27/91

Airbill Number: 9802407075

Carrier: FED-EX

Triple volume required for matrix spike/duplicate aqueous sample.

Ship medium and high concentration samples in paint cans.

See reverse for additional instructions.

5. Sample Description (Enter in Column A)
1. Surface Water
2. Ground Water
3. Leachate
4. Rinsate
5. Soil/Sediment
6. Oil (SAS)
7. Waste (SAS)
8. Other (SAS) (Specify)

CLP Sample Number (From labels)	(A) Sample Description (From box 1)	(B) Concentration L=low M=med H=high	(C) RAS Analysis VOA	BNA	Pest/PCB	(D) Special Handling	(E) Station Location	(F) Date/Time of Sample Collection	(G) Corresponding CLP Inorganic Sample Number
BHE 04	5	L	X	X	X		NJHX-S1	2/27/91 1019	MBFQ 01
05	5	L	X	X	X	MS/MSD	S2	1028	02
06	5	L	X	X	X		S3	1125	03
07	5	L	X	X	X		S4	1125	04
08	5	L	X	X	X		S5	1145	05
09	5	L	X	X	X		S6	1159	06
10	5	L	X	X	X		S7	1215	07
11	5	L	X	X	X		S8	1040	08
12	5	L	X	X	X		S9	1051	09
13	5	L	X	X	X		S10	1100	10
14	4	L	X	X	X	BOWL	RIN1	1023	11
15	4	L	X	X	X	TROWEL	RIN2	1058	12
16	4	L	X	X	X	AUGER	RIN3	1200	13

EPA Form 9110-2 (8-88) Replaces EPA Form 2075-7, which may be used. Blue - SMO Copy Pink - Region Copy White - Lab Copy for Return to SMO Yellow - Lab Copy

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY — REGION II
Environmental Services Division
EDISON, NEW JERSEY 08817

1 of 2 TR ENCLOSED

02-9011-22

Name of Unit and Address: NUS Corporation
1090 King Georges Post Road
Suite 1103
Edison, NJ 08837

Sample Number	Number of Containers	Description of Samples
BHE04	3	1-40 ml vials, 1-8 oz. jar, low concentration soil
BHE05	6	4-40 ml vials, 2-8 oz. jars, low concentration soil MS/MSD
BHE06	3	2-40 ml vials, 1-8 oz. jar. low concentration soil
BHE07	3	2-40 ml vials, 1-8 oz. jar, low concentration soil
BHE08	3	2-40 ml vials, 1-8 oz. jar, low concentration soil
BHE09	3	2-40 ml vials, 1-8 oz. jar, low concentration soil
BHE10	3	2-40 ml vials, 1-8 oz. jar, low concentration soil
BHE11	3	2-40 ml vials, 1-8 oz. jar, low concentration soil
BHE12	3	2-40 ml vials, 1-8 oz. jar, low concentration soil
BHE13	3	2-40 ml vials, 1-8 oz. jar, low concentration soil

Person Assuming Responsibility for Sample: WILLIAM J. FOSS

Time: 1246 Date: 2/27/91

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
	WILLIAM J. FOSS				All samples shipped to lab for analysis.
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

Page No.

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY — REGION II
Environmental Services Division
EDISON, NEW JERSEY 08817

1 of 2 TR in 1 of 2

03-9011-02

Name of Unit and Address: NUS Corporation
1090 King Georges Post Road
Suite 1103
Edison, NJ 08837

Sample Number	Number of Containers	Description of Samples
BHE14	4	2-40 ml vials, 2-80 oz. amber bottles, low concentration water
BHE15	4	2-40 ml vials, 2-80 oz. amber bottles, low concentration water
BHE16	4	2-40 ml vials, 2-80 oz. amber bottles, low concentration water

Person Assuming Responsibility for Sample: WILLIAM J. FOSS [signature] Time 1255 Date 2/27/91

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
	WILLIAM J. FOSS [signature]				All samples shipped to lab for analysis.
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY – REGION II
Environmental Services Division
EDISON, NEW JERSEY 08817

of 1 TR ENCLOSED

02-5011-02

Name of Unit and Address: NOS Corporation
1090 King Georges Post Road
Suite 1103
Edison, NJ 08837

Sample Number	Number of Containers	Description of Samples
MBFQ01	1	4 oz. jar, low concentration soil
BFQ02	1	8 oz. jars, low concentration soil MS/MSD
BFQ03	1	8 oz. jar, low concentration soil
MBFQ04	1	8 oz. jar, low concentration soil
BFQ05	1	8 oz. jar, low concentration soil
BFQ06	1	8 oz. jar, low concentration soil
MBFQ07	1	8 oz. jar, low concentration soil
MBFQ08	1	8 oz. jar, low concentration soil
BFQ09	1	8 oz. jar, low concentration soil
BFQ10	1	8 oz. jar, low concentration soil
MBFQ11	1	1-liter poly bottles, low concentration water
BFQ12	1	1-liter poly bottles, low concentration water
BFQ13	1	1-liter poly bottles, low concentration water

Person Assuming Responsibility for Sample: WILLIAM J. FOSS *William Foss* — **Time:** 1300 **Date:** 2/27/91

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
	WILLIAM J. FOSS *William Foss*				All samples shipped to lab for analysis.
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

NUS-FIT SAMPLING INFORMATION

Site Name: FLAGS INC.

Case No.: 15941 SAS No.: ——

TDD/BRICS: 02-9011-22/NJHX

Sampling Date(s): 2/27/91

Shipping Date(s): 2/27/91

Laboratories: Organic: CEIATEC CORP

Inorganic: NATURAL RESOURCES LAB

Field SMO: Signature/Date: [illegible] 2/27/91

Sample Type	NUS Sample No.	Organic CLP No.	Inorganic CLP No.	QC Information	Comments
SOIL	NJHX-S1	BHE04	MBFQ01		
	S2	05	02	MS/MSD	
	S3	06	03	DUPLICATE OF NJHX-S4	
	S4	07	04	DUPLICATE OF NJHX-S3	
	S5	08	05		
	S6	09	06		
	S7	10	07		
	S8	11	08		
	S9	12	09		
	S10	13	10		
RIN	RIN 1	14	11	BOWL	
	RIN 2	15	12	TROWEL	
	RIN 3	16	13	AUGER	

List samples in the following order: groundwater (GW), surfacewater (SW), sediment (SED), Soils (S), Rinsate blanks (RIN), Trip blanks (TBLK)

FEDERAL EXPRESS

USE THIS AIRBILL FOR SHIPMENTS WITHIN THE CONTINENTAL U.S.A., ALASKA AND HAWAII.
USE THE INTERNATIONAL AIR WAYBILL FOR SHIPMENTS TO PUERTO RICO AND ALL NON U.S. LOCATIONS
QUESTIONS? CALL 800-238-5355 TOLL FREE.

AIRBILL
PACKAGE TRACKING NUMBER
9802407101

1023N 9802407101

Sender's Federal Express Account Number: 1060-8152-2
Date: 2/27/91

1 From (Your Name) Please Print: WILLIAM J. FOSS
Your Phone Number (Very Important): 201-225-6160
Company: NUS CORPORATION
Department/Floor No:
Street Address: 1090 KING GEORGES POST RD 1103
City: EDISON State: NJ ZIP Required: 08837

2 To (Recipient's Name) Please Print: RICHARD SCHOTTLER
Recipient's Phone Number (Very Important): (303) 278-1868
Company: NATURAL RESOURCES LABORATORY
Department/Floor No:
Exact Street Address (We Cannot Deliver to P.O. Boxes or P.O. Zip + Codes.): 409 CORPORATE CIRCLE
City: GOLDEN, CO State: ZIP Required: 80401

YOUR INTERNAL BILLING REFERENCE INFORMATION (First 24 characters will appear on invoice.): NJHX-I

H IF HOLD FOR PICK-UP, Print FEDEX Address Here
Street Address:
City: State: ZIP Required:

3 PAYMENT 1 [X] Bill Sender 2 [ ] Bill Recipient's FedEx Acct No 3 [ ] Bill 3rd Party FedEx Acct No 4 [ ] Bill Credit Card 5 [ ] Cash/Check
Acct./Credit Card No: 1060-8152-2 Exp Date:

4 SERVICES (Check only one box)

	Priority Overnight Service (Delivery by next business morning †)		Standard Overnight Service (Delivery by next business afternoon †)
11	[X] YOUR PACKAGING	51	[ ]
16	[ ] FEDEX LETTER *	56	[ ] FEDEX LETTER *
12	[ ] FEDEX PAK *	52	[ ] FEDEX PAK *
13	[ ] FEDEX BOX	53	[ ] FEDEX BOX
14	[ ] FEDEX TUBE	54	[ ] FEDEX TUBE
	Economy Two-Day (formerly Standard Air) (Delivery by second business day †)		Priority One-Day (for Extra Large or any package over 150 lbs)
30	[ ] ECONOMY TWO-DAY SVC.	70	[ ] HEAVYWEIGHT **
		80	[ ] DEFERRED HEAVYWEIGHT **

† Delivery commitment may be later in some areas
* Declared Value Limit $100
** Call for delivery schedule

DELIVERY AND SPECIAL HANDLING (Check services required)

1 [ ] HOLD FOR PICK-UP (Fill in Box H)
2 [X] DELIVER WEEKDAY
3 DELIVER SATURDAY (Extra charge) (Not available to all locations) [ ]
4 [ ] DANGEROUS GOODS (Extra charge)
5 [ ]
6 [ ] DRY ICE Lbs
7 [ ] OTHER SPECIAL SERVICE
8 [ ]
9 [ ] SATURDAY PICK-UP
10 [ ]
11 [ ]
12 [ ] HOLIDAY DELIVERY (If offered) (Extra charge)

PACKAGES	WEIGHT In Pounds Only	YOUR DECLARED VALUE (See right)
Total	Total 149	Total

90368

SERVICE CONDITIONS, DECLARED VALUE AND LIMIT OF LIABILITY

Use of this airbill constitutes your agreement to the service conditions in our current Service Guide, available upon request. See back of sender's copy of this airbill for information.

We will not be responsible for any claim in excess of $100 per package, whether the result of loss, damage, delay, non-delivery, misdelivery, or misinformation, unless you declare a higher value, pay an additional charge, and document your actual loss for a timely claim. Maximum amount limitations found in the current Federal Express Service Guide apply. Your right to recover from Federal Express for any loss, including intrinsic value of the package, loss of sales, income interest, profit, attorney's fees, costs, and other forms of damage whether direct, incidental, consequential, or special is limited to the greater of $100 or the declared value specified to the left. Recovery cannot exceed actual documented loss. The maximum Declared Value for FedEx Letter and FedEx Pak packages is $100.00.

In the event of untimely delivery, Federal Express will at your request and with some limitations, refund all transportation charges paid. See Service Guide for further information.

Sender authorizes Federal Express to deliver this shipment without obtaining a delivery signature and shall indemnify and hold harmless Federal Express from any claims resulting therefrom.

5 Release Signature: 2-27-91 1455

REVISION DATE 8/90
FORMAT #041
041

SHIPMENT LABELS

QUESTIONS? CALL 800-238-5355 TOLL FREE

TRACKING NUMBER

1C23N 9802407075

NT 2-27-91

R MBER 9802407075

2 8334096251

TION

OF 8334096267

IPTION

OF 8334096276

RIPTION

OF 8334096285

CRIPTION

OF 8334096294

SCRIPTION

ART #106972 REV 4/90 © 1990 F.E.C.
ENDER'S COPY FORMAT #028 WCS 11-90

Sender's Federal Express Account Number: 1060-8152-2

Date: 2/27/91

1 From (Your Name) Please Print: WILLIAM J. FOSS

Your Phone Number (Very Important): 201-225-6160

Company: NUS CORPORATION

Department/Floor No.:

Street Address: 1090 KING GEORGES POST RD 1103

City: EDISON State: NJ ZIP Required: 08837

2 To (Recipient's Name) Please Print: VERONICA MORETTI

Recipient's Phone Number (Very Important): (401) 782-8900

Company: CEIMIC CORP.

Department/Floor No.:

Exact Street Address (We Cannot Deliver to P.O. Boxes or P.O. Zip Codes.): 100 DEAN KNAUSS DR. S. TERRY IND. PARK

City: NARRAGANSETT, RI State: ZIP Required: 02882

YOUR INTERNAL BILLING REFERENCE INFORMATION (First 24 characters will appear on invoice.): NJHX-0

H IF HOLD FOR PICK-UP, Print FEDEX Address Here
Street Address
City State ZIP Required

3 PAYMENT 1 [X] Bill Sender 2 [ ] Bill Recipient's FedEx Acct No 3 [ ] Bill 3rd Party FedEx Acct No 4 [ ] Bill Credit Card 5 [ ] Cash/Check

Acct/Credit Card No 1060-8152-2 Exp. Date /

4 SERVICES (Check only one box)

Priority Overnight Service (Delivery by next business morning†)
11 [X] YOUR PACKAGING
16 [ ] FEDEX LETTER *
12 [ ] FEDEX PAK *
13 [ ] FEDEX BOX
14 [ ] FEDEX TUBE

Standard Overnight Service (Delivery by next business afternoon†)
51 [ ]
56 [ ] FEDEX LETTER *
52 [ ] FEDEX PAK *
53 [ ] FEDEX BOX
54 [ ] FEDEX TUBE

Economy Two-Day Service (formerly Standard Air) (Delivery by second business day†)
30 [ ] ECONOMY TWO-DAY SVC

Heavyweight Service (for Extra Large or any package over 150 lbs.)
70 [ ] HEAVYWEIGHT **
80 [ ] DEFERRED HEAVYWEIGHT **

† Delivery commitment may be later in some areas.
*Declared Value Limit $100
**Call for delivery schedule.

DELIVERY AND SPECIAL HANDLING (Check services required)
1 [ ] HOLD FOR PICK-UP (Fill in Box H)
2 [ ] DELIVER WEEKDAY
3 DELIVER SATURDAY (Extra charge) (Not available to all locations) [ ]
4 [ ] DANGEROUS GOODS (Extra charge)
5 [ ]
6 [ ] DRY ICE Lbs
7 [ ] OTHER SPECIAL SERVICE
8 [ ]
9 [ ] SATURDAY PICK-UP
10 [ ]
11 [ ]
12 [ ] HOLIDAY DELIVERY (If offered) (Extra charge)

PACKAGES	WEIGHT In Pounds Only	YOUR DECLARED VALUE (See right)
1	49	
1	73	
Total 2	Total	Total

DIM SHIPMENT

Received At

Fed Exp Emp No 90368 2-27-91 1455

SERVICE CONDITIONS, DECLARED VALUE AND LIMIT OF LIABILITY

Use of this airbill constitutes your agreement to the service conditions in our current Service Guide, available upon request. See back of sender's copy of this airbill for information.

We will not be responsible for any claim in excess of $100 per package, whether the result of loss, damage, delay, non-delivery, misdelivery, or misinformation, unless you declare a higher value, pay an additional charge, and document your actual loss for a timely claim. Maximum amount limitations found in the current Federal Express Service Guide apply. Your right to recover from Federal Express for any loss, including intrinsic value of the package, loss of sales, income interest, profit, attorney's fees, costs, and other forms of damage whether direct, incidental, consequential, or special is limited to the greater of $100 or the declared value specified to the left. Recovery cannot exceed actual documented loss. The maximum Declared Value for FedEx Letter and FedEx Pak packages is $100.00.

In the event of untimely delivery, Federal Express will at your request and with some limitations, refund all transportation charges paid. See Service Guide for further information.

5 Sender authorizes Federal Express to deliver this shipment without obtaining a delivery signature and shall indemnify and hold harmless Federal Express from any claims resulting therefrom.

Release Signature:

REVISION DATE 8/90

FORMAT #041

041

RECEIPT FOR SAMPLES AND DOCUMENTS

DATE OF SAMPLE COLLECTION	2/27/91
NAME OF FACILITY	Flags Incorporated AKA Crackerbarrel Inc.
FACILITY LOCATION	41 Oak Avenue Bellmawr Camden Co. NJ

RECEIPT OF THE DOCUMENT(S) AND/OR SAMPLE(S) DESCRIBED IS HEREBY ACKNOWLEDGED:

NO.	DESCRIPTION
4	Subsurface Soil Samples
6	Surface Soil Samples

TRANSFERRED BY (Signature)		RECIPIENT SIGNATURE	
NAME Joseph G Filosa		NAME Blaine Purnell	
TITLE Site Manager	DATE SIGNED 2/27/91	TITLE Owner	DATE SIGNED 2/27/91

REFERENCE NO. 27

GSC-TR8645

GRAPHICAL EXPOSURE MODELING SYSTEM

(GEMS)

USER'S GUIDE

VOLUME 2. MODELING

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
EXPOSURE EVALUATION DIVISION
Task No. 3-2
Contract No. 68023970
Project Officer: Russell Kinerson
Task Manager: Loren Hall

Prepared by:

GENERAL SCIENCES CORPORATION
8401 Corporate Drive
Landover, Maryland 20785

Submitted: December 1, 1986

> I

FLAGS INCORPORATED
LATITUDE 39:52: 9 LONGITUDE 75: 4:55 1980 POPULATION

KM	0.00-.400	.400-.810	.810-1.60	1.60-3.20	3.20-4.80	4.80-6.40	SECTOR TOTALS
S 1	1210	2022	11239	41866	65961	76653	198951
RING TOTALS	1210	2022	11239	41866	65961	76653	198951

> I

FLAGS INCORPORATED
LATITUDE 39:52: 9 LONGITUDE 75: 4:55 1980 HOUSING

KM	0.00-.400	.400-.810	.810-1.60	1.60-3.20	3.20-4.80	4.80-6.40	SECTOR TOTALS
S 1	416	713	3872	15112	24966	26670	71749
RING TOTALS	416	713	3872	15112	24966	26670	71749

	.25 mile	.5 mile	1 mile	2 miles	3 miles	4 miles
1980 Population	1,210	3,232	14,471	56,337	122,298	198,951
1980 Housing	416	1,129	5,001	20,113	45,079	71,749

REFERENCE NO. 28

NATURAL LANDS MANAGEMENT

CAUTIONS AND RESTRICTIONS ON NATURAL HERITAGE DATA

The quantity and quality of data collected by the Natural Heritage Program is dependent on the research and observations of many individuals and organizations. Not all of this information is the result of comprehensive or site-specific field surveys. Some natural areas in New Jersey have never been thoroughly surveyed. As a result, new locations for plant and animal species are continuously added to the data base. Since data acquisition is a dynamic, ongoing process, this Office cannot provide a definitive statement on the presence, absence, or condition of biological elements in any part of New Jersey. Information supplied by the Natural Heritage Program summarizes existing data known to the program at the time of the request regarding the biological elements or location in question. The information should never be regarded as final statements on the elements or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments. The attached data is provided as one source of information to assist others in the preservation of natural diversity.

This office cannot provide a letter of interpretation or a statement addressing the classification of wetlands as defined by the Freshwater Wetlands Act. Requests for such determination should be sent to the DEP Division of Coastal Resources, Bureau of Freshwater Wetlands, CN 402, Trenton, NJ 08625.

Information provided by this database may not be published without first obtaining the written permission of the Office of Natural Lands Management. In addition, the Natural Heritage Program must be credited as an information source in any publication of data.

EXPLANATION OF CODES ON NATURAL HERITAGE LIST

1. FEDERAL STATUS CODES

U.S.FISH AND WILDLIFE CATEGORIES OF ENDANGERED AND THREATENED PLANTS AND ANIMALS

The following definitions are extracted from the September 27, 1985 U.S. Fish and Wildlife Service notice in the Federal Register:

LE--Taxa formally listed as endangered.

LT--Taxa formally listed as threatened.

PE--Taxa proposed to be formally listed as endangered.

PT--Taxa proposed to be formally listed as threatened.

S --Synonyms.

C1--Taxa for which the Service currently has on file substantial information on biological vulnerability and threat(s) to support the appropriateness of proposing to list them as endangered or threatened species.

C2 --Taxa for which information now in possession of the Service indicates that proposing to list them as endangered or threatened species possibly appropriate, but for which substantial data on biological vulnerability and threat(s) are not currently known or on file to support the immediate preparation of rules.

C3 --Taxa that are no longer being considered for listing as threatened or endangered species. Such taxa are further coded to indicate three subcategories, depending on the reason(s) for removal from consideration.

> 3A--Taxa for which the Service has persuasive evidence of extinction.
>
> 3B--Names that, on the basis of current taxonomic understanding, usually as represented in published revisions and monographs, do not represent taxa meeting the Act's definition of "species".
>
> 3C--Taxa that have proven to be more abundant or widespread than was previously believed and/or those that are not subject to any identifiable threat.

2. STATE STATUS CODES

These refer to State listed nongame animals and Pinelands listed plants:

D	= declining
EX	= extirpated
I	= introduced
IN	= increasing
LE	= state listed as endangered
LP	= plants listed by the N.J. Pinelands Commission
LT	= state listed as threatened
P	= peripheral
S	= stable
SC	= special concern
U	= undetermined
U:SC	= undetermined, of special concern

Status for animals separated by a slash(/) indicate a duel status. First status refers to the state breeding population, and the second status refers to the migratory or winter population.

3. EXPLANATION OF NATURAL HERITAGE PRIORITY ELEMENT RANKS

The Nature Conservancy has developed a rarity ranking system* for use in identifying elements (rare species and natural communities) of natural diversity most endangered with extinction. Each element is ranked according to it's rarity both in the state and globally. These ranks are used to prioritize conservation work so that the rarest most endangered elements receive attention first.

GLOBAL ELEMENT RANKS

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 = 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 western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout it's range; in terms of occurrences, in the range of 21 to 100.

G4 = Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.

G5 = Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

*This ranking system is adapted from that which appears in 'The Nature Conservancy, 1988. Model Heritage Operations Manual. The Nature Conservancy. Arlington VA'.

GH = Of historical occurrence throughout its range i.e., formerly part of the established biota, with the expectation that it may be rediscovered.

GU = Possibly in peril range-wide but status uncertain; need more information.

GX = Believed to be extinct throughout range (e.g., Passenger Pigeon) with virtually no likelihood that it will be rediscovered.

G? = Species has not yet been ranked.

STATE ELEMENT RANKS

S1 = Critically imperiled in state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres). Elements so ranked are often restricted to very specialized conditions or habitats and/or restricted to an extremely small geographical area of the state. Also included are elements which were formerly more abundant, but now through habitat destruction or some other critical factor of its biology have been demonstrably reduced in abundance. In essence, these are elements that even with intensive searching sizable additional occurrences are unlikely to be discovered.

S2 = Imperiled in state because of rarity (6 to 20 occurrences). Historically many of these elements may have been more frequent but are now known from very few extant occurrences. Habitat destruction being the primary cause of their rarity. Diligent searching may yield additional occurrences.

S3 = Rare in state with 21 to 100 occurrences (plant species in this category have only 21 to 50 occurrences). Includes elements which are widely distributed in the state but with small populations/acreages or elements with restricted distribution, but locally abundant. Not yet imperiled in state but may soon be if current trends continue. Searching often yields additional occurrences.

S4 = Apparently secure in state, with many occurrences.

S5 = Demonstrably secure in state and essentially ineradicable under present conditions.

SA = Accidental in state, including species (usually birds or butterflies) recorded once or twice or only at very great intervals, hundreds or even thousands of miles outside their usual range; a few of these species may even have bred on the one or two occasions they were recorded; examples include european strays or western birds on the East Coast and visa-versa.

SE = A species clearly exotic in New Jersey which includes those species not native to North America as well as any other species deliberately or accidentally introduced into the state and are therefore not a conservation priority (viable introduced occurrences of G1 or G2 elements may be exceptions).

SH = Despite some searching of both historic occurrences and suitable habitat, no extant occurrences are known. Not all historic occurrences have been checked, and unsearched potential habitat remains. Until all leads are reasonably exhausted, elements ranked SH are considered possibly extant. While the last observed dates for most elements ranked SH are 50 or more years old, elements observed much more recently are also included when the only known occurrences have been destroyed.

SN = Regularly occurring, usually migratory and typically nonbreeding species for which no significant or effective habitat conservation measures can be taken in the state; this category includes migratory birds, bats, sea turtles, and cetaceans which do not breed in the state but pass through twice a year or may remain in the winter (or, in a few cases, the summer); included also are certain lepidoptera which regularly migrate to a state where they reproduce, but then completely die out every year with no return migration. Species in this category are so widely and unreliably distributed during migration or in winter that no small set of sites could be set aside with the hope of significantly furthering their conservation. Other nonbreeding, high globally-ranked species (such as the bald eagle, whooping

crane or some seal species) which regularly spend some portion of the year at definite localities (and therefore have a valid conservation need in the state) are not ranked SN but rather S1, S2, etc.

SR = Reported from the state, but without persuasive documentation which would provide a basis for either accepting or rejecting (e.g., misidentified specimen) the report. Some of these are very recent discoveries for which NJNHP has not yet received first-hand information; others are old, obscure reports that are hard to dismiss because the habitat is now destroyed.

SRF = Reported falsely (in error) from New Jersey but this error persisting in the literature.

SU = Believed to be in peril but status uncertain. More information is needed to rank accurately.

SX = Apparently extirpated from state. All historic occurrences checked and a thorough search of potential habitat completed. The localities for many of these elements have been destroyed or greatly altered.

SXC = Species is presumed extirpated from the state but native populations collected from wild exist in cultivation.

Note: A 'T' appearing in either the G Rank or S Rank, indicates that the infraspecific taxa is being ranked differently than the species. A 'Q' in the rank indicates That there is taxonomic uncertainty about the taxa being ranked (i.e., taxa is being accepted as full species in this list but may be treated as a subspecies taxa by others). To express uncertainty, the most likely rank is assigned and a question mark added (e.g., G2?). A range is indicated by combining two ranks (e.g., G1G2, S1S3).

4. IDENTIFICATION

This code refers to whether the identification of the species/community has been checked by a reliable individual and is indicative of significant habitat. Codes are as follows:

Y = Identification has been verified and is indicative of significant habitat.

BLANK = Identification has not been verified but there is no reason to believe it is not indicative of significant habitat.

? = Either it has not been determined if the record is indicative of significant habitat, or the identification of the species/community may be confusing or disputed.

5/18/87

NEW JERSEY NATURAL HERITAGE PROGRAM
POTENTIAL THREATENED AND ENDANGERED VERTEBRATE SPECIES
IN CAMDEN COUNTY

AMERICAN BITTERN — FEDERAL STATUS: — COUNTY
BOTAURUS LENTIGINOSUS — STATE STATUS: LT — OCCURRENCE: ?

HABITAT COMMENTS
Fresh water bogs, swamps, wet fields, cattail and bulrush marshes, brackish and saltwater marshes and meadows.

BARRED OWL — FEDERAL STATUS: — COUNTY
STRIX VARIA — STATE STATUS: LT — OCCURRENCE: ?

HABITAT COMMENTS
Dense woodland and forest (conif. or hardwood), swamps, wooded river valleys, cabbage palm-live oak hammocks, especially where bordering streams, marshes, and meadows.

BOG TURTLE — FEDERAL STATUS: C2 — COUNTY
CLEMMYS MUHLENBERGII — STATE STATUS: LE — OCCURRENCE: Y

HABITAT COMMENTS
Slow, shallow rivulets of sphagnum bogs, swamps, and marshy meadows; sea level to 1200 m in Appalachians. Commonly basks on tussocks in morning in spring and early summer. Hibernates in subterreanean rivulet or seepage area.

BROOK TROUT — FEDERAL STATUS: — COUNTY
SALVELINUS FONTINALIS — STATE STATUS: LT — OCCURRENCE: Y

HABITAT COMMENTS
Clear cool well-oxygenated streams and lakes. May move from streams into lakes or sea to avoid high temps. in summer.

COOPER'S HAWK — FEDERAL STATUS: — COUNTY
ACCIPITER COOPERII — STATE STATUS: LE — OCCURRENCE: ?

HABITAT COMMENTS
Primarily mature forest, either broadleaf or coniferous, mostly the former; also open woodland and forest edge.

GREAT BLUE HERON — FEDERAL STATUS: — COUNTY
ARDEA HERODIAS — STATE STATUS: LT — OCCURRENCE: N*

HABITAT COMMENTS
Freshwater and brackish marshes, along lakes, rivers, bays, lagoons, ocean beaches, mangroves, fields, and meadows.

5/18/87

MUD SALAMANDER
PSEUDOTRITON MONTANUS

FEDERAL STATUS:
STATE STATUS: LT

COUNTY
OCCURRENCE: ?

HABITAT COMMENTS
Muddy springs, slow floodplain streams, and swamps along slow streams. Nonlarval forms usually found beneath logs and rocks, in decaying vegetation, and in muddy stream-bank burrows. Occasionally disperses from wet muddy areas.

NORTHERN GOSHAWK
ACCIPITER GENTILIS

FEDERAL STATUS:
STATE STATUS: LT

COUNTY
OCCURRENCE: W

HABITAT COMMENTS
Deciduous and coniferous forest, forest edge and open woodland, foraging also in cultivated regions; primarily in mountains towards the south.

PEREGRINE FALCON
FALCO PEREGRINUS

FEDERAL STATUS: LE
STATE STATUS: LE

COUNTY
OCCURRENCE: Y

HABITAT COMMENTS
"A variety of open situations from tundra, moorlands, steppe and seacoasts, especially where there are suitable nesting cliffs, to high mountains, more open forested regions, and even human population centers...".

PIED-BILLED GREBE
PODILYMBUS PODICEPS

FEDERAL STATUS:
STATE STATUS: LE

COUNTY
OCCURRENCE: ?

HABITAT COMMENTS
Lakes, ponds, sluggish streams, and marshes; in migration and in winter also in brackish bays and estuaries.

PINE BARRENS TREEFROG
HYLA ANDERSONII

FEDERAL STATUS: C2
STATE STATUS: LE

COUNTY
OCCURRENCE: Y

HABITAT COMMENTS
Streams, ponds, cranberry bogs, and other wetland habitats. Post-breeding habitat the woodlands bordering these areas.

PINE SNAKE
PITUOPHIS MELANOLEUCUS

FEDERAL STATUS:
STATE STATUS: LT

COUNTY
OCCURRENCE: Y

HABITAT COMMENTS
Lowlands to mountains; desert, prairie, brushland, woodland, open coniferous forest, farmland, marshes. Terrestrial, fossorial, and arboreal. Underground in cold weather.

5/18/87

RED-SHOULDERED HAWK
BUTEO LINEATUS

FEDERAL STATUS:
STATE STATUS: LT

COUNTY
OCCURRENCE: ?

HABITAT COMMENTS
Moist and riverine forest, and in e. N. Am. in wooded swamps, foraging in forest edge and open woodland.

SAVANNAH SPARROW
PASSERCULUS SANDWICHENSIS

FEDERAL STATUS:
STATE STATUS: LT

COUNTY
OCCURRENCE: W*

HABITAT COMMENTS
"Open areas, especially grasslands, tundra, meadows, bogs, farmlands, grassy areas with scattered bushes, and marshes, including salt marshes in the BELDINGI and ROSTRATUS groups (Subtropical and Temperate zones)".

SEDGE WREN
CISTOTHORUS PLATENSIS

FEDERAL STATUS:
STATE STATUS: LE

COUNTY
OCCURRENCE: ?

HABITAT COMMENTS
Grasslands and savanna, especially where wet or boggy, sedge marshes, locally in dry cultivated grainfields. In migration and winter also in brushy grasslands.

SHORT-EARED OWL
ASIO FLAMMEUS

FEDERAL STATUS:
STATE STATUS: LE/S

COUNTY
OCCURRENCE: ?

HABITAT COMMENTS
Open country, including prairie, meadows, tundra, moorlands, marshes, savanna, dunes, fields, and open woodland. Roosts by day on ground or on low open perches.

TIGER SALAMANDER
AMBYSTOMA TIGRINUM

FEDERAL STATUS:
STATE STATUS: LE

COUNTY
OCCURRENCE: ?

HABITAT COMMENTS
Found in virtually any habitat, providing there is a body of water nearby suitable for breeding. Terrestrial adults primarily subterranean.

TIMBER RATTLESNAKE
CROTALUS HORRIDUS

FEDERAL STATUS:
STATE STATUS: LE

COUNTY
OCCURRENCE: ?

HABITAT COMMENTS
Wooded rocky hillsides in north; swampy areas, canebrake thickets, and floodplains in south. Near streams in late summer in some areas. Often hibernates in burrows and crevices of rock outcroppings.

5/18/87

WOOD TURTLE
CLEMMYS INSCULPTA

FEDERAL STATUS:
STATE STATUS: LT

COUNTY
OCCURRENCE: Y

HABITAT COMMENTS
Vicinity of streams and rivers. In streams and in wooded areas and fields adjacent to streams in summer. In streams in spring and fall. Hibernates in banks or bottoms of streams in winter.

DEFINITION OF ACRONYMS

FEDERAL STATUS

LE=listed endangered.
LT=listed threatened.
PE=proposed endangered.
PT=proposed threatened.
C2=candidate for listing.

STATE STATUS

LE=listed as endangered. (short-eared owl winter pop. listed as stable:S)
LT=listed as threatened.

COUNTY OCCURRENCE

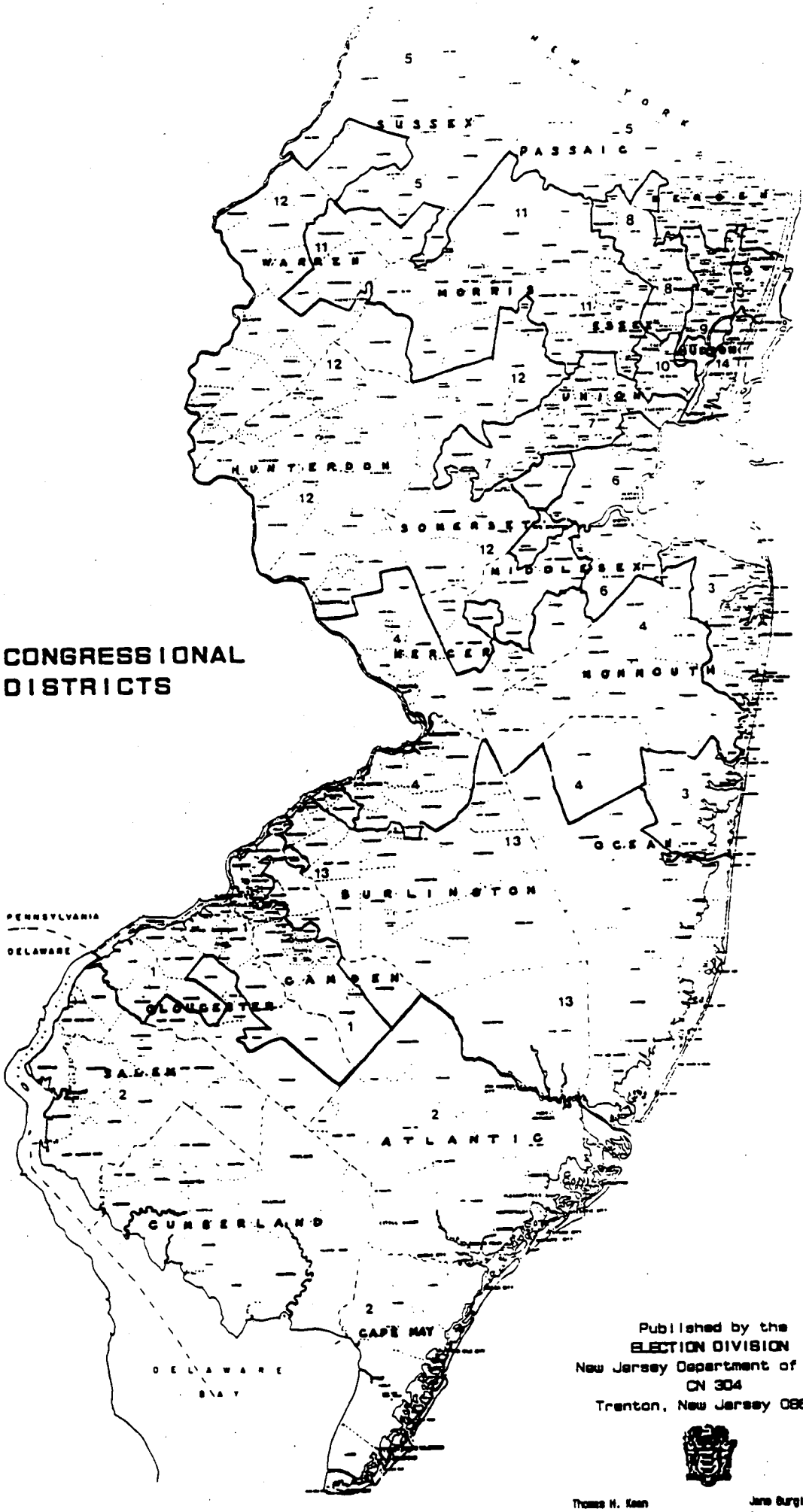
Y=present year-round, breeds.
N=present year-round, not recorded breeding.
B=present during the summer, breeds.
W=present during the winter.
T=present as a transient.
?=present status undetermined.
*=indicates that the county is within the species known breeding range.

REFERENCE NO. 29

EPA ID NO.	SITE NAME STREET CITY COUNTY CODE AND NAME	STATE ZIP CONG DIST.	NFA. FLAG	OPRBLE UNIT	EVENT TYPE	ACTUAL START DATE	ACTUAL COMPL DATE	CURRENT EVENT LEAD
NJD092338722	FINA OIL AND CHEMICAL CO - COSDEN DIV.			00	DS1		06/01/81	EPA (FUND)
	PO BOX 316 /MAIN ST				PA1	09/01/84	09/01/84	STATE(FUND)
	WINDSOR	NJ 08561			SI1	01/01/90	03/30/90	STATE(FUND)
	021 MERCER							
NJD002263622	FINNESSY BODY WORKS			00	DS1		01/21/86	STATE(FUND)
	100 CRESCENT BOULEVARD				PA1		02/20/86	STATE(FUND)
	COLLINGSWOOD	NJ 08108						
	007 CAMDEN							
NJD980529127	FIORE DEMOLITION			00	DS1		08/01/79	EPA (FUND)
	192 DELANY				PA1		07/01/80	EPA (FUND)
	NEWARK	NJ 07105			HR1		08/01/82	OTHER
	013 ESSEX				SI1	08/01/79	08/01/82	EPA (FUND)
					SI2	08/01/79	08/01/82	STATE(FUND)
NJD980771612	FISH ROAD SITE		NFA	00	DS1		04/10/84	STATE(FUND)
	FISH RD				PA1		08/21/87	STATE(FUND)
	JACKSON TWP	NJ 08527						
	029 OCEAN							
NJD004362059	FISHER SCIENTIFIC			00	DS1		08/15/83	RESP. PARTY
	1 REAGENT LANE				PA1	11/01/85	12/01/85	STATE(FUND)
	FAIR LAWN	NJ 07410			SI1	06/30/89	09/29/89	STATE(FUND)
	003 BERGEN							
NJD052207982	FISHER SCIENTIFIC			00	DS1		04/03/84	RESP. PARTY
	755 STATE HIGHWAY 202				PA1		08/01/84	STATE(FUND)
	BRIDGEWATER TWP	NJ 08807			SI1	11/01/89	12/31/89	STATE(FUND)
	035 SOMERSET							
NJD002352300	FLAGS, INC.			00	DS1		02/11/86	STATE(FUND) ←
	41 OAK AVENUE				PA1		03/10/86	STATE(FUND)
	BELLMAWR	NJ 08031						
	007 CAMDEN							
NJD982187346	FLEMINGTON COAL GAS SITE			00	DS1		09/19/83	EPA (FUND)
	EAST MAIN ST				PA1	12/28/87	12/29/87	STATE(FUND)
	FLEMINGTON	NJ 08822			SI1	06/23/88	06/30/88	STATE(FUND)
	019 HUNTERDON							

REFERENCE NO. 30

CONGRESSIONAL DISTRICTS



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Thomas H. Kean
Governor

Jane Burgio
Secretary of State

CONGRESSIONAL DISTRICTS

DISTRICT ONE: **Part of Burlington County** (Maple Shade Twp., Palmyra Borough, Riverton Borough), **Part of Camden County** (Audubon Park Borough, Barrington Borough, Bellmawr Borough, Berlin Borough, Berlin Twp., Brooklawn Borough, Camden City, Chesilhurst Borough, Clementon Borough, Collingswood Borough, Gibbsboro Borough, Gloucester City, Gloucester Twp., Haddon Twp., Hi-Nella Borough, Laurel Springs Borough, Lawnside Borough, Lindenwold Borough, Magnolia Borough, Mount Ephraim Borough, Oaklyn Borough, Pennsauken Twp., Pine Hill Borough, Pine Valley Borough, Runnemede Borough, Somerdale Borough, Stratford Borough, Tavistock Borough, Winslow Twp. and Woodlynne Borough), and **Part of Gloucester County** (Clayton Borough, Deptford Twp., East Greenwich Twp., Greenwich Twp., Harrison Twp., Logan Twp., Monroe Twp., National Park Borough, Paulsboro Borough, Swedesboro Borough, Washington Twp., Wenonah Borough, West Deptford Twp., Westville Borough, Woodbury City, Woodbury Hts. Borough and Woolwich Twp.).

DISTRICT TWO: **Atlantic County, Cape May County, Cumberland County, Salem County** and **Part of Gloucester County** (Elk Twp., Franklin Twp., Glassboro Borough, Mantua Twp., Newfield Borough, Pitman Borough and South Harrison Twp.).

DISTRICT THREE: **Part Of Monmouth County** (Allenhurst Borough, Asbury Park City, Atlantic Highlands, Borough, Avon-by-the-Sea Borough, Belmar Borough, Bradley Beach Borough, Deal Borough, Eatontown Borough, Fair Haven Borough, Hazlet Twp., Highlands Borough, Interlaken Borough, Keansburg Borough, Keyport Borough, Little Silver Borough, Loch Arbour Village, Long Branch City, Manasquan Borough, Middletown Twp., Monmouth Beach Boro, Neptune City Borough, Neptune Twp., Oceanport Borough, Ocean Twp., Red Bank Borough, Rumson Borough, Sea Bright Borough, Sea Girt Borough, Shrewsbury Borough, Shrewsbury Twp., Spring Lake Borough, Spring Lake Heights Borough, South Belmar Borough, Tinton Falls Borough, Union Beach Borough and West Long Branch Borough) and **Part of Ocean County** (Bay Head Borough, Brick Twp., Dover Twp., Island Heights Borough, Lakewood Twp., Lavallette Borough, Mantoloking Borough, Point Pleasant Beach Borough, Point Pleasant Borough, Seaside Heights Borough and South Toms River Borough).

DISTRICT FOUR: **Part of Burlington County** (Bordentown City, Bordentown Twp., Burlington City, Burlington Twp., Chesterfield Twp., Eastampton Twp., Fieldsboro Borough, Florence Twp., Mansfield Twp., Springfield Twp. and Westampton Twp.) **Part of Mercer County** (East Windsor Twp., Ewing Twp., Hamilton Twp., Hightstown Borough, Hopewell Borough, Hopewell Twp., Lawrence Twp., Pennington Borough, Trenton City and Washington Twp.), **Part of Middlesex County** (Jamesburg Borough, Monroe Twp. and Plainsboro Twp.), **Part of Monmouth County** (Allentown Borough, Brielle Borough, Colts Neck Twp., Englishtown Borough, Farmingdale Borough, Freehold Borough, Freehold Twp., Holmdel Twp., Howell Twp., Manalapan Twp., Marlboro Twp., Millstone Twp., Roosevelt Borough, Upper Freehold Twp. and Wall Twp.), and **Part of Ocean County** (Jackson Twp.).

DISTRICT FIVE: **Part of Bergen County** (Allendale Borough, Alpine Borough, Bergenfield Borough, Closter Borough, Cresskill Borough, Demarest Borough, Dumont Borough, Emerson Borough, Glen Rock Borough, Harrington Park Borough, Haworth Borough, Hillsdale Borough, Ho-Ho-Kus Borough, Mahwah Twp., Midland Park Borough, Montvale Borough, Northvale Borough, Norwood Borough, Oakland Borough, Old Tappan Borough, Oradell Borough, Paramus Borough, Park Ridge Borough, Ramsey Borough, Ridgewood Village, River Vale Twp., Rochelle Park Twp., Rockleigh Borough, Saddle River Borough, Tenafly Borough, Upper Saddle River Borough, Waldwick Borough, Washington Twp., Westwood Borough, Woodcliff Lake Borough and Wyckoff Twp.), **Part of Passaic County** (Bloomingdale Borough, Haledon Borough, Hawthorne Borough, North Haledon Borough, Ringwood Borough, Wanaque Borough and West Milford Twp.), and **Part of Sussex County** (Andover Borough, Andover Twp., Branchville Borough, Frankford Twp., Franklin Borough, Fredon Twp., Hamburg Borough, Hardyston Twp., Hopatcong Borough, Lafayette Twp., Montague Twp., Newton Town, Ogdensburg Borough, Sandyston Twp., Sparta Twp., Stanhope Borough, Sussex Borough, Vernon Twp., Walpack Twp. and Wantage Twp.).

DISTRICT SIX: **Part of Middlesex County** (Carteret Borough, Edison Twp., Highland Park Borough, Metuchen Borough, New Brunswick City, North Brunswick Twp., Old Bridge Twp., Perth Amboy City, Sayreville Borough, South Amboy City, South River Borough and Woodbridge Twp.), **Part of Monmouth County** (Aberdeen Twp. and Matawan Borough), and **Part of Union County** (Linden City, Rahway City and Roselle Borough).

DISTRICT SEVEN: **Part of Essex County** (Millburn Twp.), **Part of Middlesex County** (Dunellen Borough and Middlesex Borough), **Part of Somerset County** (Bound Brook Borough, Bridgewater Twp., Green Brook Twp., Manville Borough, North Plainfield Borough, Warren Twp. and Watchung Borough) and **Part of Union County** (Berkeley Heights Twp., Clark Twp., Cranford Twp., Elizabeth City, Fanwood Borough, Garwood Borough, Kenilworth Borough, Mountainside Borough, New Providence Borough, Plainfield City, Roselle Park Borough, Scotch Plains Twp., Springfield Twp., Summit City, Union Twp., Westfield Town and Winfield Twp.).

DISTRICT EIGHT: **Part of Bergen County** (Franklin Lakes Borough), **Part of Essex County** (Part of Belleville Town, Bloomfield Town, Glen Ridge Borough, Montclair Town and Nutley Town), **Part of Morris County** (Riverdale Borough) and **Part of Passaic County** (Clifton City, Little Falls Twp., Passaic City, Paterson City, Pompton Lakes Borough, Prospect Park Borough, Totowa Borough, Wayne Twp. and West Paterson Borough).

DISTRICT NINE: **Part of Bergen County** (Bogota Borough, Carlstadt Borough, Cliffside Park Borough, East Rutherford Borough, Edgewater Borough, Elmwood Park Borough, Englewood City, Englewood Cliffs Borough, Fair Lawn Borough, Fairview Borough, Fort Lee Borough, Garfield City, Hackensack City, Hasbrouck Heights Borough, Leonia Borough, Little Ferry Borough, Lodi Borough, Lyndhurst Twp., Maywood Borough, Moonachie Borough, New Milford Borough, North Arlington Borough, Palisades Park Borough, Ridgefield Borough, Ridgefield Park Village, River Edge Borough, Rutherford Borough, Saddle Brook Twp., South Hackensack Twp., Teaneck Twp., Teterboro Borough, Wallington Borough and Wood-Ridge Borough) and **Part of Hudson County** (East Newark Borough, Part of Kearny Town, and Secaucus Town).

DISTRICT TEN: **Part of Essex County** (Part of Belleville Town, East Orange City, Irvington Town, Newark City and Orange City) and **Part of Union County** (Hillside Township).

DISTRICT ELEVEN: **Part of Essex County** (Caldwell Borough, Cedar Grove Twp., Essex Fells Borough, Fairfield Borough, Livingston Twp., Maplewood Twp., North Caldwell Borough, Roseland Borough, South Orange Village, Verona Borough, West Caldwell Borough and West Orange Town), **Part of Morris County** (Boonton Town, Boonton Twp., Butler Borough, Chatham Borough, Chester Borough, Chester Twp., Denville Twp., Dover Town, East Hanover Twp., Florham Park Borough, Hanover Twp., Jefferson Twp., Kinnelon Borough, Lincoln Park Borough, Madison Borough, Mendham Borough, Mendham Twp., Mine Hill Twp., Montville Twp., Mountain Lakes Borough, Mount Arlington Borough, Mount Olive Twp., Netcong Borough, Parsippany-Troy Hills Twp., Pequannock Twp., Randolph Twp., Rockaway Borough, Rockaway Twp., Roxbury Twp., Victory Gardens Borough and Wharton Borough), **Part of Sussex County** (Byram Twp. and Green Twp.) and **Part of Warren County** (Allamuchy Twp., Freilinghysen Twp., Independence Twp. and Liberty Twp.).

DISTRICT TWELVE: **Hunterdon County, Part of Mercer County** (Princeton Borough, Princeton Twp. and West Windsor Twp.) **Part of Middlesex County** (Cranbury Twp., East Brunswick Twp., Helmetta Borough, Milltown Borough, Piscataway Twp., South Brunswick Twp., South Plainfield Borough and Spotswood Borough), **Part of Morris County** (Chatham Twp., Harding Twp., Morris Plains Borough, Morristown Town, Morris Twp., Passaic Twp. and Washington Twp.), **Part of Somerset County** (Bedminster Twp., Bernards Twp., Bernardsville Borough, Branchburg Twp., Far Hills Borough, Franklin Twp., Hillsborough Twp., Millstone Borough, Montgomery Twp., Peapack-Gladstone Borough, Raritan Borough, Rocky Hill Borough, Somerville Borough and South Bound Brook Borough), **Part of Sussex County** (Hampton Twp. and Stillwater Twp.) and **Part of Warren County** (Alpha Borough, Belvidere Town, Blairstown Twp., Franklin Twp., Greenwich Twp., Hackettstown Town, Hardwick Twp., Harmony Twp., Hope Twp., Knowlton Twp., Lopatcong Twp., Mansfield Twp., Oxford Twp., Pahaquarry Twp., Phillipsburg Town, Pohatcong Twp., Washington Borough, Washington Twp. and White Twp.).

DISTRICT THIRTEEN: **Part of Burlington County** (Bass River Twp., Beverly City, Cinnaminson Twp., Delanco Twp., Delran Twp., Edgewater Park Twp., Evesham Twp., Hainsport Twp., Lumberton Twp., Medford Lakes Borough, Medford Twp., Moorestown Twp., Mount Holly Twp., Mount Laurel Twp., New Hanover Twp., North Hanover Twp., Pemberton Borough, Pemberton Twp., Riverside Twp., Shamong Twp., Southampton Twp., Tabernacle Twp., Washington Twp., Willingboro Twp., Woodland Twp. and Wrightstown Borough), **Part of Camden County** (Audubon Borough, Cherry Hill Twp., Haddonfield Borough, Haddon Heights Borough, Merchantville Borough, Voorhees Twp. and Waterford Twp.) and **Part of Ocean County** (Barnegat Light Borough, Barnegat Twp., Beach Haven Borough, Beachwood Borough, Berkeley Twp., Eagleswood Twp., Harvey Cedars Borough, Lacey Twp., Lakehurst Borough, Little Egg Harbor Twp., Long Beach Twp., Manchester Twp., Ocean Gate Borough, Ocean Township, Pine Beach Borough, Plumstead Twp., Seaside Park Borough, Ship Bottom Borough, Stafford Twp., Surf City Borough and Tuckerton Borough).

DISTRICT FOURTEEN: **Part of Hudson County** (Bayonne City, Guttenberg Town, Harrison Town, Hoboken City, Jersey City, Part of Kearny Town, North Bergen Twp., Union City, Weehawken Twp. and West New York Town).

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January 1987

REFERENCE NO. 31

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Table 2.2 Range of Values of Hydraulic Conductivity and Permeability

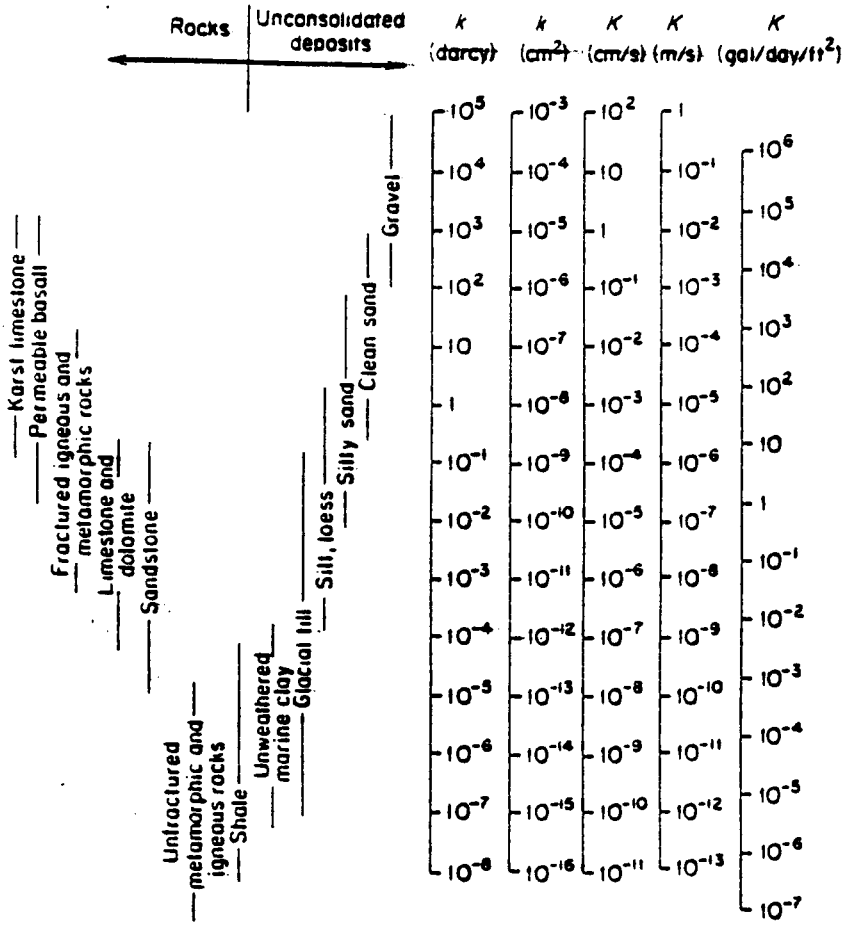


Table 2.3 Conversion Factors for Permeability and Hydraulic Conductivity Units

	Permeability, k*			Hydraulic conductivity, K		
	cm²	ft²	darcy	m/s	ft/s	U.S. gal/day/ft²
cm²	1	1.08×10^{-3}	1.01×10^{8}	9.80×10^{2}	3.22×10^{3}	1.85×10^{9}
ft²	9.29×10^{2}	1	9.42×10^{10}	9.11×10^{5}	2.99×10^{6}	1.71×10^{12}
darcy	9.87×10^{-9}	1.06×10^{-11}	1	9.66×10^{-6}	3.17×10^{-5}	1.82×10^{1}
m/s	1.02×10^{-3}	1.10×10^{-6}	1.04×10^{5}	1	3.28	2.12×10^{6}
ft/s	3.11×10^{-4}	3.35×10^{-7}	3.15×10^{4}	3.05×10^{-1}	1	6.46×10^{5}
U.S. gal/day/ft²	5.42×10^{-10}	5.83×10^{-13}	5.49×10^{-2}	4.72×10^{-7}	1.55×10^{-6}	1

*To obtain k in ft², multiply k in cm² by 1.08×10^{-3}.

REFERENCE NO. 32

COPY OF CLP DATA
COMPUTER QA'D PRINTOUT

ORGANICS

___ Laboratory QA

✓ FIT Validation

___ EPA Approved / Final Data

INORGANICS

___ Laboratory QA

___ FIT Validation

✓ EPA Approved / Final Data

Site Name : Flags Inc

Case No. and/or SAS No. : 15941

BRICS No. : NJHX

TDD No. : 02-9011-22

SITE NAME: FLAGS INCORPORATED
TDD#: 02-9011-22
SAMPLING DATE: 2/27/91
EPA CASE NO.: 15941 LAB: CEIMIC

TABLE 1
SITE INSPECTION SAMPLE RESULTS
FLAGS INCORPORATED
BELLMAWR, NEW JERSEY

VOLATILES													
Sample ID No.	NJHX-S1	NJHX-S2(MS/MSD)	NJHX-S3	NJHX-S4(DUP)	NJHX-S5	NJHX-S6	NJHX-S7	NJHX-S8	NJHX-S9	NJHX-S10	NJHX-RIN1	NJHX-RIN2	NJHX-RIN3
Traffic Report No.	BHE04	BHE05	BHE06	BHE07	BHE08	BHE09	BHE10	BHE11	BHE12	BHE13	BHE14	BHE15	BHE16
Matrix	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	WATER	WATER	WATER
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/L	ug/L	ug/L
Dilution Factor	1	1	1	1	1	1	1	1	1	1	1	1	1
Percent Moisture	9	16	14	14	14	18	13	6	21	17	--	--	--
Chloromethane											J	J	
Bromomethane											J		
Vinyl Chloride													
Chloroethane													
Methylene Chloride											B	B	B
Acetone											12 E	J	10 E
Carbon Disulfide													
1,1-Dichloroethene													
1,1-Dichloroethane													
Trans-1,2-Dichloroethene (total)													
Chloroform													
1,2-Dichloroethane													
2-Butanone													
1,1,1-Trichloroethane													
Carbon Tetrachloride													
Vinyl Acetate													
Bromodichloromethane													
1,2-Dichloropropane													
cis-1,3-Dichloropropene													
Trichloroethene													
Dibromochloromethane													
1,1,2-Trichloroethane													
Benzene													
trans-1,3-Dichloropropene													
Bromoform													
4-Methyl-2-Pentanone													
2-Hexanone													
Tetrachloroethene													
1,1,2,2-Tetrachloroethane													
Toluene													
Chlorobenzene													
Ethylbenzene													
Styrene													
Xylenes (Total)													

NOTES:
Blank space - compound analyzed for but not detected
B - compound found in lab blank as well as sample, indicates possible/probable blank contamination
E - estimated value
J - estimated value, compound present below CRQL but above IDL
R - analysis did not pass EPA QA/QC
N - Presumptive evidence of the presence of the material
NR - analysis not required
Detection limits elevated if Dilution Factor >1 and/or percent moisture >0%

TABLE I
SITE INSPECTION SAMPLE RESULTS
FLAGS INCORPORATED
BELLMAWR, NEW JERSEY
(cont'd)

SITE NAME: FLAGS INCORPORATED
TDD#: 02-9011-22
SAMPLING DATE: 2/27/91
EPA CASE NO.: 15941 LAB: CEIMIC

SEMI-VOLATILES													
Sample ID No.	NJHX-S1	NJHX-S2(MS/MSD)	NJHX-S3	NJHX-S4(DUP)	NJHX-S5	NJHX-S6	NJHX-S7	NJHX-S8	NJHX-S9	NJHX-S10	NJHX-RIN1	NJHX-RIN2	NJHX-RIN3
Traffic Report No.	BHE04	BHE05	BHE06	BHE07	BHE08	BHE09	BHE10	BHE11	BHE12	BHE13	BHE14	BHE15	BHE16
Matrix	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	WATER	WATER	WATER
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/L	ug/L	ug/L
Dilution Factor/GPC Cleanup (Y)	1	1	1	1	1	1	1	1	1	1	1	1	1
Percent Moisture	9	17	15	16	15	18	13	8	21	17	--	--	--
Phenol													
bis(2-Chloroethyl)ether													
2-Chlorophenol													
1,3-Dichlorobenzene													
1,4-Dichlorobenzene													
Benzyl alcohol													
1,2-Dichlorobenzene													
2-Methylphenol													
bis(2-Chloroisopropyl)ether													
4-Methylphenol													
N-Nitroso-di-n-dipropylamine													
Hexachloroethane													
Nitrobenzene													
Isophorone													
2-Nitrophenol													
2,4-Dimethylphenol													
Benzoic acid										J			
bis(2-Chloroethoxy)methane													
2,4-Dichlorophenol													
1,2,4-Trichlorobenzene													
Naphthalene													
4-Chloroaniline													
Hexachlorobutadiene													
4-Chloro-3-Methylphenol													
2-Methylnaphthalene													
Hexachlorocyclopentadiene													
2,4,6-Trichlorophenol													
2,4,5-Trichlorophenol													
2-Chloronaphthalene													
2-Nitroaniline													
Dimethylphthalate													
Acenaphthylene													
2,6-Dinitrotoluene													
3-Nitroaniline													
Acenaphthene													
2,4-Dinitrophenol													
4-Nitrophenol													
Dibenzofuran													
2,4-Dinitrotoluene													
Diethylphthalate													
4-Chlorophenyl-phenyl ether													
Fluorene													
4-Nitroaniline													
4,6-Dinitro-2-methylphenol													
N-nitrosodiphenylamine													
4-Bromophenyl-phenyl ether													
Hexachlorobenzene													

SITE NAME: FLAGS INCORPORATED
TDD#: 02-9011-22
SAMPLING DATE: 2/27/91
EPA CASE NO.: 15941 LAB: CEIMIC

TABLE I
SITE INSPECTION SAMPLE RESULTS
FLAGS INCORPORATED
BELLMAWR, NEW JERSEY
(cont'd)

SEMI-VOLATILES													
Sample ID No.	NJHX-S1	NJHX-S2(MS/MSD)	NJHX-S3	NJHX-S4(DUP)	NJHX-S5	NJHX-S6	NJHX-S7	NJHX-S8	NJHX-S9	NJHX-S10	NJHX-RIN1	NJHX-RIN2	NJHX-RIN3
Traffic Report No.	BHE04	BHE05	BHE06	BHE07	BHE08	BHE09	BHE10	BHE11	BHE12	BHE13	BHE14	BHE15	BHE16
Matrix	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	WATER	WATER	WATER
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/L	ug/L	ug/L
Dilution Factor/GPC Cleanup (Y)	1	1	1	1	1	1	1	1	1	1	1	1	1
Percent Moisture	9	17	15	16	15	18	13	8	21	17	--	--	--
Pentachlorophenol													
Phenanthrene	J	J							J				
Anthracene													
Di-n-butylphthalate	J								J				
Fluoranthene	J	J						J	J	J			
Pyrene	J	J						J	J	J			
Butylbenzylphthalate													
3,3'-Dichlorobenzidine													
Benzo(a)anthracene	J	J							J				
Chrysene	J	J						J	J				
bis(2-Ethylhexyl)phthalate	J	J						J	J				
Di-n-octylphthalate							380 E						
Benzo(b)fluoranthene	J	J					380 E		J				
Benzo(k)fluoranthene	J	J					380 E		J				
Benzo(a)pyrene	J						380 E		J				
Indeno(1,2,3-cd)pyrene	J						380 E		J				
Dibenz(a,h)anthracene							380 E						
Benzo(g,h,i)perylene	J						380 E		J				

NOTES:
Blank space - compound analyzed for but not detected
B - compound found in lab blank as well as sample, indicates possible/probable blank contamination
E - estimated value
J - estimated value, compound present below CRQL but above IDL
R - analysis did not pass EPA QA/QC
N - Presumptive evidence of the presence of the material
NR - analysis not required
Detection limits elevated if Dilution Factor >1 and/or percent moisture >0%

TABLE I
SITE INSPECTION SAMPLE RESULTS
FLAGS INCORPORATED
BELLMAWR, NEW JERSEY
(cont'd)

SITE NAME: FLAGS INCORPORATED
TDD#: 02-9011-22
SAMPLING DATE: 2/27/91
EPA CASE NO.: 15941 LAB: CEIMIC

PESTICIDES													
Sample ID No.	NJHX-S1	NJHX-S2(MS/MSD)	NJHX-S3	NJHX-S4(DUP)	NJHX-S5	NJHX-S6	NJHX-S7	NJHX-S8	NJHX-S9	NJHX-S10	NJHX-RIN1	NJHX-RIN2	NJHX-RIN3
Traffic Report No.	BHE04	BHE05	BHE06	BHE07	BHE08	BHE09	BHE10	BHE11	BHE12	BHE13	BHE14	BHE15	BHE16
Matrix	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	WATER	WATER	WATER
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/L	ug/L	ug/L
Dilution Factor/GPC Cleanup (Y)	1	1	1	1	1	1	1	1	1	1	1	2	1
Percent Moisture	9	17	15	16	15	18	13	8	21	17	--	--	--
alpha-BHC													
beta-BHC													
delta-BHC													
gamma-BHC (Lindane)													
Heptachlor													
Aldrin									21 E				
Heptachlor epoxide													
Endosulfan I													
Dieldrin		30 E											
4,4'-DDE	J								240 E				
Endrin													
Endosulfan II													
4,4'-DDD													
Endosulfan sulfate													
4,4'-DDT	49 E								420 E	26 E			
Methoxychlor													
Endrin ketone													
alpha-Chlordane													
gamma-Chlordane													
Toxaphene													
Aroclor-1016													
Aroclor-1221													
Aroclor-1232													
Aroclor-1242													
Aroclor-1248													
Aroclor-1254													
Aroclor-1260													

NOTES:
Blank space - compound analyzed for but not detected
B - compound found in lab blank as well as sample, indicates possible/probable blank contamination
E - estimated value
J - estimated value, compound present below CRQL but above IDL
R - analysis did not pass EPA QA/QC
N - Presumptive evidence of the presence of the material
NR - analysis not required
Detection limits elevated if Dilution Factor >1 and/or percent moisture >0%

SITE NAME: FLAGS INCORPORATED
TOD#: 02-9011-22
SAMPLING DATE: 2/27/91
EPA CASE NO.: 15941
LAB NAME: NATURAL RESOURCES

TABLE I
SITE INSPECTION SAMPLE RESULTS
FLAGS INCORPORATED
BELLMAWR, NEW JERSEY
(cont'd)

INORGANICS													
Sample ID No.	NJHX-S1	NJHX-S2(MS/MSD)	NJHX-S3	NJHX-S4(DUP)	NJHX-S5	NJHX-S6	NJHX-S7	NJHX-S8	NJHX-S9	NJHX-S10	NJHX-RIN1	NJHX-RIN2	NJHX-RIN3
Traffic Report No.	MBFQ01	MBFQ02	MBFQ03	MBFQ04	MBFQ05	MBFQ06	MBFQ07	MBFQ08	MBFQ09	MBFQ10	MBFQ11	MBFQ12	MBFQ13
Matrix	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	WATER	WATER	WATER
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/L	ug/L	ug/L
Dilution Factor													
Aluminum	4700	11900	14100	14900	11100	9270	11800	2420	10200	7800			
Antimony													
Arsenic	J	7.4 E	6 E	6.2 E	5.3 E	7.8 E	6.8 E	2.7 E	7.1 E	11.3 E			
Barium	J	67.4	72.3	81.2	J	50.7	J	J	77.3	J			
Beryllium	J	J	J	J	J	J	J	J	J	J			
Cadmium	1.5							4.7	1.7				
Calcium	1210	J	J	J	J	J	J	1450	1290	J			
Chromium	19.9	21	24	23.3	22.6	17.8	24.4	28.8	21.6	19.3			
Cobalt	J	J	J	J	J	J	J		J	J			
Copper	260	29.5	20.6	23.3	J	16	J	688	82.3	17.2			
Iron	9150	16000	21800	19300	17800	12200	19700	5430	14200	12500		J	
Lead	68.4 E	60.2 E	10.7	9.4	5.3	31.2 E	5.1	37.8 E	134 E	58.5 E			
Magnesium	1460	J	1460	1520	1310	J	1290	J	J	J			
Manganese	72.2	159	146	191	71.1	204	111	32.8	196	158			
Mercury						0.13 E				0.13 E			
Nickel	19.9	11.6	J	10.2	J	J	J	34.4	12.7	J			
Potassium	J	J	J	J	1740	J	1870	J	J	1340			
Selenium									J				
Silver	173	7.4	J	J		2.7		193	73.1	3			
Sodium	J												
Thallium				J					J		J		
Vanadium	19.5	26.3	33.1	30.9	29.5	21.7	31.6	J	25.3	22.3			
Zinc	97.8	67.8	37.6	41.8	17.4	32.1	18	206	147	71.8			

NOTES:
Blank space - compound analyzed for but not detected
E - estimated value
J - estimated value, compound present below CRDL but above IDL
R - analysis did not pass EPA QA/QC
NR - analysis not required

02-9011-22-SI
Rev. No. 0

SAMPLING TRIP REPORT

NJHX

SITE NAME: Flags Incorporated

TDD NO.: 02-9011-22

SAMPLING DATE: February 27, 1991

EPA CASE NO.: 15941

1. Site Location: Refer to Figure 1

2. Sample Locations: Refer to Figure 2

3. Sample Descriptions: Refer to Table 1

4. Laboratories Receiving Samples:

Sample Type	Name and Address of Laboratory
Organic	Ceimic Corp. 100 Dean Knauss Drive S. Terry Industrial Park Narragansett, RI 02882
Inorganic	Natural Resources Laboratory 409 Corporate Circle Golden, CO 80401

5. Sample Dispatch Data:

A total of three aqueous and ten soil samples for organic analysis were shipped by NUS Corporation Region 2 FIT personnel via Federal Express under Airbill No. 9802407075 to Ceimic Corp. on February 27, 1991 at 1455 hours.

A total of three aqueous and ten soil samples for inorganic analysis were shipped by NUS Corporation Region 2 FIT personnel via Federal Express under Airbill No. 9802407101 to Natural Resources Labratory on February 27, 1991 at 1455 hours.

6. Sampling Personnel:

Name	Organization	Duties on Site
Joe Filosa	NUS Corporation, FIT 2	Site Manager
Kathy Indelicato	NUS Corporation, FIT 2	Site Safety Officer
Bill Foss	NUS Corporation, FIT 2	Sample Management Officer
Keith Billy	NUS Corporation, FIT 2	Sampler
Anthony Bonasara	NUS Corporation, FIT 2	Sampler

7. Weather Conditions:

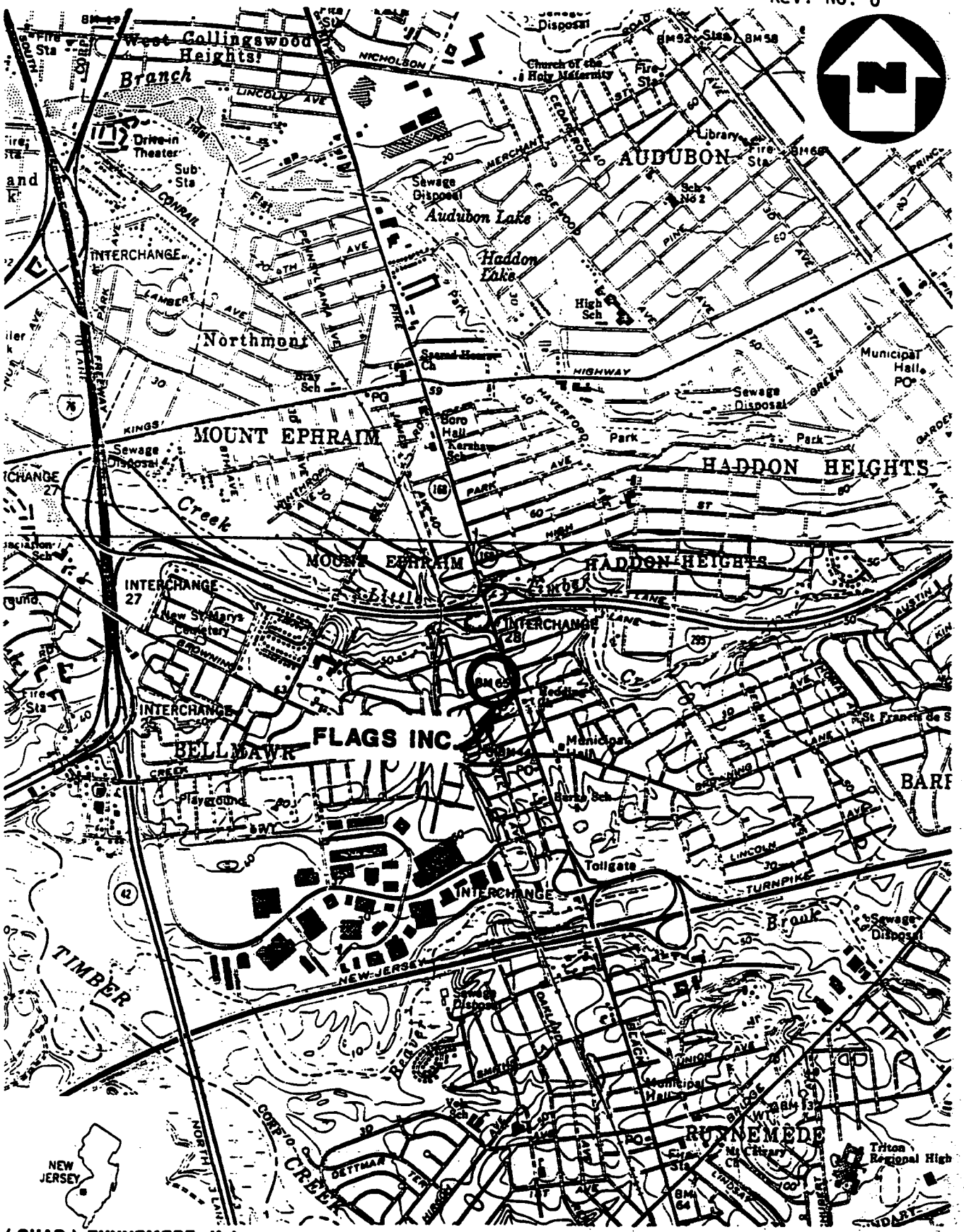
Sunny cold, temperature 30 - 35°F, winds 0 - 10 mph from the northwest.

8. Additional Comments:

All samples will be analyzed for Target Compound List (TCL) organic and inorganic compounds, excluding cyanide. No trip blank was collected, as no aqueous environmental samples were collected on-site. Continous air monitoring was conducted on site using the Organic Vapor Analyzer (OVA), HNu photoionization detector and the Monitor 4 radiation detector. No readings above background were obtained anywhere on - site.

9. Report Prepared By: Joseph G. Filosa Date: February 28, 1991

10. Approved By: Gary Rogh Date: 3/7/91



(QUAD) RUNNEMEDE, N.J.

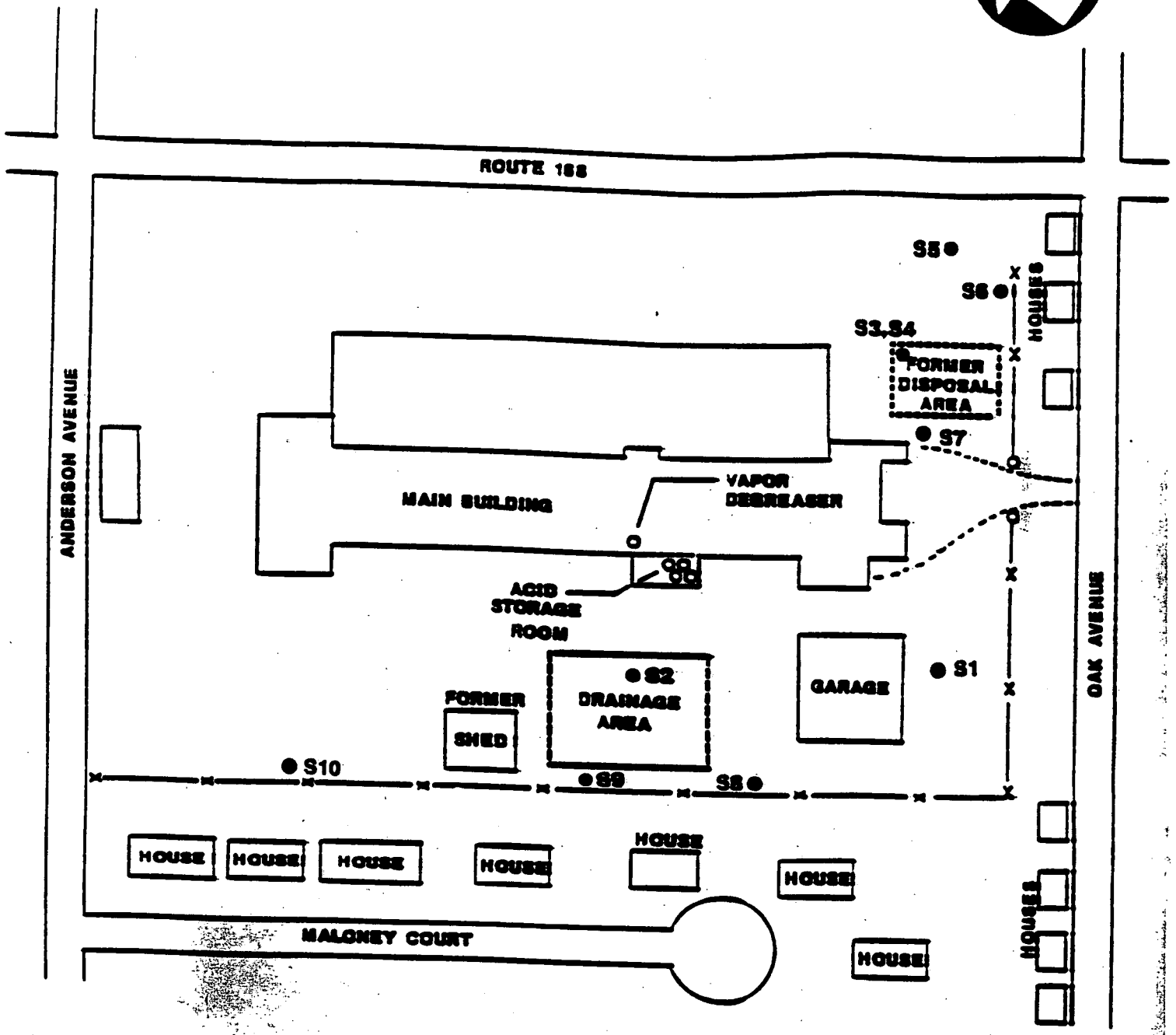
FIGURE 1

SITE LOCATION MAP

FLAGS INC., BELLMAWR, N.J.

SCALE: 1" = 2000'

NUS CORPORATION



LEGEND

● SOIL SAMPLE LOCATION

● ALL SAMPLE NUMBERS ARE PRECEEDED BY NJHX

FIGURE 2

SAMPLE LOCATION MAP

FLAGS INC.,

BELLMAWR, N.J.

(NOT TO SCALE)

NUS CORPORATION

TABLE I
SAMPLE DESCRIPTIONS
FLAGS INCORPORATED
BELLMAWR, NEW JERSEY
CASE NO. 15941

NUS Sample Number	CLP Organic Traffic Report Number	CLP Inorganic Traffic Report Number	Collection Time	Sample Type	Sample Location
NJHX - SI	BHE - 04	MBFQ - 01	1019	Soil	Surface soil sample SI collected at a depth of 0-6 inches beneath the surface, and at a bearing of 180° and a distance of 20 feet from the northeastern corner of the garage.
NJHX - S2*	BHE - 05	MBFQ - 02	1028	Soil	Surface soil sample S2 collected at a depth of 0-6 inches beneath the surface, and at a bearing of 250° and 14 feet from the south-west corner of the former acid storage room.
NJHX - S3	BHE - 06	MBFQ - 03	1125	Soil	Subsurface soil sample S3 collected at a depth of 1.5 to 3 feet beneath the surface, and at a bearing of 170° and 110 feet from the northern corner of the main building.
NJHX - S4**	BHE - 07	MBFQ - 04	1125	Soil	Same location as sample S3.

* MS/MSD - Indicates that an additional sample volume was collected and shipped to the labratory for Matrix Spike (MS) and Matrix Spike duplicate (MSD) analysis.

** Duplicate - Indicates that a sample was designated for duplicate analysis.

TABLE 1 (CONT'D)
SAMPLE DESCRIPTIONS
FLAGS INCORPORATED
BELLMAWR, NEW JERSEY
CASE NO. 15941

	NUS Sample Number	CLP Organic Traffic Report Number	CLP Inorganic Traffic Report Number	Collection Time	Sample Type	Sample Location
15 15	NJHX-S5	BHE-08	MBFQ-05	1145	Soil	Subsurface soil sample S5 collected at a depth of 4 - 6 feet beneath the surface, and at a bearing of 350° and 150 feet from the northeastern corner of the property.
18 18	NJHX-S6	BHE-09	MBFQ-06	1159	Soil	Surface soil sample S6 collected at a depth of 0 - 6 inches beneath the surface, and a bearing of 340° and 65 feet from the north-eastern corner of the property.
13 13	NJHX-S7	BHE-10	MBFQ-07	1215	Soil	Subsurface soil sample S7 collected at a depth of 4 - 6 feet beneath the surface, and at a bearing of 330° and 85 feet from the north-eastern corner of the property.
8 8	NJHX-S8	BHE-11	MBFQ-08	1040	Soil	Surface soil sample S8 collected at a depth of 0 - 6 inches beneath the surface, and at a bearing of 320° and 19 feet from the south-west corner of the garage.

TABLE 1 (CON'T)
SAMPLE DESCRIPTIONS
FLAGS INCORPORATED
BELLMAWR, NEW JERSEY
CASE NO. 15941

	NUS Sample Number	CLP Organic Traffic Report Number	CLP Inorganic Traffic Report Number	Collection Time	Sample Type	Sample Location
1 20 20	NJHX - S9	BHE - 12	MBFQ - 09	1051	Soil	Surface soil sample S9 collected at a depth of 0 - 6 inches beneath the surface, and at a bearing of 270° and 51 feet from the southwest corner of the former acid storage room.
1 17 17	NJHX - S10	BHE - 13	MBFQ - 10	1100	Soil	Surface soil sample S10 collected at a depth of 0 - 6 inches beneath the surface, and at a bearing of 240° and 49 feet from the southwestern corner of the main building.
— —	NJHX - RIN 1	BHE - 14	MBFQ - 11	1023	Aqueous	Bowl rinsate collected in the field.
— —	NJHX - RIN 2	BHE - 15	2 MBFQ - 12	1058	Aqueous	Trowel rinste collected in the field.
— —	NJHX - RIN 3	BHE - 16	MBFQ - 13	1200	Aqueous	Auger rinsate collected in the field.

ATTACHMENT 1
SOP NO. HW-6

PAGE __OF__

TOTAL REVIEW

CLP DATA ASSESSMENT

Functional Guidelines for Evaluating Organics Analysis

Case No. 15941 SDG No BH204 LABORATORY Cosmic SITE Hayden

DATA ASSESSMENT:

The current functional guidelines (1988) for evaluating organic data have been applied.

All data are valid and acceptable except those analytes which have been qualified with a "J" (estimated), "U" (non-detects), "R" (unusable),or "JN" (presumptive evidence for the presence of the material at an estimated value). All action is detailed on the attached sheets.

Two facts should be noted by all data users. First, the "R" flag means that the associated value is unusable. In other words, due to significant QC problems the analysis is invalid and provides no information as to whether the compound is present or not. "R" values should not appear on data tables because they cannot be relied upon, even as a last resort. The second fact to keep in mind is that no compound concentration, even if it has passed all QC tests, is guaranteed to be accurate. Strict QC serves to increase confidence in data but any value potentially contains error.

Reviewer's Signature: Josephine Brown Date: 5/9/1991

Verified By: [signature] Date: 5/15/1991

DATA ASSESSMENT:

1. HOLDING TIME:

The amount of an analyte in a sample can change with time due to chemical instability, degradation, volatilization, etc. If the specified holding time is exceeded, the data may not be valid. Those analytes detected in the samples whose holding time has been exceeded will be qualified as estimated, "J". The non-detects (sample quantitation limits) will be flagged as estimated, "J", or unusable, "R", if the holding times are grossly exceeded.

The following action was taken in the samples and analytes shown due to excessive holding time.

BNA - Extraction holding times were exceeded for Sample BHE 04-13 therefore all analytes were flagged estimated 'J'.

PEST - See above

DATA ASSESSMENT:

3. MASS SPECTROMETER TUNING:

Tuning and performance criteria are established to ensure adequate mass resolution, proper identification of compounds, and to some degree, sufficient instrument sensitivity. These criteria are not sample specific. Instrument performance is determined using standard materials. Therefore, these criteria should be met in all circumstances. The tuning standard for volatile organics is bromofluorobenzene (BFB) and for semi-volatiles is decafluorotriphenyl- phosphine (DFTPP).

If the mass calibration is in error, all associated data will be classified as unusable, "R".

DATA ASSESSMENT:

2. BLANK CONTAMINATION:

Quality assurance (QA) blanks, i.e., method, trip field, rinse and water blanks are prepared to identify any contamination which may have been introduced into the samples during sample preparation or field activity. Method blanks measure laboratory contamination. Trip blanks measure cross-contamination of samples during shipment. Field blanks measure cross- contamination of samples during field operations. If the concentration of the analyte is less than 5 times the blank contaminant level (10 times for the common contaminants), the analytes are qualified as non- detects, "U". The following analytes in the samples shown were qualified with "U" for these reasons:

A) Method blank contamination

CA -Methylene Chloride flagged undetected 'U' in BAE04-13
-Acetone flagged undetected 'U' in BAE04,05,06,08,09,10,11
BnA -1,4 Dichlorobenzene flagged undetected "U" in BAE 04-13

B) Field or rinse blank contamination ("water blanks" or "distilled water blanks" are validated like any other sample)

C) Trip blank contamination

DATA ASSESSMENT:

4. CALIBRATION:

Satisfactory instrument calibration is established to ensure that the instrument is capable of producing acceptable quantitative data. An initial calibration demonstrates that the instrument is capable of giving acceptable performance at the beginning of an experimental sequence. The continuing calibration checks document that the instrument is giving satisfactory daily performance.

A) RESPONSE FACTOR:

The response factor measures the instrument's response to specific chemical compounds. The response factor for the Target Compound List (TCL) must be $\geq$ 0.05 in both the initial and continuing calibrations. A value < 0.05 indicates a serious detection and quantitation problem (poor sensitivity). Analytes detected in the sample will be qualified as estimated, "J". All non-detects for that compound will be rejected ("R").

DATA ASSESSMENT:

5. CALIBRATION:

A) PERCENT RELATIVE STANDARD DEVIATION (%RSD) AND PERCENT DIFFERENCE (%D):

Percent RSD is calculated from the initial calibration and is used to indicate the stability of the specific compound response factor over increasing concentration. Percent D compares the response factor of the continuing calibration check to the mean response factor (RRF) from the initial calibration. Percent D is a measure of the instrument's daily performance. Percent RSD must be <30% and %D must be <25%. A value outside of these limits indicates potential detection and quantitation errors. For these reasons, all positive results are flagged as estimated, "J" and non-detects are flagged "UJ" (if %D or RSD >50%). If there is a gross deviation of %RSD and %D, the non-detects may be rejected ("R").

For the PCB/PESTICIDE fraction, %RSD for aldrin, endrin, DDT, and dibutylchlorendate must not exceed 10%. Percent D must be within 15% on the quantitation column and 20% on the confirmation column.

VOA - Chloromethane and trans-1,3-Dichloropropene were qualified estimated J due to %D>50 in CCC in the following samples BHE04,05,06,07

Acetone was flagged estimated "J" in BHE14&16 due IC >30%.

SV - The analytes listed below would have been flagged estimated "J" due to Calibrations out of QC but were previously flagged due to holding time being exceeded by 3 days.

Benzyl alcohol-(J) >50%D in BHE04,06,07,09,13,08,10
hexachlorocyclopentadiene-(J) >50%D in BHE04,06,07,09,13,05,11,12,08,10
2,4-Dinitrophenol-(J) >50%D in BHE04,06,07,09,13,08,10
4-nitrophenol-(J) >50%D in BHE04,06,07,09,13
4-nitroaniline-(J) >50%D in BHE04,06,07,09,13

SV - Bis(2-chloroisopropyl)ether was flagged estimated (J) in BHE15 due to %D 750 and benzo(ghi)perylene

DATA ASSESSMENT:

6. SURROGATES:

All samples are spiked with surrogate compounds prior to sample preparation to evaluate overall laboratory performance and efficiency of the analytical technique. If the measured surrogate concentrations were outside contract specifications, qualifications were applied to the samples and analytes as shown below.

DATA ASSESSMENT:

7. INTERNAL STANDARDS PERFORMANCE:

Internal standard (IS) performance criteria ensure that the GC/MS sensitivity and response are stable during every experimental run. The internal standard area count must not vary by more than a factor of 2 (-50% to +100%) from the associated continuing calibration standard. The retention time of the internal standard must not vary more than ±30 seconds from the associated continuing calibration standard. If the area count is outside the (-50% to +100%) range of the associated standard, all of the positive results for compounds quantitated using that IS are qualified as estimated, "J", and all non-detects as "UJ", or "R" if there is a severe loss of sensitivity.

If an internal standard retention time varies by more than 30 seconds, the reviewer will use professional judgment to determine either partial or total rejection of the data for that sample fraction.

SV - Perylene-d12 showed low area counts for sample BHE10, therefore those analytes (7) quantitated using this standard were flagged ~~rejected~~ ~~(R)~~ Estimated J.

DATA ASSESSMENT:

8. COMPOUND IDENTIFICATION:

A) VOLATILE AND SEMI-VOLATILE FRACTIONS:

TCL compounds are identified on the GC/MS by using the analyte's relative retention time (RRT) and by comparison to the ion spectra obtained from known standards. For the results to be a positive hit, the sample peak must be within ± 0.06 RRT units of the standard compound and have an ion spectra which has a ratio of the primary and secondary m/e intensities within 20% of that in the standard compound. For the tentatively identified compounds (TIC) the ion spectra must match accurately. In the cases where there is not an adequate ion spectrum match, the laboratory may have provided false positive identifications.

B) PESTICIDE FRACTION:

The retention times of reported compounds must fall within the calculated retention time windows for the two chromatographic columns and a GC/MS confirmation is required if the concentration exceeds 10 ng/ml in the final sample extract.

PEST - DDT is out of RT window for one column in BHE13, this analyte was previously flagged estimated (J) due to exceedance of holding time. Therefore no further action was taken.

DATA ASSESSMENT:

9. MATRIX SPIKE/SPIKE DUPLICATE, MS/MSD:

The MS/MSD data are generated to determine the long-term precision and accuracy of the analytical method in various matrices. The MS/MSD may be used in conjunction with other QC criteria for some additional qualification of the data.

ATTACHMENT 1
SOP NO. HW-6

PAGE__OF__

DATA ASSESSMENT:

10. OTHER QC DATA OUT OF SPECIFICATION:

11. SYSTEM PERFORMANCE AND OVERALL ASSESSMENT (continued on next page if necessary):

12. CONTRACT PROBLEMS____NON-COMPLIANCE:

SV- The 6th IS was out of QC Criteria for BHE10 and was not reanalyzed by the laboratory.

13. This package contains re-extraction, re-analysis or dilution. Upon reviewing the QA results, the following form I(s) are identified to be used.

DATA ASSESSMENT:

11. SYSTEM PERFORMANCE AND OVERALL ASSESSMENT (continued):

Type of Review: Total

Date: 5/9/91

Case #: 15941

Project: Flagrchic

Lab Name: Cimic

Reviewer's Initials: JB

Number of Samples: 13

Analytes Rejected Due to Exceeding Review Criteria:

	Surrogates	Holding Time	Calibration	Method Contamination	Field Contamination	ID	IS Other	Total # Samples	Total # Rejected/ Total # in all Samples
Acids (15)								13	0 / 195
B/N (50)				10/10			~~7/13~~	13	IS 5/15/91 ~~17~~ ~~10~~ 10 / 650
VOA (35)				17/10				13	17 / 455
PEST (20)								13	0 / 260
PCB (7)								13	0 / 91
TCDD (1)								~~0~~	

Analytes Estimated Due to Exceeding Review Criteria for:

Acids (15)		149/10					13	149 / 195
B/N (50)		462/10	2/1			7/1	13	IS 5/16/91 ~~464~~ 447 / 650
VOA (35)			4/4				13	4 / 455
PEST (20)		199/10					13	199 / 260
PCB (7)		70/10					13	70 / 91
TCDD (1)							~~0~~	

Region ____

ORGANIC REGIONAL DATA ASSESSMENT SUMMARY

CASE NO. 15941

SDG NO. BHE04

SOW ____

LABORATORY Comtd

DATA USER FIT2

REVIEW COMPLETION DATE 5/9/91

NO. OF SAMPLES 3 WATER 10 SOIL ____ OTHER

REVIEWER [ ] ESD [ ] ESAT [X] OTHER, CONTRACT/CONTRACTOR FIT2

	VOA	BNA	PEST	OTHER
1. HOLDING TIMES	O	M	M	
2. GC-MS TUNE/ GC PERFORMANCE	O	O	O	
3. INITIAL CALIBRATIONS	O	O	O	
4. CONTINUING CALIBRATIONS	X	O	O	
5. FIELD BLANKS ("F" = not applicable)	O	O	O	
6. LABORATORY BLANKS	X	X	O	
7. SURROGATES	O	O	O	
8. MATRIX SPIKE/DUPLICATES	O	O	O	
9. REGIONAL QC ("F" = not applicable)	F	F	F	
10. INTERNAL STANDARDS	O	O		
11. COMPOUND IDENTIFICATION	O	O	O	
12. COMPOUND QUANTITATION	O	O	O	
13. SYSTEM PERFORMANCE	X	M	M	
14. OVERALL ASSESSMENT	X	M	M	

O = No problems or minor problems that do not affect data usability.
X = No more than *about* 5% of the data points are qualified as either estimated or unusable.
M = More than *about* 5% of the data points are qualified as estimated.
Z = More than *about* 5% of the data points are qualified as unusable.

DPO ACTION ITEMS: ____

AREAS OF CONCERN: ____

CLP Data Tracking Form 1 - Revalidation of Case # : 15941
revision 0

Type :ORGANIC

Contractor : FIT

Reviewer : J. Brown

TYPE OF ERROR (Crit,Signif,Trans) :

Description :

Page 782 is missing from data package

Action :

TYPE OF ERROR (Crit,Signif,Trans) :

Description : The reviewer rejected (flagged R) all the non-detect data of sample BHE10 quantitated with the internal Standard Perylene-D12 because the area of the IS was below the lower limit. However since the area was not extremely low a J qualification is more appropriate.

Action : Change R to J for non-detect data of sample BHE10, quantitated with Perylene-D12

Critical error = a significant error which effects 2 or more samples
Significant error = categories identified on the Functional Guidelines
Transcription error = can also be considered as major or minor

TOTAL ERRORS - # Crit :_____ # SIGNIF :_____ # TRANS : _____

ESAT REVIEWER : James E. Davis DATE: 30 May 1991
James E. Davis

5/30/91

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE04

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-01

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3216

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 9 Date Analyzed: 03/05/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
74-87-3	Chloromethane	11	U J
74-83-9	Bromomethane	11	U
75-01-4	Vinyl Chloride	11	U
75-00-3	Chloroethane	11	U
75-09-2	Methylene Chloride	5	~~BJ~~
67-64-1	Acetone	~~7~~	~~BJ~~
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	11	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	11	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	Trans-1,3-Dichloropropene	5	U J
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	11	U
591-78-6	2-Hexanone	11	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Total Xylenes	5	U

FORM I VOA 1/87 Rev.

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE04

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-01

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3216

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 9 Date Analyzed: 03/05/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

FORM I VOA-TIC

1/87 Rev.

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE05

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-02

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3217

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 16 Date Analyzed: 03/05/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
74-87-3	Chloromethane	12	U J
74-83-9	Bromomethane	12	U
75-01-4	Vinyl Chloride	12	U
75-00-3	Chloroethane	12	U
75-09-2	Methylene Chloride	6 ~~5~~	~~BJ~~ U
67-64-1	Acetone	~~10~~	~~BJ~~ U
75-15-0	Carbon Disulfide	6	U
75-35-4	1,1-Dichloroethene	6	U
75-34-3	1,1-Dichloroethane	6	U
540-59-0	1,2-Dichloroethene (total)	6	U
67-66-3	Chloroform	6	U
107-06-2	1,2-Dichloroethane	6	U
78-93-3	2-Butanone	12	U
71-55-6	1,1,1-Trichloroethane	6	U
56-23-5	Carbon Tetrachloride	6	U
108-05-4	Vinyl Acetate	12	U
75-27-4	Bromodichloromethane	6	U
78-87-5	1,2-Dichloropropane	6	U
10061-01-5	cis-1,3-Dichloropropene	6	U
79-01-6	Trichloroethene	6	U
124-48-1	Dibromochloromethane	6	U
79-00-5	1,1,2-Trichloroethane	6	U
71-43-2	Benzene	6	U
10061-02-6	Trans-1,3-Dichloropropene	6	U J
75-25-2	Bromoform	6	U
108-10-1	4-Methyl-2-Pentanone	12	U
591-78-6	2-Hexanone	12	U
127-18-4	Tetrachloroethene	6	U
79-34-5	1,1,2,2-Tetrachloroethane	6	U
108-88-3	Toluene	6	U
108-90-7	Chlorobenzene	6	U
100-41-4	Ethylbenzene	6	U
100-42-5	Styrene	6	U
1330-20-7	Total Xylenes	6	U

FORM I VOA

1/87 Rev.

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE05

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-02

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3217

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 16 Date Analyzed: 03/05/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

171

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE06

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-03

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3220

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 14 Date Analyzed: 03/06/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NO.	COMPOUND		Q
74-87-3	Chloromethane	12	U
74-83-9	Bromomethane	12	U
75-01-4	Vinyl Chloride	12	U
75-00-3	Chloroethane	12	U
75-09-2	Methylene Chloride	12	U
67-64-1	Acetone	6	~~B~~ U
75-15-0	Carbon Disulfide	18	~~B~~ U
75-35-4	1,1-Dichloroethene	6	U
75-34-3	1,1-Dichloroethane	6	U
540-59-0	1,2-Dichloroethene (total)	6	U
67-66-3	Chloroform	6	U
107-06-2	1,2-Dichloroethane	6	U
78-93-3	2-Butanone	6	U
71-55-6	1,1,1-Trichloroethane	12	U
56-23-5	Carbon Tetrachloride	6	U
108-05-4	Vinyl Acetate	6	U
75-27-4	Bromodichloromethane	12	U
78-87-5	1,2-Dichloropropane	6	U
10061-01-5	cis-1,3-Dichloropropene	6	U
79-01-6	Trichloroethene	6	U
124-48-1	Dibromochloromethane	6	U
79-00-5	1,1,2-Trichloroethane	6	U
71-43-2	Benzene	6	U
10061-02-6	Trans-1,3-Dichloropropene	6	U
75-25-2	Bromoform	6	U
108-10-1	4-Methyl-2-Pentanone	6	U
591-78-6	2-Hexanone	12	U
127-18-4	Tetrachloroethene	12	U
79-34-5	1,1,2,2-Tetrachloroethane	6	U
108-88-3	Toluene	6	U
108-90-7	Chlorobenzene	6	U
100-41-4	Ethylbenzene	6	U
100-42-5	Styrene	6	U
1330-20-7	Total Xylenes	6	U

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE06

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-03

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3220

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 14 Date Analyzed: 03/06/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 2

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	26.92	5.8	J N
2. 000000	C10H16O isomer	28.77	28	J N

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE07

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-04

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3221

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 14 Date Analyzed: 03/06/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
74-87-3	Chloromethane	12	U J
74-83-9	Bromomethane	12	U
75-01-4	Vinyl Chloride	12	U
75-00-3	Chloroethane	12	U
75-09-2	Methylene Chloride	6	~~5~~ ~~U~~
67-64-1	Acetone	12	U
75-15-0	Carbon Disulfide	6	U
75-35-4	1,1-Dichloroethene	6	U
75-34-3	1,1-Dichloroethane	6	U
540-59-0	1,2-Dichloroethene (total)	6	U
67-66-3	Chloroform	6	U
107-06-2	1,2-Dichloroethane	6	U
78-93-3	2-Butanone	12	U
71-55-6	1,1,1-Trichloroethane	6	U
56-23-5	Carbon Tetrachloride	6	U
108-05-4	Vinyl Acetate	12	U
75-27-4	Bromodichloromethane	6	U
78-87-5	1,2-Dichloropropane	6	U
10061-01-5	cis-1,3-Dichloropropene	6	U
79-01-6	Trichloroethene	6	U
124-48-1	Dibromochloromethane	6	U
79-00-5	1,1,2-Trichloroethane	6	U
71-43-2	Benzene	6	U
10061-02-6	Trans-1,3-Dichloropropene	6	U J
75-25-2	Bromoform	6	U
108-10-1	4-Methyl-2-Pentanone	12	U
591-78-6	2-Hexanone	12	U
127-18-4	Tetrachloroethene	6	U
79-34-5	1,1,2,2-Tetrachloroethane	6	U
108-88-3	Toluene	6	U
108-90-7	Chlorobenzene	6	U
100-41-4	Ethylbenzene	6	U
100-42-5	Styrene	6	U
1330-20-7	Total Xylenes	6	U

FORM I VOA 1/87 Rev.

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE07

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-04

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3221

Level: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 14 Date Analyzed: 03/06/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

C.1187

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE08

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-05

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3234

Level: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 14 Date Analyzed: 03/06/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
74-87-3	Chloromethane	12	U
74-83-9	Bromomethane	12	U
75-01-4	Vinyl Chloride	12	U
75-00-3	Chloroethane	12	U
75-09-2	Methylene Chloride	6 ~~8~~	~~BJ~~
67-64-1	Acetone	12 ~~5~~	~~BJ~~
75-15-0	Carbon Disulfide	6	U
75-35-4	1,1-Dichloroethene	6	U
75-34-3	1,1-Dichloroethane	6	U
540-59-0	1,2-Dichloroethene (total)	6	U
67-66-3	Chloroform	6	U
107-06-2	1,2-Dichloroethane	6	U
78-93-3	2-Butanone	12	U
71-55-6	1,1,1-Trichloroethane	6	U
56-23-5	Carbon Tetrachloride	6	U
108-05-4	Vinyl Acetate	12	U
75-27-4	Bromodichloromethane	6	U
78-87-5	1,2-Dichloropropane	6	U
10061-01-5	cis-1,3-Dichloropropene	6	U
79-01-6	Trichloroethene	6	U
124-48-1	Dibromochloromethane	6	U
79-00-5	1,1,2-Trichloroethane	6	U
71-43-2	Benzene	6	U
10061-02-6	Trans-1,3-Dichloropropene	6	U
75-25-2	Bromoform	6	U
108-10-1	4-Methyl-2-Pentanone	12	U
591-78-6	2-Hexanone	12	U
127-18-4	Tetrachloroethene	6	U
79-34-5	1,1,2,2-Tetrachloroethane	6	U
108-88-3	Toluene	6	U
108-90-7	Chlorobenzene	6	U
100-41-4	Ethylbenzene	6	U
100-42-5	Styrene	6	U
1330-20-7	Total Xylenes	6	U

0.1192

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE08

Lab Name: CEIMIC CORP

Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL

Sample wt/vol: 5.0 (g/mL) G

Lab Sample ID: 910113-05

Level: (low/med) LOW

Lab File ID: E3234

% Moisture: not dec. 14

Date Received: 02/28/91

Column (pack/cap) PACK

Date Analyzed: 03/06/91

Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

FORM I VOA-TIC

1/87 Rev.

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE09

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-06

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3235

Level: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 18 Date Analyzed: 03/06/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
74-87-3	Chloromethane	12	U
74-83-9	Bromomethane	12	U
75-01-4	Vinyl Chloride	12	U
75-00-3	Chloroethane	12	U
75-09-2	Methylene Chloride	4	BJ
67-64-1	Acetone	5	BJ
75-15-0	Carbon Disulfide	6	U
75-35-4	1,1-Dichloroethene	6	U
75-34-3	1,1-Dichloroethane	6	U
540-59-0	1,2-Dichloroethene (total)	6	U
67-66-3	Chloroform	6	U
107-06-2	1,2-Dichloroethane	6	U
78-93-3	2-Butanone	12	U
71-55-6	1,1,1-Trichloroethane	6	U
56-23-5	Carbon Tetrachloride	6	U
108-05-4	Vinyl Acetate	12	U
75-27-4	Bromodichloromethane	6	U
78-87-5	1,2-Dichloropropane	6	U
10061-01-5	cis-1,3-Dichloropropene	6	U
79-01-6	Trichloroethene	6	U
124-48-1	Dibromochloromethane	6	U
79-00-5	1,1,2-Trichloroethane	6	U
71-43-2	Benzene	6	U
10061-02-6	Trans-1,3-Dichloropropene	6	U
75-25-2	Bromoform	6	U
108-10-1	4-Methyl-2-Pentanone	12	U
591-78-6	2-Hexanone	12	U
127-18-4	Tetrachloroethene	6	U
79-34-5	1,1,2,2-Tetrachloroethane	6	U
108-88-3	Toluene	6	U
108-90-7	Chlorobenzene	6	U
100-41-4	Ethylbenzene	6	U
100-42-5	Styrene	6	U
1330-20-7	Total Xylenes	6	U

FORM I VOA 1/87 Rev.

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE09

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-06

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3235

Level: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 18 Date Analyzed: 03/06/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

C.1200

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE10

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15341 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-07

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3236

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 13 Date Analyzed: 03/06/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NO.	COMPOUND		Q
74-87-3	Chloromethane	11	U
74-83-9	Bromomethane	11	U
75-01-4	Vinyl Chloride	11	U
75-00-3	Chloroethane	11	U
75-09-2	Methylene Chloride	~~4~~ 6	~~BJ~~
67-64-1	Acetone	~~8~~ 11	~~BJ~~
75-15-0	Carbon Disulfide	6	U
75-35-4	1,1-Dichloroethene	6	U
75-34-3	1,1-Dichloroethane	6	U
540-59-0	1,2-Dichloroethene (total)	6	U
67-66-3	Chloroform	6	U
107-06-2	1,2-Dichloroethane	6	U
78-93-3	2-Butanone	11	U
71-55-6	1,1,1-Trichloroethane	6	U
56-23-5	Carbon Tetrachloride	6	U
108-05-4	Vinyl Acetate	11	U
75-27-4	Bromodichloromethane	6	U
78-87-5	1,2-Dichloropropane	6	U
10061-01-5	cis-1,3-Dichloropropene	6	U
79-01-6	Trichloroethene	6	U
124-48-1	Dibromochloromethane	6	U
79-00-5	1,1,2-Trichloroethane	6	U
71-43-2	Benzene	6	U
10061-02-6	Trans-1,3-Dichloropropene	6	U
75-25-2	Bromoform	6	U
108-10-1	4-Methyl-2-Pentanone	11	U
591-78-6	2-Hexanone	11	U
127-18-4	Tetrachloroethene	6	U
79-34-5	1,1,2,2-Tetrachloroethane	6	U
108-88-3	Toluene	6	U
108-90-7	Chlorobenzene	6	U
100-41-4	Ethylbenzene	6	U
100-42-5	Styrene	6	U
1330-20-7	Total Xylenes	6	U

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE10

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-07

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3236

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 13 Date Analyzed: 03/06/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

C.1207

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE11

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-08

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3237

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 6 Date Analyzed: 03/06/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NO.	COMPOUND		Q
74-87-3	Chloromethane	11	U
74-83-9	Bromomethane	11	U
75-01-4	Vinyl Chloride	11	U
75-00-3	Chloroethane	11	U
75-09-2	Methylene Chloride	5 ~~2~~	~~BJ~~
67-64-1	Acetone	11 ~~4~~	~~BJ~~
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	11	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	11	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	Trans-1,3-Dichloropropene	5	U
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	11	U
591-78-6	2-Hexanone	11	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Total Xylenes	5	U

0.1213

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE11

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-08

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3237

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 6 Date Analyzed: 03/06/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

C.1214

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE12

Lab Name: CEIMIC CORP Contract: 68D90029

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-09

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3238

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 21 Date Analyzed: 03/06/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NO.	COMPOUND		Q
74-87-3	Chloromethane	13	U
74-83-9	Bromomethane	13	U
75-01-4	Vinyl Chloride	13	U
75-00-3	Chloroethane	13	U
75-09-2	Methylene Chloride	~~8~~	~~BJ~~
67-64-1	Acetone	13	U
75-15-0	Carbon Disulfide	6	U
75-35-4	1,1-Dichloroethene	6	U
75-34-3	1,1-Dichloroethane	6	U
540-59-0	1,2-Dichloroethene (total)	6	U
67-66-3	Chloroform	6	U
107-06-2	1,2-Dichloroethane	6	U
78-93-3	2-Butanone	13	U
71-55-6	1,1,1-Trichloroethane	6	U
56-23-5	Carbon Tetrachloride	6	U
108-05-4	Vinyl Acetate	13	U
75-27-4	Bromodichloromethane	6	U
78-87-5	1,2-Dichloropropane	6	U
10061-01-5	cis-1,3-Dichloropropene	6	U
79-01-6	Trichloroethene	6	U
124-48-1	Dibromochloromethane	6	U
79-00-5	1,1,2-Trichloroethane	6	U
71-43-2	Benzene	6	U
10061-02-6	Trans-1,3-Dichloropropene	6	U
75-25-2	Bromoform	6	U
108-10-1	4-Methyl-2-Pentanone	13	U
591-78-6	2-Hexanone	13	U
127-18-4	Tetrachloroethene	6	U
79-34-5	1,1,2,2-Tetrachloroethane	6	U
108-88-3	Toluene	6	U
108-90-7	Chlorobenzene	6	U
100-41-4	Ethylbenzene	6	U
100-42-5	Styrene	6	U
1330-20-7	Total Xylenes	6	U

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE12

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-09

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3238

Level: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 21 Date Analyzed: 03/06/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0 CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

FORM I VOA-TIC

1/87 Rev.

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE13

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-10

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3239

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 Date Analyzed: 03/06/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
74-87-3	Chloromethane	12	U
74-83-9	Bromomethane	12	U
75-01-4	Vinyl Chloride	12	U
75-00-3	Chloroethane	12	U
75-09-2	Methylene Chloride	6 ~~3~~	~~BJ~~
67-64-1	Acetone	12	U
75-15-0	Carbon Disulfide	6	U
75-35-4	1,1-Dichloroethene	6	U
75-34-3	1,1-Dichloroethane	6	U
540-59-0	1,2-Dichloroethene (total)	6	U
67-66-3	Chloroform	6	U
107-06-2	1,2-Dichloroethane	6	U
78-93-3	2-Butanone	12	U
71-55-6	1,1,1-Trichloroethane	6	U
56-23-5	Carbon Tetrachloride	6	U
108-05-4	Vinyl Acetate	12	U
75-27-4	Bromodichloromethane	6	U
78-87-5	1,2-Dichloropropane	6	U
10061-01-5	cis-1,3-Dichloropropene	6	U
79-01-6	Trichloroethene	6	U
124-48-1	Dibromochloromethane	6	U
79-00-5	1,1,2-Trichloroethane	6	U
71-43-2	Benzene	6	U
10061-02-6	Trans-1,3-Dichloropropene	6	U
75-25-2	Bromoform	6	U
108-10-1	4-Methyl-2-Pentanone	12	U
591-78-6	2-Hexanone	12	U
127-18-4	Tetrachloroethene	6	U
79-34-5	1,1,2,2-Tetrachloroethane	6	U
108-88-3	Toluene	6	U
108-90-7	Chlorobenzene	6	U
100-41-4	Ethylbenzene	6	U
100-42-5	Styrene	6	U
1330-20-7	Total Xylenes	6	U

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE13

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-10

Sample wt/vol: 5.0 (g/mL) G Lab File ID: E3239

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 Date Analyzed: 03/06/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

FORM I VOA-TIC

1/87 Rev.

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE14

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-11

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: F2469

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ Date Analyzed: 03/05/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND		Q
74-87-3	Chloromethane	4	J
74-83-9	Bromomethane	1	J
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	13	B
67-64-1	Acetone	12	J
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	10	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	Trans-1,3-Dichloropropene	5	U
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Total Xylenes	5	U

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE14

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-11

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: F2469

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ Date Analyzed: 03/05/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

233

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE15

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-12

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: F2470

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ Date Analyzed: 03/05/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND		Q
74-87-3	Chloromethane	2	J
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	6	B
67-64-1	Acetone	7	J
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	10	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	Trans-1,3-Dichloropropene	5	U
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Total Xylenes	5	U

C. 1240

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE15

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-12

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: F2470

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ Date Analyzed: 03/05/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

FORM I VOA-TIC 1/87 Rev.

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE16

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-13

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: F2471

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ Date Analyzed: 03/05/91

Column: (pack/cap) PACK Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND		Q
74-87-3	Chloromethane	10	U
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	8	B
67-64-1	Acetone	10	J
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	10	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	Trans-1,3-Dichloropropene	5	U
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Total Xylenes	5	U

248

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE16

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-13

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: F2471

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ Date Analyzed: 03/05/91

Column (pack/cap) PACK Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE04

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-01

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7327

Level: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 9 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 6.5 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	360	U
111-44-4	bis(2-Chloroethyl)Ether	360	U
95-57-8	2-Chlorophenol	360	U
541-73-1	1,3-Dichlorobenzene	360	U
106-46-7	1,4-Dichlorobenzene	360	U
100-51-6	Benzyl Alcohol	360 ~~140~~	~~BJ~~ U
95-50-1	1,2-Dichlorobenzene	360	U
95-48-7	2-Methylphenol	360	U
108-60-1	bis(2-Chloroisopropyl)Ether	360	U
106-44-5	4-Methylphenol	360	U
621-64-7	N-Nitroso-Di-n-Propylamine	360	U
67-72-1	Hexachloroethane	360	U
98-95-3	Nitrobenzene	360	U
78-59-1	Isophorone	360	U
88-75-5	2-Nitrophenol	360	U
105-67-9	2,4-Dimethylphenol	360	U
65-85-0	Benzoic Acid	360	U
111-91-1	bis(2-Chloroethoxy)Methane	1800	U
120-83-2	2,4-Dichlorophenol	360	U
120-82-1	1,2,4-Trichlorobenzene	360	U
91-20-3	Naphthalene	360	U
106-47-8	4-Chloroaniline	360	U
87-68-3	Hexachlorobutadiene	360	U
59-50-7	4-Chloro-3-Methylphenol	360	U
91-57-6	2-Methylnaphthalene	360	U
77-47-4	Hexachlorocyclopentadiene	360	U
88-06-2	2,4,6-Trichlorophenol	360	U
95-95-4	2,4,5-Trichlorophenol	360	U
91-58-7	2-Chloronaphthalene	1800	U
88-74-4	2-Nitroaniline	360	U
131-11-3	Dimethyl Phthalate	1800	U
208-96-8	Acenaphthylene	360	U
606-20-2	2,6-Dinitrotoluene	360	U
		360	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE04

Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-01

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7327

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 9 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 6.5 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	1800	U J
83-32-9	Acenaphthene	360	U
51-28-5	2,4-Dinitrophenol	1800	U
100-02-7	4-Nitrophenol	1800	U
132-64-9	Dibenzofuran	360	U
121-14-2	2,4-Dinitrotoluene	360	U
84-66-2	Diethylphthalate	360	U
7005-72-3	4-Chlorophenyl-phenylether	360	U
86-73-7	Fluorene	360	U
100-01-6	4-Nitroaniline	1800	U
534-52-1	4,6-Dinitro-2-Methylphenol	1800	U
86-30-6	N-Nitrosodiphenylamine (1)	360	U
101-55-3	4-Bromophenyl-phenylether	360	U
118-74-1	Hexachlorobenzene	360	U
87-86-5	Pentachlorophenol	1800	U J
85-01-8	Phenanthrene	43	J
120-12-7	Anthracene	360	U J
84-74-2	Di-n-Butylphthalate	44	J
206-44-0	Fluoranthene	120	J
129-00-0	Pyrene	160	J
85-68-7	Butylbenzylphthalate	360	U J
91-94-1	3,3'-Dichlorobenzidine	730	U
56-55-3	Benzo(a)Anthracene	61	J
218-01-9	Chrysene	150	J
117-81-7	bis(2-Ethylhexyl)Phthalate	120	J
117-84-0	Di-n-Octyl Phthalate	360	U J
205-99-2	Benzo(b)Fluoranthene	180	J
207-08-9	Benzo(k)Fluoranthene	110	J
50-32-8	Benzo(a)Pyrene	67	J
193-39-5	Indeno(1,2,3-cd)Pyrene	72	J
53-70-3	Dibenz(a,h)Anthracene	360	U J
191-24-2	Benzo(g,h,i)Perylene	69	J

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE04

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-01

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7327

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 9 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 6.5 Dilution Factor: 1.0

Number TICs found: 9

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	C6H10O isomer	5.02	540	~~BJ~~ R
2. 000000	Unknown	5.10	1200	~~BJ~~
3. 000000	C6H10O isomer	5.27	720	~~BJ~~
4. 000000	Unknown	5.60	1800	~~BJ~~
5. 123422	2-Pentanone, 4-Hydroxy-4-Met	6.37	47000	~~ABJ~~
6. 000000	C7H12O isomer	7.43	3100	~~BJ~~
7. 000000	Unknown	7.92	1800	~~BJ~~
8. 000000	Aliphatic hydrocarbon	36.01	3000	~~BJ~~
9. 000000	Aliphatic hydrocarbon	38.64	430	~~BJ~~ R

C.1364

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE05

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-02

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7338

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 5.2 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	400	U
111-44-4	bis(2-Chloroethyl)Ether	400	U
95-57-8	2-Chlorophenol	400	U
541-73-1	1,3-Dichlorobenzene	400	U
106-46-7	1,4-Dichlorobenzene	400	U
100-51-6	Benzyl Alcohol	400 ~~130~~	~~JB~~
95-50-1	1,2-Dichlorobenzene	400	U
95-48-7	2-Methylphenol	400	U
108-60-1	bis(2-Chloroisopropyl)Ether	400	U
106-44-5	4-Methylphenol	400	U
621-64-7	N-Nitroso-Di-n-Propylamine	400	U
67-72-1	Hexachloroethane	400	U
98-95-3	Nitrobenzene	400	U
78-59-1	Isophorone	400	U
88-75-5	2-Nitrophenol	400	U
105-67-9	2,4-Dimethylphenol	400	U
65-85-0	Benzoic Acid	400	U
111-91-1	bis(2-Chloroethoxy)Methane	1900	U
120-83-2	2,4-Dichlorophenol	400	U
120-82-1	1,2,4-Trichlorobenzene	400	U
91-20-3	Naphthalene	400	U
106-47-8	4-Chloroaniline	400	U
87-68-3	Hexachlorobutadiene	400	U
59-50-7	4-Chloro-3-Methylphenol	400	U
91-57-6	2-Methylnaphthalene	400	U
77-47-4	Hexachlorocyclopentadiene	400	U
88-06-2	2,4,6-Trichlorophenol	400	U
95-95-4	2,4,5-Trichlorophenol	400	U
91-58-7	2-Chloronaphthalene	1900	U
88-74-4	2-Nitroaniline	400	U
131-11-3	Dimethyl Phthalate	1900	U
208-96-8	Acenaphthylene	400	U
606-20-2	2,6-Dinitrotoluene	400	U
		400	U

D390

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE05

Name: CEIMIC CORP Contract: 68D90028

Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-02

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7338

Level: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 17 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 5.2 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	1900	U
83-32-9	Acenaphthene	400	U
51-28-5	2,4-Dinitrophenol	1900	U
100-02-7	4-Nitrophenol	1900	U
132-64-9	Dibenzofuran	400	U
121-14-2	2,4-Dinitrotoluene	400	U
84-66-2	Diethylphthalate	400	U
7005-72-3	4-Chlorophenyl-phenylether	400	U
86-73-7	Fluorene	400	U
100-01-6	4-Nitroaniline	1900	U
534-52-1	4,6-Dinitro-2-Methylphenol	1900	U
86-30-6	N-Nitrosodiphenylamine (1)	400	U
101-55-3	4-Bromophenyl-phenylether	400	U
118-74-1	Hexachlorobenzene	400	U
87-86-5	Pentachlorophenol	1900	U
85-01-8	Phenanthrene	46	J
120-12-7	Anthracene	400	U J
84-74-2	Di-n-Butylphthalate	400	U J
206-44-0	Fluoranthene	89	J
129-00-0	Pyrene	77	J
85-68-7	Butylbenzylphthalate	400	U J
91-94-1	3,3'-Dichlorobenzidine	800	U J
56-55-3	Benzo(a)Anthracene	42	J
218-01-9	Chrysene	62	J
117-81-7	bis(2-Ethylhexyl)Phthalate	52	J
117-84-0	Di-n-Octyl Phthalate	400	U J
205-99-2	Benzo(b)Fluoranthene	60	J
207-08-9	Benzo(k)Fluoranthene	42	J
50-32-8	Benzo(a)Pyrene	400	U J
193-39-5	Indeno(1,2,3-cd)Pyrene	400	U J
53-70-3	Dibenz(a,h)Anthracene	400	U J
191-24-2	Benzo(g,h,i)Perylene	400	U J

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE05

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-02

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7338

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 5.2 Dilution Factor: 1.0

Number TICs found: 22

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	C7H14 isomer	5.05	1300	~~BJ~~ R
2. 000000	Unknown	5.58	1700	~~BJ~~
3. 123422	2-Pentanone, 4-Hydroxy-4-Met	6.33	34000	~~ABJ~~
4. 000000	Unknown	7.88	1300	~~BJ~~
5. 000000	Unknown	16.62	520	~~BJ~~
6. 000000	Unknown	24.17	360	~~BJ~~
7. 000000	Unknown	24.90	320	~~BJ~~
8. 000000	Unknown	25.72	360	~~BJ~~
9. 000000	Unknown	26.47	400	~~BJ~~
10. 000000	Unknown	26.69	240	~~BJ~~ R
11. 57114	Octadecanoic acid (9CI)	28.42	550	J N
12. 638664	Octadecanal (9CI)	31.32	320	J N
13. 000000	Aliphatic hydrocarbon	33.97	400	~~BJ~~ R
14. 000000	Aliphatic hydrocarbon	35.99	2100	~~BJ~~ R
15. 000000	Unknown	36.77	1300	~~BJ~~ R
16. 124254	Tetradecanal (ACN)(9CI)	37.81	360	J N
17. 7098228	Tetratetracontane (8CI9CI)	38.64	2700	J N
18. 000000	Unknown	40.19	1100	~~BJ~~ R
19. 638664	Octadecanal (9CI)	41.22	520	J N
20. 000000	Aliphatic hydrocarbon	42.33	1500	~~BJ~~ R
21. 000000	Unknown	42.49	1300	~~BJ~~ R
22. 000000	Unknown	42.94	320	~~BJ~~ R

1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE06

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-03

Sample wt/vol: 30.3 (g/mL) G Lab File ID: A7321

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 15 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

GPC Cleanup: (Y/N) N pH: 5.1 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	390	U
111-44-4	bis(2-Chloroethyl)Ether	390	U
95-57-8	2-Chlorophenol	390	U
541-73-1	1,3-Dichlorobenzene	390	U
106-46-7	1,4-Dichlorobenzene	390 ~~120~~	~~BJ~~
100-51-6	Benzyl Alcohol	390	U
95-50-1	1,2-Dichlorobenzene	390	U
95-48-7	2-Methylphenol	390	U
108-60-1	bis(2-Chloroisopropyl)Ether	390	U
106-44-5	4-Methylphenol	390	U
621-64-7	N-Nitroso-Di-n-Propylamine	390	U
67-72-1	Hexachloroethane	390	U
98-95-3	Nitrobenzene	390	U
78-59-1	Isophorone	390	U
88-75-5	2-Nitrophenol	390	U
105-67-9	2,4-Dimethylphenol	390	U
65-85-0	Benzoic Acid	1900	U
111-91-1	bis(2-Chloroethoxy)Methane	390	U
120-83-2	2,4-Dichlorophenol	390	U
120-82-1	1,2,4-Trichlorobenzene	390	U
91-20-3	Naphthalene	390	U
106-47-8	4-Chloroaniline	390	U
87-68-3	Hexachlorobutadiene	390	U
59-50-7	4-Chloro-3-Methylphenol	390	U
91-57-6	2-Methylnaphthalene	390	U
77-47-4	Hexachlorocyclopentadiene	390	U
88-06-2	2,4,6-Trichlorophenol	390	U
95-95-4	2,4,5-Trichlorophenol	1900	U
91-58-7	2-Chloronaphthalene	390	U
88-74-4	2-Nitroaniline	1900	U
131-11-3	Dimethyl Phthalate	390	U
208-96-8	Acenaphthylene	390	U
606-20-2	2,6-Dinitrotoluene	390	U

427

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE06

ab Name: CEIMIC CORP Contract: 68D90028

Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

rix: (soil/water) SOIL Lab Sample ID: 910113-03

ample wt/vol: 30.3 (g/mL) G Lab File ID: A7321

el: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 15 dec. ____ Date Extracted: 03/09/91

raction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

Cleanup: (Y/N) N pH: 5.1 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	1900	U
83-32-9	Acenaphthene	390	U
51-28-5	2,4-Dinitrophenol	1900	U
100-02-7	4-Nitrophenol	1900	U
132-64-9	Dibenzofuran	390	U
121-14-2	2,4-Dinitrotoluene	390	U
84-66-2	Diethylphthalate	390	U
7005-72-3	4-Chlorophenyl-phenylether	390	U
86-73-7	Fluorene	390	U
100-01-6	4-Nitroaniline	1900	U
534-52-1	4,6-Dinitro-2-Methylphenol	1900	U
86-30-6	N-Nitrosodiphenylamine (1)	390	U
101-55-3	4-Bromophenyl-phenylether	390	U
118-74-1	Hexachlorobenzene	390	U
87-86-5	Pentachlorophenol	1900	U
85-01-8	Phenanthrene	390	U
120-12-7	Anthracene	390	U
84-74-2	Di-n-Butylphthalate	390	U
206-44-0	Fluoranthene	390	U
129-00-0	Pyrene	390	U
85-68-7	Butylbenzylphthalate	390	U
91-94-1	3,3'-Dichlorobenzidine	780	U
56-55-3	Benzo(a)Anthracene	390	U
218-01-9	Chrysene	390	U
117-81-7	bis(2-Ethylhexyl)Phthalate	390	U
117-84-0	Di-n-Octyl Phthalate	390	U
205-99-2	Benzo(b)Fluoranthene	390	U
207-08-9	Benzo(k)Fluoranthene	390	U
50-32-8	Benzo(a)Pyrene	390	U
193-39-5	Indeno(1,2,3-cd)Pyrene	390	U
53-70-3	Dibenz(a,h)Anthracene	390	U
191-24-2	Benzo(g,h,i)Perylene	390	U

(1) - Cannot be separated from Diphenylamine

428

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE06

ab Name: CEIMIC CORP Contract: 68D90028

Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

atrix: (soil/water) SOIL Lab Sample ID: 910113-03

ample wt/vol: 30.3 (g/mL) G Lab File ID: A7321

evel: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 15 dec. ____ Date Extracted: 03/09/91

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

PC Cleanup: (Y/N) N pH: 5.1 Dilution Factor: 1.0

umber TICs found: 5

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

	CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	000000	Unknown	5.02	1100	~~BJ~~ R
2.	000000	Unknown	5.53	1900	~~BJ~~
3.	123422	4-Hydroxy-4-methyl-2-pentano	6.32	54000	~~ABJ~~
4.	000000	Unknown	7.85	1700	~~BJ~~
5.	000000	C10H1002 isomer	15.79	3200	~~BJ~~ R

1429

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE07

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-04

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7322

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 16 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

GPC Cleanup: (Y/N) N pH: 4.2 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	390	U
111-44-4	bis(2-Chloroethyl)Ether	390	U
95-57-8	2-Chlorophenol	390	U
541-73-1	1,3-Dichlorobenzene	390	U
106-46-7	1,4-Dichlorobenzene	390 ~~130~~	~~BJ~~
100-51-6	Benzyl Alcohol	390	U
95-50-1	1,2-Dichlorobenzene	390	U
95-48-7	2-Methylphenol	390	U
108-60-1	bis(2-Chloroisopropyl)Ether	390	U
106-44-5	4-Methylphenol	390	U
621-64-7	N-Nitroso-Di-n-Propylamine	390	U
67-72-1	Hexachloroethane	390	U
98-95-3	Nitrobenzene	390	U
78-59-1	Isophorone	390	U
88-75-5	2-Nitrophenol	390	U
105-67-9	2,4-Dimethylphenol	390	U
65-85-0	Benzoic Acid	1900	U
111-91-1	bis(2-Chloroethoxy)Methane	390	U
120-83-2	2,4-Dichlorophenol	390	U
120-82-1	1,2,4-Trichlorobenzene	390	U
91-20-3	Naphthalene	390	U
106-47-8	4-Chloroaniline	390	U
87-68-3	Hexachlorobutadiene	390	U
59-50-7	4-Chloro-3-Methylphenol	390	U
91-57-6	2-Methylnaphthalene	390	U
77-47-4	Hexachlorocyclopentadiene	390	U
88-06-2	2,4,6-Trichlorophenol	390	U
95-95-4	2,4,5-Trichlorophenol	1900	U
91-58-7	2-Chloronaphthalene	390	U
88-74-4	2-Nitroaniline	1900	U
131-11-3	Dimethyl Phthalate	390	U
208-96-8	Acenaphthylene	390	U
606-20-2	2,6-Dinitrotoluene	390	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE07

ab Name: CEIMIC CORP Contract: 68D90028

Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

atrix: (soil/water) SOIL Lab Sample ID: 910113-04

ample wt/vol: 30.4 (g/mL) G Lab File ID: A7322

evel: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 16 dec. ____ Date Extracted: 03/09/91

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

PC Cleanup: (Y/N) N pH: 4.2 Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NO.	COMPOUND		Q
99-09-2	3-Nitroaniline	1900	U
83-32-9	Acenaphthene	390	U
51-28-5	2,4-Dinitrophenol	1900	U
100-02-7	4-Nitrophenol	1900	U
132-64-9	Dibenzofuran	390	U
121-14-2	2,4-Dinitrotoluene	390	U
84-66-2	Diethylphthalate	390	U
7005-72-3	4-Chlorophenyl-phenylether	390	U
86-73-7	Fluorene	390	U
100-01-6	4-Nitroaniline	1900	U
534-52-1	4,6-Dinitro-2-Methylphenol	1900	U
86-30-6	N-Nitrosodiphenylamine (1)	390	U
101-55-3	4-Bromophenyl-phenylether	390	U
118-74-1	Hexachlorobenzene	390	U
87-86-5	Pentachlorophenol	1900	U
85-01-8	Phenanthrene	390	U
120-12-7	Anthracene	390	U
84-74-2	Di-n-Butylphthalate	390	U
206-44-0	Fluoranthene	390	U
129-00-0	Pyrene	390	U
85-68-7	Butylbenzylphthalate	390	U
91-94-1	3,3'-Dichlorobenzidine	790	U
56-55-3	Benzo(a)Anthracene	390	U
218-01-9	Chrysene	390	U
117-81-7	bis(2-Ethylhexyl)Phthalate	390	U
117-84-0	Di-n-Octyl Phthalate	390	U
205-99-2	Benzo(b)Fluoranthene	390	U
207-08-9	Benzo(k)Fluoranthene	390	U
50-32-8	Benzo(a)Pyrene	390	U
193-39-5	Indeno(1,2,3-cd)Pyrene	390	U
53-70-3	Dibenz(a,h)Anthracene	390	U
191-24-2	Benzo(g,h,i)Perylene	390	U

(1) - Cannot be separated from Diphenylamine

C.1440

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE08

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-05

Sample wt/vol: 30.1 (g/mL) G Lab File ID: A7360

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 15 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/07/91

GPC Cleanup: (Y/N) N pH: 4.8 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	390	U
111-44-4	bis(2-Chloroethyl)Ether	390	U
95-57-8	2-Chlorophenol	390	U
541-73-1	1,3-Dichlorobenzene	390	U
106-46-7	1,4-Dichlorobenzene	390 ~~79~~	~~BJ~~
100-51-6	Benzyl Alcohol	390	U
95-50-1	1,2-Dichlorobenzene	390	U
95-48-7	2-Methylphenol	390	U
108-60-1	bis(2-Chloroisopropyl)Ether	390	U
106-44-5	4-Methylphenol	390	U
621-64-7	N-Nitroso-Di-n-Propylamine	390	U
67-72-1	Hexachloroethane	390	U
98-95-3	Nitrobenzene	390	U
78-59-1	Isophorone	390	U
88-75-5	2-Nitrophenol	390	U
105-67-9	2,4-Dimethylphenol	390	U
65-85-0	Benzoic Acid	1900	U
111-91-1	bis(2-Chloroethoxy)Methane	390	U
120-83-2	2,4-Dichlorophenol	390	U
120-82-1	1,2,4-Trichlorobenzene	390	U
91-20-3	Naphthalene	390	U
106-47-8	4-Chloroaniline	390	U
87-68-3	Hexachlorobutadiene	390	U
59-50-7	4-Chloro-3-Methylphenol	390	U
91-57-6	2-Methylnaphthalene	390	U
77-47-4	Hexachlorocyclopentadiene	390	U
88-06-2	2,4,6-Trichlorophenol	390	U
95-95-4	2,4,5-Trichlorophenol	1900	U
91-58-7	2-Chloronaphthalene	390	U
88-74-4	2-Nitroaniline	1900	U
131-11-3	Dimethyl Phthalate	390	U
208-96-8	Acenaphthylene	390	U
606-20-2	2,6-Dinitrotoluene	390	U

451

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE08

ab Name: CEIMIC CORP Contract: 68D90028

Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

atrix: (soil/water) SOIL Lab Sample ID: 910113-05

ple wt/vol: 30.1 (g/mL) G Lab File ID: A7360

el: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 15 dec. ____ Date Extracted: 03/09/91

raction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/07/91

PC Cleanup: (Y/N) N pH: 4.8 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	1900	U
83-32-9	Acenaphthene	390	U
51-28-5	2,4-Dinitrophenol	1900	U
100-02-7	4-Nitrophenol	1900	U
132-64-9	Dibenzofuran	390	U
121-14-2	2,4-Dinitrotoluene	390	U
84-66-2	Diethylphthalate	390	U
7005-72-3	4-Chlorophenyl-phenylether	390	U
86-73-7	Fluorene	390	U
100-01-6	4-Nitroaniline	1900	U
534-52-1	4,6-Dinitro-2-Methylphenol	1900	U
86-30-6	N-Nitrosodiphenylamine (1)	390	U
101-55-3	4-Bromophenyl-phenylether	390	U
118-74-1	Hexachlorobenzene	390	U
87-86-5	Pentachlorophenol	1900	U
85-01-8	Phenanthrene	390	U
120-12-7	Anthracene	390	U
84-74-2	Di-n-Butylphthalate	390	U
206-44-0	Fluoranthene	390	U
129-00-0	Pyrene	390	U
85-68-7	Butylbenzylphthalate	390	U
91-94-1	3,3'-Dichlorobenzidine	780	U
56-55-3	Benzo(a)Anthracene	390	U
218-01-9	Chrysene	390	U
117-81-7	bis(2-Ethylhexyl)Phthalate	390	U
117-84-0	Di-n-Octyl Phthalate	390	U
205-99-2	Benzo(b)Fluoranthene	390	U
207-08-9	Benzo(k)Fluoranthene	390	U
50-32-8	Benzo(a)Pyrene	390	U
193-39-5	Indeno(1,2,3-cd)Pyrene	390	U
53-70-3	Dibenz(a,h)Anthracene	390	U
191-24-2	Benzo(g,h,i)Perylene	390	U

(1) - Cannot be separated from Diphenylamine

011452

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE08

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-05

Sample wt/vol: 30.1 (g/mL) G Lab File ID: A7360

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 15 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/07/91

GPC Cleanup: (Y/N) N pH: 4.8 Dilution Factor: 1.0

Number TICs found: 6

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	4.08	270	~~BJ~~ R
2. 000000	Unknown	4.73	470	~~BJ~~ R
3. 141797	3-Penten-2-one, 4-methyl- (8	5.07	1900	JN
4. 000000	Unknown	5.55	470	~~BJ~~ R
5. 123422	2-Pentanone, 4-Hydroxy-4-Met	6.18	15000	~~ABJ~~ R
6. 000000	Unknown	7.85	230	~~BJ~~ R

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE09

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-06

Sample wt/vol: 30.5 (g/mL) G Lab File ID: A7324

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 18 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

GPC Cleanup: (Y/N) N pH: 5.0 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	400	U
111-44-4	bis(2-Chloroethyl)Ether	400	U
95-57-8	2-Chlorophenol	400	U
541-73-1	1,3-Dichlorobenzene	400	U
106-46-7	1,4-Dichlorobenzene	400	U
100-51-6	Benzyl Alcohol	400 ~~180~~	~~BJ~~
95-50-1	1,2-Dichlorobenzene	400	U
95-48-7	2-Methylphenol	400	U
108-60-1	bis(2-Chloroisopropyl)Ether	400	U
106-44-5	4-Methylphenol	400	U
621-64-7	N-Nitroso-Di-n-Propylamine	400	U
67-72-1	Hexachloroethane	400	U
98-95-3	Nitrobenzene	400	U
78-59-1	Isophorone	400	U
88-75-5	2-Nitrophenol	400	U
105-67-9	2,4-Dimethylphenol	400	U
65-85-0	Benzoic Acid	400	U
111-91-1	bis(2-Chloroethoxy)Methane	2000	U
120-83-2	2,4-Dichlorophenol	400	U
120-82-1	1,2,4-Trichlorobenzene	400	U
91-20-3	Naphthalene	400	U
106-47-8	4-Chloroaniline	400	U
87-68-3	Hexachlorobutadiene	400	U
59-50-7	4-Chloro-3-Methylphenol	400	U
91-57-6	2-Methylnaphthalene	400	U
77-47-4	Hexachlorocyclopentadiene	400	U
88-06-2	2,4,6-Trichlorophenol	400	U
95-95-4	2,4,5-Trichlorophenol	400	U
91-58-7	2-Chloronaphthalene	2000	U
88-74-4	2-Nitroaniline	400	U
131-11-3	Dimethyl Phthalate	2000	U
208-96-8	Acenaphthylene	400	U
606-20-2	2,6-Dinitrotoluene	400	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE09

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

trix: (soil/water) SOIL Lab Sample ID: 910113-06

Sample wt/vol: 30.5 (g/mL) G Lab File ID: A7324

vel: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 18 dec. ____ Date Extracted: 03/09/91

traction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

PC Cleanup: (Y/N) N pH: 5.0 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	2000	U J
83-32-9	Acenaphthene	400	U
51-28-5	2,4-Dinitrophenol	2000	U
100-02-7	4-Nitrophenol	2000	U
132-64-9	Dibenzofuran	400	U
121-14-2	2,4-Dinitrotoluene	400	U
84-66-2	Diethylphthalate	400	U
7005-72-3	4-Chlorophenyl-phenylether	400	U
86-73-7	Fluorene	400	U
100-01-6	4-Nitroaniline	2000	U
534-52-1	4,6-Dinitro-2-Methylphenol	2000	U
86-30-6	N-Nitrosodiphenylamine (1)	400	U
101-55-3	4-Bromophenyl-phenylether	400	U
118-74-1	Hexachlorobenzene	400	U
87-86-5	Pentachlorophenol	2000	U
85-01-8	Phenanthrene	400	U
120-12-7	Anthracene	400	U
84-74-2	Di-n-Butylphthalate	400	U
206-44-0	Fluoranthene	400	U
129-00-0	Pyrene	400	U
85-68-7	Butylbenzylphthalate	400	U
91-94-1	3,3'-Dichlorobenzidine	810	U
56-55-3	Benzo(a)Anthracene	400	U
218-01-9	Chrysene	400	U
117-81-7	bis(2-Ethylhexyl)Phthalate	400	U
117-84-0	Di-n-Octyl Phthalate	400	U
205-99-2	Benzo(b)Fluoranthene	400	U
207-08-9	Benzo(k)Fluoranthene	400	U
50-32-8	Benzo(a)Pyrene	400	U
193-39-5	Indeno(1,2,3-cd)Pyrene	400	U
53-70-3	Dibenz(a,h)Anthracene	400	U
191-24-2	Benzo(g,h,i)Perylene	400	U J

(1) - Cannot be separated from Diphenylamine

465 4

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE09

ab Name: CEIMIC CORP Contract: 68D90028

Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

trix: (soil/water) SOIL Lab Sample ID: 910113-06

ple wt/vol: 30.5 (g/mL) G Lab File ID: A7324

el: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. 18 dec. ____ Date Extracted: 03/09/91

raction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

PC Cleanup: (Y/N) N pH: 5.0 Dilution Factor: 1.0

umber TICs found: 6

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 141797	4-Methyl-3-penten-2-one	5.02	520	J N
2. 000000	Unknown	5.58	1200	~~J~~ R
3. 123422	4-Hydroxy-4-methyl-2-pentano	6.33	39000	~~ABJ~~
4. 000000	Unknown	7.87	1200	~~J~~
5. 000000	Aliphatic hydrocarbon	33.97	280	~~J~~
6. 000000	Unknown	38.81	23000	~~J~~ R

466

C. 1 ~~464~~

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE10

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-07

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7361

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 13 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/07/91

GPC Cleanup: (Y/N) N pH: 5.2 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	380	U
111-44-4	bis(2-Chloroethyl)Ether	380	U
95-57-8	2-Chlorophenol	380	U
541-73-1	1,3-Dichlorobenzene	380	U
106-46-7	1,4-Dichlorobenzene	~~120~~ 380	~~BJ~~ U
100-51-6	Benzyl Alcohol	380	U
95-50-1	1,2-Dichlorobenzene	380	U
95-48-7	2-Methylphenol	380	U
108-60-1	bis(2-Chloroisopropyl)Ether	380	U
106-44-5	4-Methylphenol	380	U
621-64-7	N-Nitroso-Di-n-Propylamine	380	U
67-72-1	Hexachloroethane	380	U
98-95-3	Nitrobenzene	380	U
78-59-1	Isophorone	380	U
88-75-5	2-Nitrophenol	380	U
105-67-9	2,4-Dimethylphenol	380	U
65-85-0	Benzoic Acid	1800	U
111-91-1	bis(2-Chloroethoxy)Methane	380	U
120-83-2	2,4-Dichlorophenol	380	U
120-82-1	1,2,4-Trichlorobenzene	380	U
91-20-3	Naphthalene	380	U
106-47-8	4-Chloroaniline	380	U
87-68-3	Hexachlorobutadiene	380	U
59-50-7	4-Chloro-3-Methylphenol	380	U
91-57-6	2-Methylnaphthalene	380	U
77-47-4	Hexachlorocyclopentadiene	380	U
88-06-2	2,4,6-Trichlorophenol	380	U
95-95-4	2,4,5-Trichlorophenol	1800	U
91-58-7	2-Chloronaphthalene	380	U
88-74-4	2-Nitroaniline	1800	U
131-11-3	Dimethyl Phthalate	380	U
208-96-8	Acenaphthylene	380	U
606-20-2	2,6-Dinitrotoluene	380	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE10

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-07

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7361

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 13 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/07/91

GPC Cleanup: (Y/N) N pH: 5.2 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	1800	U
83-32-9	Acenaphthene	380	U
51-28-5	2,4-Dinitrophenol	1800	U
100-02-7	4-Nitrophenol	1800	U
132-64-9	Dibenzofuran	380	U
121-14-2	2,4-Dinitrotoluene	380	U
84-66-2	Diethylphthalate	380	U
7005-72-3	4-Chlorophenyl-phenylether	380	U
86-73-7	Fluorene	380	U
100-01-6	4-Nitroaniline	1800	U
534-52-1	4,6-Dinitro-2-Methylphenol	1800	U
86-30-6	N-Nitrosodiphenylamine (1)	380	U
101-55-3	4-Bromophenyl-phenylether	380	U
118-74-1	Hexachlorobenzene	380	U
87-86-5	Pentachlorophenol	1800	U
85-01-8	Phenanthrene	380	U
120-12-7	Anthracene	380	U
84-74-2	Di-n-Butylphthalate	380	U
206-44-0	Fluoranthene	380	U
129-00-0	Pyrene	380	U
85-68-7	Butylbenzylphthalate	380	U
91-94-1	3,3'-Dichlorobenzidine	760	U
56-55-3	Benzo(a)Anthracene	380	U
218-01-9	Chrysene	380	U
117-81-7	bis(2-Ethylhexyl)Phthalate	380	U
117-84-0	Di-n-Octyl Phthalate	380	~~U~~ J
205-99-2	Benzo(b)Fluoranthene	380	~~U~~
207-08-9	Benzo(k)Fluoranthene	380	~~U~~
50-32-8	Benzo(a)Pyrene	380	~~U~~
193-39-5	Indeno(1,2,3-cd)Pyrene	380	~~U~~
53-70-3	Dibenz(a,h)Anthracene	380	~~U~~
191-24-2	Benzo(g,h,i)Perylene	380	~~U~~ J

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE10

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-07

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7361

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 13 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/07/91

GPC Cleanup: (Y/N) N pH: 5.2 Dilution Factor: 1.0

Number TICs found: 5

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	4.08	610	~~BJ~~ R
2. 16745941	1-Hexene, 3,4-dimethyl- (8CI	4.72	300	JN
3. 000000	C6H10O isomer	5.07	5300	~~BJ~~ R
4. 123422	2-Pentanone, 4-Hydroxy-4-Met	6.13	7900	~~ABJ~~ R
5. 000000	C7H12O isomer	7.43	190	~~BJ~~ R

FORM I SV-TIC

1/87 Rev.

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE11

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-08

Sample wt/vol: 30.0 (g/mL) G Lab File ID: A7336

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 8 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 6.2 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	360	U
111-44-4	bis(2-Chloroethyl)Ether	360	U
95-57-8	2-Chlorophenol	360	U
541-73-1	1,3-Dichlorobenzene	360	U
106-46-7	1,4-Dichlorobenzene	360 ~~130~~	~~BB~~ U
100-51-6	Benzyl Alcohol	360	U
95-50-1	1,2-Dichlorobenzene	360	U
95-48-7	2-Methylphenol	360	U
108-60-1	bis(2-Chloroisopropyl)Ether	360	U
106-44-5	4-Methylphenol	360	U
621-64-7	N-Nitroso-Di-n-Propylamine	360	U
67-72-1	Hexachloroethane	360	U
98-95-3	Nitrobenzene	360	U
78-59-1	Isophorone	360	U
88-75-5	2-Nitrophenol	360	U
105-67-9	2,4-Dimethylphenol	360	U
65-85-0	Benzoic Acid	1700	U
111-91-1	bis(2-Chloroethoxy)Methane	360	U
120-83-2	2,4-Dichlorophenol	360	U
120-82-1	1,2,4-Trichlorobenzene	360	U
91-20-3	Naphthalene	360	U
106-47-8	4-Chloroaniline	360	U
87-68-3	Hexachlorobutadiene	360	U
59-50-7	4-Chloro-3-Methylphenol	360	U
91-57-6	2-Methylnaphthalene	360	U
77-47-4	Hexachlorocyclopentadiene	360	U
88-06-2	2,4,6-Trichlorophenol	360	U
95-95-4	2,4,5-Trichlorophenol	1700	U
91-58-7	2-Chloronaphthalene	360	U
88-74-4	2-Nitroaniline	1700	U
131-11-3	Dimethyl Phthalate	360	U
208-96-8	Acenaphthylene	360	U
606-20-2	2,6-Dinitrotoluene	360	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE11

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-08

Sample wt/vol: 30.0 (g/mL) G Lab File ID: A7336

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 8 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 6.2 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	1700	U J
83-32-9	Acenaphthene	360	U
51-28-5	2,4-Dinitrophenol	1700	U
100-02-7	4-Nitrophenol	1700	U
132-64-9	Dibenzofuran	360	U
121-14-2	2,4-Dinitrotoluene	360	U
84-66-2	Diethylphthalate	360	U
7005-72-3	4-Chlorophenyl-phenylether	360	U
86-73-7	Fluorene	360	U
100-01-6	4-Nitroaniline	1700	U
534-52-1	4,6-Dinitro-2-Methylphenol	1700	U
86-30-6	N-Nitrosodiphenylamine (1)	360	U
101-55-3	4-Bromophenyl-phenylether	360	U
118-74-1	Hexachlorobenzene	360	U
87-86-5	Pentachlorophenol	1700	U
85-01-8	Phenanthrene	360	U
120-12-7	Anthracene	360	U
84-74-2	Di-n-Butylphthalate	360	U J
206-44-0	Fluoranthene	49	J
129-00-0	Pyrene	47	J
85-68-7	Butylbenzylphthalate	360	U J
91-94-1	3,3'-Dichlorobenzidine	720	U J
56-55-3	Benzo(a)Anthracene	360	U J
218-01-9	Chrysene	40	J
117-81-7	bis(2-Ethylhexyl)Phthalate	81	J
117-84-0	Di-n-Octyl Phthalate	360	U J
205-99-2	Benzo(b)Fluoranthene	360	U
207-08-9	Benzo(k)Fluoranthene	360	U
50-32-8	Benzo(a)Pyrene	360	U
193-39-5	Indeno(1,2,3-cd)Pyrene	360	U
53-70-3	Dibenz(a,h)Anthracene	360	U
191-24-2	Benzo(g,h,i)Perylene	360	U J

(1) - Cannot be separated from Diphenylamine

498

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE11

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-08

Sample wt/vol: 30.0 (g/mL) G Lab File ID: A7336

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 8 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/06/91

GPC Cleanup: (Y/N) N pH: 6.2 Dilution Factor: 1.00

Number TICs found: 9

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	C7H14 isomer	5.05	360	~~BJ~~ R
2. 000000	Unknown	5.63	1300	~~BJ~~
3. 123422	2-Pentanone, 4-Hydroxy-4-Met	6.38	33000	~~ABJ~~
4. 000000	Unknown	7.90	1300	~~BJ~~ R
5. 57103	Hexadecanoic acid (9CI)	25.94	250	J N
6. 000000	Aliphatic hydrocarbon	34.01	620	~~BJ~~ R
7. 000000	Aliphatic hydrocarbon	36.01	1000	~~BJ~~
8. 000000	Aliphatic hydrocarbon	38.66	830	~~BJ~~
9. 000000	Aliphatic hydrocarbon	42.36	180	~~BJ~~ R

C.1499

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE12

Lab Name: CEIMIC CORP

Lab Code: CEIMIC Case No.: 15941 Contract: 68D90028

Matrix: (soil/water) SOIL SAS No.: _____ SDG No.: BHE04

Sample wt/vol: 30.3 (g/mL) G Lab Sample ID: 910113-09

Level: (low/med) LOW Lab File ID: A7337

% Moisture: not dec. 20 dec. ____ Date Received: 02/28/91

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 03/09/91

GPC Cleanup: (Y/N) N pH: 5.9 Date Analyzed: 04/06/91

Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NO.	COMPOUND		Q
108-95-2	Phenol	410	U J
111-44-4	bis(2-Chloroethyl)Ether	410	U
95-57-8	2-Chlorophenol	410	U
541-73-1	1,3-Dichlorobenzene	410	U
106-46-7	1,4-Dichlorobenzene	410	U
100-51-6	Benzyl Alcohol	410	U J
95-50-1	1,2-Dichlorobenzene	410	~~150~~ ~~BJ~~
95-48-7	2-Methylphenol	410	U J
108-60-1	bis(2-Chloroisopropyl)Ether	410	U
106-44-5	4-Methylphenol	410	U
621-64-7	N-Nitroso-Di-n-Propylamine	410	U
67-72-1	Hexachloroethane	410	U
98-95-3	Nitrobenzene	410	U
78-59-1	Isophorone	410	U
88-75-5	2-Nitrophenol	410	U
105-67-9	2,4-Dimethylphenol	410	U
65-85-0	Benzoic Acid	410	U
111-91-1	bis(2-Chloroethoxy)Methane	410	U
120-83-2	2,4-Dichlorophenol	410	U J
120-82-1	1,2,4-Trichlorobenzene	220	J
91-20-3	Naphthalene	410	U J
106-47-8	4-Chloroaniline	410	U
87-68-3	Hexachlorobutadiene	410	U
59-50-7	4-Chloro-3-Methylphenol	410	U
91-57-6	2-Methylnaphthalene	410	U
77-47-4	Hexachlorocyclopentadiene	410	U
88-06-2	2,4,6-Trichlorophenol	410	U
95-95-4	2,4,5-Trichlorophenol	410	U
91-58-7	2-Chloronaphthalene	410	U
88-74-4	2-Nitroaniline	2000	U
131-11-3	Dimethyl Phthalate	410	U
208-96-8	Acenaphthylene	2000	U
606-20-2	2,6-Dinitrotoluene	410	U
		410	U
		410	U J

517

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE12

Name: CEIMIC CORP

Lab Code: CEIMIC Case No.: 15941 Contract: 68D90028

Matrix: (soil/water) SOIL SAS No.: _____ SDG No.: BHE04

Sample wt/vol: 30.3 (g/mL) G Lab Sample ID: 910113-09

Level: (low/med) LOW Lab File ID: A7337

% Moisture: not dec. 20 dec. ____ Date Received: 02/28/91

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 03/09/91

GPC Cleanup: (Y/N) N pH: 5.9 Date Analyzed: 04/06/91

Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NO.	COMPOUND		Q
99-09-2	3-Nitroaniline	2000	U J
83-32-9	Acenaphthene	410	U
51-28-5	2,4-Dinitrophenol	2000	U
100-02-7	4-Nitrophenol	2000	U
132-64-9	Dibenzofuran	410	U
121-14-2	2,4-Dinitrotoluene	410	U
84-66-2	Diethylphthalate	410	U
7005-72-3	4-Chlorophenyl-phenylether	410	U
86-73-7	Fluorene	410	U
100-01-6	4-Nitroaniline	410	U
534-52-1	4,6-Dinitro-2-Methylphenol	2000	U
86-30-6	N-Nitrosodiphenylamine (1)	2000	U
101-55-3	4-Bromophenyl-phenylether	410	U
118-74-1	Hexachlorobenzene	410	U
87-86-5	Pentachlorophenol	410	U
85-01-8	Phenanthrene	2000	U J
120-12-7	Anthracene	100	J
84-74-2	Di-n-Butylphthalate	410	U J
206-44-0	Fluoranthene	54	J
129-00-0	Pyrene	190	J
85-68-7	Butylbenzylphthalate	260	J
91-94-1	3,3'-Dichlorobenzidine	410	U J
56-55-3	Benzo(a)Anthracene	820	U J
218-01-9	Chrysene	140	J
117-81-7	bis(2-Ethylhexyl)Phthalate	180	J
117-84-0	Di-n-Octyl Phthalate	44	J
205-99-2	Benzo(b)Fluoranthene	410	U J
207-08-9	Benzo(k)Fluoranthene	150	J
50-32-8	Benzo(a)Pyrene	100	J
193-39-5	Indeno(1,2,3-cd)Pyrene	130	J
53-70-3	Dibenz(a,h)Anthracene	87	J
191-24-2	Benzo(g,h,i)Perylene	410	U J
		74	J

1 - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE12

Name: CEIMIC CORP

Lab Code: CEIMIC Case No.: 15941 Contract: 68D90028

Matrix: (soil/water) SOIL SAS No.: _____ SDG No.: BHE04

Sample wt/vol: 30.3 (g/mL) G Lab Sample ID: 910113-09

Level: (low/med) LOW Lab File ID: A7337

% Moisture: not dec. 20 dec. ____ Date Received: 02/28/91

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 03/09/91

GPC Cleanup: (Y/N) N pH: 5.9 Date Analyzed: 04/06/91

Dilution Factor: 1.0

Number TICs found: 21

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

	CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	000000	C7H14 isomer	5.03	330	~~BJ~~ R
2.	000000	Unknown	5.12	330	~~BJ~~
3.	000000	Unknown	5.62	1400	~~BJ~~
4.	123422	2-Pentanone, 4-Hydroxy-4-Met	6.35	33000	~~ABJ~~
5.	000000	Unknown	7.92	2100	~~BJ~~
6.	000000	Unknown	22.82	330	~~BJ~~
7.	000000	C16H16 isomer	23.30	330	~~BJ~~
8.	000000	Unknown	25.72	250	~~BJ~~ R
9.	57114	Octadecanoic acid (9CI)	28.41	370	J N
10.	000000	Unknown	28.66	330	~~BJ~~ R
11.	000000	Ester of octadecanoic acid	30.89	290	~~BJ~~
12.	000000	Unknown	31.76	1700	~~BJ~~
13.	000000	Unknown	32.77	1100	~~BJ~~
14.	000000	Unknown	32.91	1500	~~BJ~~
15.	000000	Unknown	32.97	620	~~BJ~~
16.	000000	Unknown	33.07	620	~~BJ~~
17.	000000	Aliphatic hydrocarbon	33.92	290	~~BJ~~
18.	000000	Aliphatic hydrocarbon	33.97	540	~~BJ~~
19.	000000	Aliphatic hydrocarbon	35.99	1400	~~BJ~~
20.	000000	Aliphatic hydrocarbon	38.64	1300	~~BJ~~
21.	000000	Aliphatic hydrocarbon	42.33	580	~~BJ~~ R

FORM I SV-TIC

1/87 Rev.

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE13

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-10

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7326

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

GPC Cleanup: (Y/N) N pH: 6.0 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	400	U
111-44-4	bis(2-Chloroethyl)Ether	400	U
95-57-8	2-Chlorophenol	400	U
541-73-1	1,3-Dichlorobenzene	400	U
106-46-7	1,4-Dichlorobenzene	400	U
100-51-6	Benzyl Alcohol	400 ~~140~~	B
95-50-1	1,2-Dichlorobenzene	400	U
95-48-7	2-Methylphenol	400	U
108-60-1	bis(2-Chloroisopropyl)Ether	400	U
106-44-5	4-Methylphenol	400	U
621-64-7	N-Nitroso-Di-n-Propylamine	400	U
67-72-1	Hexachloroethane	400	U
98-95-3	Nitrobenzene	400	U
78-59-1	Isophorone	400	U
88-75-5	2-Nitrophenol	400	U
105-67-9	2,4-Dimethylphenol	400	U
65-85-0	Benzoic Acid	400	U
111-91-1	bis(2-Chloroethoxy)Methane	1900	U
120-83-2	2,4-Dichlorophenol	400	U
120-82-1	1,2,4-Trichlorobenzene	400	U
91-20-3	Naphthalene	400	U
106-47-8	4-Chloroaniline	400	U
87-68-3	Hexachlorobutadiene	400	U
59-50-7	4-Chloro-3-Methylphenol	400	U
91-57-6	2-Methylnaphthalene	400	U
77-47-4	Hexachlorocyclopentadiene	400	U
88-06-2	2,4,6-Trichlorophenol	400	U
95-95-4	2,4,5-Trichlorophenol	400	U
91-58-7	2-Chloronaphthalene	1900	U
88-74-4	2-Nitroaniline	400	U
131-11-3	Dimethyl Phthalate	1900	U
208-96-8	Acenaphthylene	400	U
606-20-2	2,6-Dinitrotoluene	400	U
		400	U

558

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE13

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-10

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7326

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

GPC Cleanup: (Y/N) N pH: 6.0 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	1900	U J
83-32-9	Acenaphthene	400	U
51-28-5	2,4-Dinitrophenol	1900	U
100-02-7	4-Nitrophenol	1900	U
132-64-9	Dibenzofuran	400	U
121-14-2	2,4-Dinitrotoluene	400	U
84-66-2	Diethylphthalate	400	U
7005-72-3	4-Chlorophenyl-phenylether	400	U
86-73-7	Fluorene	400	U
100-01-6	4-Nitroaniline	400	U
534-52-1	4,6-Dinitro-2-Methylphenol	1900	U
86-30-6	N-Nitrosodiphenylamine (1)	1900	U
101-55-3	4-Bromophenyl-phenylether	400	U
118-74-1	Hexachlorobenzene	400	U
87-86-5	Pentachlorophenol	400	U
85-01-8	Phenanthrene	1900	U
120-12-7	Anthracene	400	U
84-74-2	Di-n-Butylphthalate	400	U
206-44-0	Fluoranthene	400	U J
129-00-0	Pyrene	66	J
85-68-7	Butylbenzylphthalate	62	J
91-94-1	3,3'-Dichlorobenzidine	400	U J
56-55-3	Benzo(a)Anthracene	800	U
218-01-9	Chrysene	400	U
117-81-7	bis(2-Ethylhexyl)Phthalate	400	U
117-84-0	Di-n-Octyl Phthalate	400	U
205-99-2	Benzo(b)Fluoranthene	400	U
207-08-9	Benzo(k)Fluoranthene	400	U
50-32-8	Benzo(a)Pyrene	400	U
193-39-5	Indeno(1,2,3-cd)Pyrene	400	U
53-70-3	Dibenz(a,h)Anthracene	400	U
191-24-2	Benzo(g,h,i)Perylene	400	U
		400	U J

(1) - Cannot be separated from Diphenylamine

FORM I SV-2

1F

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE13

CEIMIC CORP Contract: 68D90028

de: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

rix: (soil/water) SOIL Lab Sample ID: 910113-10

Sample wt/vol: 30.4 (g/mL) G Lab File ID: A7326

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 04/05/91

GPC Cleanup: (Y/N) N pH: 6.0 Dilution Factor: 1.0

Number TICs found: 10

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	4.67	280	~~BJ~~ R
2. 000000	C7H14 isomer	5.02	520	~~BJ~~
3. 000000	Unknown	5.10	360	~~BJ~~
4. 000000	Unknown	5.58	1600	~~BJ~~
5. 123422	2-Pentanone, 4-Hydroxy-4-Met	6.30	40000	~~BJ~~
6. 000000	C7H12O isomer	7.42	240	~~BJ~~
7. 000000	Unknown	7.87	1900	~~BJ~~
8. 000000	Unknown	35.36	950	~~BJ~~
9. 000000	Aliphatic hydrocarbon	35.99	1500	~~BJ~~
10. 000000	Aliphatic hydrocarbon	38.62	2100	~~BJ~~ R

0.1560

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE14

ab Name: CEIMIC CORP Contract: 68D90028

Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

atrix: (soil/water) WATER Lab Sample ID: 910113-11

ample wt/vol: 1000 (g/mL) ML Lab File ID: D5349

el: (low/med) LOW Date Received: 02/28/91

Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

raction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/04/91

C Cleanup: (Y/N) N pH: 7.6 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl Alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)Ether	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	10	U
111-91-1	bis(2-Chloroethoxy)Methane	50	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-Methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	10	U
91-58-7	2-Chloronaphthalene	50	U
88-74-4	2-Nitroaniline	10	U
131-11-3	Dimethyl Phthalate	50	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U
		10	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE14

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-11

Sample wt/vol: 1000 (g/mL) ML Lab File ID: D5349

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/04/91

GPC Cleanup: (Y/N) N pH: 7.6 Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND		Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-Methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-Butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	10	U
117-84-0	Di-n-Octyl Phthalate	10	U
205-99-2	Benzo(b)Fluoranthene	10	U
207-08-9	Benzo(k)Fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

C.1578

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE14

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-11

Sample wt/vol: 1000 (g/mL) ML Lab File ID: D5349

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/04/91

GPC Cleanup: (Y/N) N pH: 7.6 Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

C.1579

Howell 02-3

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE15

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-12

Sample wt/vol: 1000 (g/mL) ML Lab File ID: D5298

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/01/91

GPC Cleanup: (Y/N) N pH: 7.7 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl Alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)Ether	10	UJ
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	50	U
111-91-1	bis(2-Chloroethoxy)Methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-Methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	50	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	50	U
131-11-3	Dimethyl Phthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE15

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-12

Sample wt/vol: 1000 (g/mL) ML Lab File ID: D5298

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/01/91

GPC Cleanup: (Y/N) N pH: 7.7 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-Methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-Butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	10	U
117-84-0	Di-n-Octyl Phthalate	10	U
205-99-2	Benzo(b)Fluoranthene	10	U
207-08-9	Benzo(k)Fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

J584

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE15

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-12

Sample wt/vol: 1000 (g/mL) ML Lab File ID: D5298

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/01/91

GPC Cleanup: (Y/N) N pH: 7.7 Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

1585

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE16

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-13

Sample wt/vol: 1000 (g/mL) ML Lab File ID: D5348

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/04/91

GPC Cleanup: (Y/N) N pH: 7.5 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl Alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)Ether	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	50	U
111-91-1	bis(2-Chloroethoxy)Methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-Methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	50	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	50	U
131-11-3	Dimethyl Phthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

589

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE16

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-13

Sample wt/vol: 1000 (g/mL) ML Lab File ID: D5348

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/04/91

GPC Cleanup: (Y/N) N pH: 7.5 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-Methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-Butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	10	U
117-84-0	Di-n-Octyl Phthalate	10	U
205-99-2	Benzo(b)Fluoranthene	10	U
207-08-9	Benzo(k)Fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

590

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BHE16

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-13

Sample wt/vol: 1000 (g/mL) ML Lab File ID: D5348

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 04/04/91

GPC Cleanup: (Y/N) N pH: 7.5 Dilution Factor: 1.0

Number TICs found: 0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

1D

PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE04

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-01

Sample wt/vol: 30.1 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 9 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 6.5 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	8.8	U
319-85-7	beta-BHC	8.8	U
319-86-8	delta-BHC	8.8	U
58-89-9	gamma-BHC (Lindane)	8.8	U
76-44-8	Heptachlor	8.8	U
309-00-2	Aldrin	8.8	U
1024-57-3	Heptachlor epoxide	8.8	U
959-98-8	Endosulfan I	8.8	U
60-57-1	Dieldrin	18	U
72-55-9	4,4'-DDE	16	J
72-20-8	Endrin	18	U
33213-65-9	Endosulfan II	18	U
72-54-8	4,4'-DDD	18	U
1031-07-8	Endosulfan sulfate	18	U
50-29-3	4,4'-DDT	49	J
72-43-5	Methoxychlor	88	U
53494-70-5	Endrin ketone	18	U
5103-71-9	alpha-Chlordane	88	U
5103-74-2	gamma-Chlordane	88	U
8001-35-2	Toxaphene	180	U
12674-11-2	Aroclor-1016	88	U
11104-28-2	Aroclor-1221	88	U
11141-16-5	Aroclor-1232	88	U
53469-21-9	Aroclor-1242	88	U
12672-29-6	Aroclor-1248	88	U
11097-69-1	Aroclor-1254	180	U
11096-82-5	Aroclor-1260	180	U

1D

PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE05

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-02

Sample wt/vol: 30.3 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 5.2 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	9.5	U J
319-85-7	beta-BHC	9.5	U
319-86-8	delta-BHC	9.5	U
58-89-9	gamma-BHC (Lindane)	9.5	U
76-44-8	Heptachlor	9.5	U
309-00-2	Aldrin	9.5	U
1024-57-3	Heptachlor epoxide	9.5	U
959-98-8	Endosulfan I	9.5	U J
60-57-1	Dieldrin	30	J
72-55-9	4,4'-DDE	19	U J
72-20-8	Endrin	19	U
33213-65-9	Endosulfan II	19	U
72-54-8	4,4'-DDD	19	U
1031-07-8	Endosulfan sulfate	19	U
50-29-3	4,4'-DDT	19	U
72-43-5	Methoxychlor	95	U
53494-70-5	Endrin ketone	19	U
5103-71-9	alpha-Chlordane	95	U
5103-74-2	gamma-Chlordane	95	U
8001-35-2	Toxaphene	190	U
12674-11-2	Aroclor-1016	95	U
11104-28-2	Aroclor-1221	95	U
11141-16-5	Aroclor-1232	95	U
53469-21-9	Aroclor-1242	95	U
12672-29-6	Aroclor-1248	95	U
11097-69-1	Aroclor-1254	190	U
11096-82-5	Aroclor-1260	190	U J

C.1745

1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE06

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-03

Sample wt/vol: 30.3 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 15 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 5.1 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	9.3	U
319-85-7	beta-BHC	9.3	U
319-86-8	delta-BHC	9.3	U
58-89-9	gamma-BHC (Lindane)	9.3	U
76-44-8	Heptachlor	9.3	U
309-00-2	Aldrin	9.3	U
1024-57-3	Heptachlor epoxide	9.3	U
959-98-8	Endosulfan I	9.3	U
60-57-1	Dieldrin	19	U
72-55-9	4,4'-DDE	19	U
72-20-8	Endrin	19	U
33213-65-9	Endosulfan II	19	U
72-54-8	4,4'-DDD	19	U
1031-07-8	Endosulfan sulfate	19	U
50-29-3	4,4'-DDT	19	U
72-43-5	Methoxychlor	93	U
53494-70-5	Endrin ketone	19	U
5103-71-9	alpha-Chlordane	93	U
5103-74-2	gamma-Chlordane	93	U
8001-35-2	Toxaphene	190	U
12674-11-2	Aroclor-1016	93	U
11104-28-2	Aroclor-1221	93	U
11141-16-5	Aroclor-1232	93	U
53469-21-9	Aroclor-1242	93	U
12672-29-6	Aroclor-1248	93	U
11097-69-1	Aroclor-1254	190	U
11096-82-5	Aroclor-1260	190	U

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1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE07

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-04

Sample wt/vol: 30.0 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 16 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 4.2 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	9.5	U
319-85-7	beta-BHC	9.5	U
319-86-8	delta-BHC	9.5	U
58-89-9	gamma-BHC (Lindane)	9.5	U
76-44-8	Heptachlor	9.5	U
309-00-2	Aldrin	9.5	U
1024-57-3	Heptachlor epoxide	9.5	U
959-98-8	Endosulfan I	9.5	U
60-57-1	Dieldrin	19	U
72-55-9	4,4'-DDE	19	U
72-20-8	Endrin	19	U
33213-65-9	Endosulfan II	19	U
72-54-8	4,4'-DDD	19	U
1031-07-8	Endosulfan sulfate	19	U
50-29-3	4,4'-DDT	19	U
72-43-5	Methoxychlor	95	U
53494-70-5	Endrin ketone	19	U
5103-71-9	alpha-Chlordane	95	U
5103-74-2	gamma-Chlordane	95	U
8001-35-2	Toxaphene	190	U
12674-11-2	Aroclor-1016	95	U
11104-28-2	Aroclor-1221	95	U
11141-16-5	Aroclor-1232	95	U
53469-21-9	Aroclor-1242	95	U
12672-29-6	Aroclor-1248	95	U
11097-69-1	Aroclor-1254	190	U
11096-82-5	Aroclor-1260	190	U

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PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE08

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-05

Sample wt/vol: 30.1 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 15 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 4.8 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	9.4	U
319-85-7	beta-BHC	9.4	U
319-86-8	delta-BHC	9.4	U
58-89-9	gamma-BHC (Lindane)	9.4	U
76-44-8	Heptachlor	9.4	U
309-00-2	Aldrin	9.4	U
1024-57-3	Heptachlor epoxide	9.4	U
959-98-8	Endosulfan I	9.4	U
60-57-1	Dieldrin	19	U
72-55-9	4,4'-DDE	19	U
72-20-8	Endrin	19	U
33213-65-9	Endosulfan II	19	U
72-54-8	4,4'-DDD	19	U
1031-07-8	Endosulfan sulfate	19	U
50-29-3	4,4'-DDT	19	U
72-43-5	Methoxychlor	94	U
53494-70-5	Endrin ketone	19	U
5103-71-9	alpha-Chlordane	94	U
5103-74-2	gamma-Chlordane	94	U
8001-35-2	Toxaphene	190	U
12674-11-2	Aroclor-1016	94	U
11104-28-2	Aroclor-1221	94	U
11141-16-5	Aroclor-1232	94	U
53469-21-9	Aroclor-1242	94	U
12672-29-6	Aroclor-1248	94	U
11097-69-1	Aroclor-1254	190	U
11096-82-5	Aroclor-1260	190	U

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PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE09

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-06

Sample wt/vol: 30.0 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 18 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 5.0 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	9.8	U
319-85-7	beta-BHC	9.8	U
319-86-8	delta-BHC	9.8	U
58-89-9	gamma-BHC (Lindane)	9.8	U
76-44-8	Heptachlor	9.8	U
309-00-2	Aldrin	9.8	U
1024-57-3	Heptachlor epoxide	9.8	U
959-98-8	Endosulfan I	9.8	U
60-57-1	Dieldrin	9.8	U
72-55-9	4,4'-DDE	20	U
72-20-8	Endrin	20	U
33213-65-9	Endosulfan II	20	U
72-54-8	4,4'-DDD	20	U
1031-07-8	Endosulfan sulfate	20	U
50-29-3	4,4'-DDT	20	U
72-43-5	Methoxychlor	20	U
53494-70-5	Endrin ketone	98	U
5103-71-9	alpha-Chlordane	20	U
5103-74-2	gamma-Chlordane	98	U
8001-35-2	Toxaphene	98	U
12674-11-2	Aroclor-1016	200	U
11104-28-2	Aroclor-1221	98	U
11141-16-5	Aroclor-1232	98	U
53469-21-9	Aroclor-1242	98	U
12672-29-6	Aroclor-1248	98	U
11097-69-1	Aroclor-1254	98	U
11096-82-5	Aroclor-1260	200	U
		200	U

755

1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE10

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-07

Sample wt/vol: 30.4 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 13 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 5.2 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	9.1	U J
319-85-7	beta-BHC	9.1	U
319-86-8	delta-BHC	9.1	U
58-89-9	gamma-BHC (Lindane)	9.1	U
76-44-8	Heptachlor	9.1	U
309-00-2	Aldrin	9.1	U
1024-57-3	Heptachlor epoxide	9.1	U
959-98-8	Endosulfan I	9.1	U
60-57-1	Dieldrin	18	U
72-55-9	4,4'-DDE	18	U
72-20-8	Endrin	18	U
33213-65-9	Endosulfan II	18	U
72-54-8	4,4'-DDD	18	U
1031-07-8	Endosulfan sulfate	18	U
50-29-3	4,4'-DDT	18	U
72-43-5	Methoxychlor	91	U
53494-70-5	Endrin ketone	18	U
5103-71-9	alpha-Chlordane	91	U
5103-74-2	gamma-Chlordane	91	U
8001-35-2	Toxaphene	180	U
12674-11-2	Aroclor-1016	91	U
11104-28-2	Aroclor-1221	91	U
11141-16-5	Aroclor-1232	91	U
53469-21-9	Aroclor-1242	91	U
12672-29-6	Aroclor-1248	91	U
11097-69-1	Aroclor-1254	180	U
11096-82-5	Aroclor-1260	180	U J

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1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE11

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-08

Sample wt/vol: 30.3 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 8 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 6.2 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	8.6	U J
319-85-7	beta-BHC	8.6	U
319-86-8	delta-BHC	8.6	U
58-89-9	gamma-BHC (Lindane)	8.6	U
76-44-8	Heptachlor	8.6	U
309-00-2	Aldrin	8.6	U
1024-57-3	Heptachlor epoxide	8.6	U
959-98-8	Endosulfan I	8.6	U
60-57-1	Dieldrin	17	U
72-55-9	4,4'-DDE	17	U
72-20-8	Endrin	17	U
33213-65-9	Endosulfan II	17	U
72-54-8	4,4'-DDD	17	U
1031-07-8	Endosulfan sulfate	17	U
50-29-3	4,4'-DDT	17	U
72-43-5	Methoxychlor	86	U
53494-70-5	Endrin ketone	17	U
5103-71-9	alpha-Chlordane	86	U
5103-74-2	gamma-Chlordane	86	U
8001-35-2	Toxaphene	170	U
12674-11-2	Aroclor-1016	86	U
11104-28-2	Aroclor-1221	86	U
11141-16-5	Aroclor-1232	86	U
53469-21-9	Aroclor-1242	86	U
12672-29-6	Aroclor-1248	86	U
11097-69-1	Aroclor-1254	170	U
11096-82-5	Aroclor-1260	170	U J

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PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE12

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-09

Sample wt/vol: 30.4 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 20 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 5.9 Dilution Factor: 2.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	20	U
319-85-7	beta-BHC	20	U
319-86-8	delta-BHC	20	U
58-89-9	gamma-BHC (Lindane)	20	U
76-44-8	Heptachlor	20	U
309-00-2	Aldrin	20	U
1024-57-3	Heptachlor epoxide	21	J
959-98-8	Endosulfan I	20	U
60-57-1	Dieldrin	20	U
72-55-9	4,4'-DDE	39	U
72-20-8	Endrin	240	J
33213-65-9	Endosulfan II	39	U
72-54-8	4,4'-DDD	39	U
1031-07-8	Endosulfan sulfate	39	U
50-29-3	4,4'-DDT	39	U
72-43-5	Methoxychlor	420	J
53494-70-5	Endrin ketone	200	U
5103-71-9	alpha-Chlordane	39	U
5103-74-2	gamma-Chlordane	200	U
8001-35-2	Toxaphene	200	U
12674-11-2	Aroclor-1016	390	U
11104-28-2	Aroclor-1221	200	U
11141-16-5	Aroclor-1232	200	U
53469-21-9	Aroclor-1242	200	U
12672-29-6	Aroclor-1248	200	U
11097-69-1	Aroclor-1254	200	U
11096-82-5	Aroclor-1260	390	U
		390	U

762

1D

PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE13

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) SOIL Lab Sample ID: 910113-10

Sample wt/vol: 30.4 (g/mL) G Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. 17 dec. ____ Date Extracted: 03/09/91

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 6.0 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	9.5	U J
319-85-7	beta-BHC	9.5	U
319-86-8	delta-BHC	9.5	U
58-89-9	gamma-BHC (Lindane)	9.5	U
76-44-8	Heptachlor	9.5	U
309-00-2	Aldrin	9.5	U
1024-57-3	Heptachlor epoxide	9.5	U
959-98-8	Endosulfan I	9.5	U
60-57-1	Dieldrin	19	U
72-55-9	4,4'-DDE	19	U
72-20-8	Endrin	19	U
33213-65-9	Endosulfan II	19	U
72-54-8	4,4'-DDD	19	U
1031-07-8	Endosulfan sulfate	19	U J
50-29-3	4,4'-DDT	26	J
72-43-5	Methoxychlor	95	U J
53494-70-5	Endrin ketone	19	U
5103-71-9	alpha-Chlordane	95	U
5103-74-2	gamma-Chlordane	95	U
8001-35-2	Toxaphene	190	U
12674-11-2	Aroclor-1016	95	U
11104-28-2	Aroclor-1221	95	U
11141-16-5	Aroclor-1232	95	U
53469-21-9	Aroclor-1242	95	U
12672-29-6	Aroclor-1248	95	U
11097-69-1	Aroclor-1254	190	U
11096-82-5	Aroclor-1260	190	U J

Soil 4-13

1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE14

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-11

Sample wt/vol: 1000 (g/mL) ML Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 03/28/91

GPC Cleanup: (Y/N) N pH: 7.6 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
319-84-6	alpha-BHC	0.050	U
319-85-7	beta-BHC	0.050	U
319-86-8	delta-BHC	0.050	U
58-89-9	gamma-BHC (Lindane)	0.050	U
76-44-8	Heptachlor	0.050	U
309-00-2	Aldrin	0.050	U
1024-57-3	Heptachlor epoxide	0.050	U
959-98-8	Endosulfan I	0.050	U
60-57-1	Dieldrin	0.10	U
72-55-9	4,4'-DDE	0.10	U
72-20-8	Endrin	0.10	U
33213-65-9	Endosulfan II	0.10	U
72-54-8	4,4'-DDD	0.10	U
1031-07-8	Endosulfan sulfate	0.10	U
50-29-3	4,4'-DDT	0.10	U
72-43-5	Methoxychlor	0.50	U
53494-70-5	Endrin ketone	0.10	U
5103-71-9	alpha-Chlordane	0.50	U
5103-74-2	gamma-Chlordane	0.50	U
8001-35-2	Toxaphene	1.0	U
12674-11-2	Aroclor-1016	0.50	U
11104-28-2	Aroclor-1221	0.50	U
11141-16-5	Aroclor-1232	0.50	U
53469-21-9	Aroclor-1242	0.50	U
12672-29-6	Aroclor-1248	0.50	U
11097-69-1	Aroclor-1254	1.0	U
11096-82-5	Aroclor-1260	1.0	U

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PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BHE15

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 15941 SAS No.: _____ SDG No.: BHE04

Matrix: (soil/water) WATER Lab Sample ID: 910113-12

Sample wt/vol: 1000 (g/mL) ML Lab File ID: _____

Level: (low/med) LOW Date Received: 02/28/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 03/01/91

Extraction: (SepF/Cont/Sonc) SEPF Date Analyzed: 03/29/91

GPC Cleanup: (Y/N) N pH: 7.7 Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND	Q
319-84-6	alpha-BHC	0.050 U
319-85-7	beta-BHC	0.050 U
319-86-8	delta-BHC	0.050 U
58-89-9	gamma-BHC (Lindane)	0.050 U
76-44-8	Heptachlor	0.050 U
309-00-2	Aldrin	0.050 U
1024-57-3	Heptachlor epoxide	0.050 U
959-98-8	Endosulfan I	0.050 U
60-57-1	Dieldrin	0.10 U
72-55-9	4,4'-DDE	0.10 U
72-20-8	Endrin	0.10 U
33213-65-9	Endosulfan II	0.10 U
72-54-8	4,4'-DDD	0.10 U
1031-07-8	Endosulfan sulfate	0.10 U
50-29-3	4,4'-DDT	0.10 U
72-43-5	Methoxychlor	0.50 U
53494-70-5	Endrin ketone	0.10 U
5103-71-9	alpha-Chlordane	0.50 U
5103-74-2	gamma-Chlordane	0.50 U
8001-35-2	Toxaphene	1.0 U
12674-11-2	Aroclor-1016	0.50 U
11104-28-2	Aroclor-1221	0.50 U
11141-16-5	Aroclor-1232	0.50 U
53469-21-9	Aroclor-1242	0.50 U
12672-29-6	Aroclor-1248	0.50 U
11097-69-1	Aroclor-1254	1.0 U
11096-82-5	Aroclor-1260	1.0 U

CLP Data Tracking Form 1 - Revalidation of Case # : 15941
revision 0

Type : Inorganic

CONTRACTOR : EIT REVIEWER : Jennifer Leahy

TYPE OF ERROR (Crit,Signif,Trans) : Calibration

DESCRIPTION : Correlation coefficients were less than 0.995 for mercury, therefore flag all associated data as estimated.
"J" Hg : MBFQ 01 → 13. (MBFQ [illegible])

ACTION : Please add "J" flags to mercury results not previously estimated due to matrix spike criteria; also correct checklist, data assessment and summary form.

TYPE OF ERROR (Crit,Signif,Trans) : Instrument detection limit

DESCRIPTION : Lead results for samples MBFQ 03, 04, 05 and 07 are reported from furnace and all lead data points reported from ICP are greater than 5 x IDL (120 ug/L).

ACTION : Please remove "J" flags from lead results; also correct checklist, data assessment and summary form.

Critical error= a significant error which effects 2 or more samples
Significant error= categories identified on the Functional Guidelines
Transcription error = can also be considered as major or minor

TOTAL ERRORS - # CRIT : _____ # SIGNIF : _____ # TRANS : _____

EPA REVIEWER : Karen Taylor DATE : 7/22/91

7/24/91

	YES	NO	N/A
A.1.9.17 **Form X, XI, XII (Verification of Instrumental Parameters).**			
A.1.9.17.1 Is verification report present for:			
Instrument Detection Limits (quarterly)?	[ ]		
ICP Interelement Correction Factors (annually)?	[ ]		
ICP Linear Ranges (quarterly)?	[ ]		
ACTION: If no, contact DPO of the lab.			
A.1.9.17.2 Form X (Instrument Detection Limits) - (Note: IDL is not required for Cyanide.)			
Are IDLs present for: all the analytes?	[ ]		
all the instruments used?	[ ]		
For both AA and ICP when both are used for same analyte?	[ ]		✓
ACTION: If no for any of the above, prepare Telephone Record Log and contact laboratory.			
Is IDL greater than CRDL for any analyte?		[ ]	
If yes, is the concentration on Form I of the sample analyzed on the instrument whose IDL exceeds CRDL, greater than 5 x IDL?	[ ]	✓	
ACTION: If no, flag as estimated all values less than five times IDL of the instrument whose IDL exceeds CRDL.			

	YES	NO	N/A
A.1.9.17.3 Form XI (Linear Ranges)			
Was any sample result higher than high linear range of ICP.	___	[✓]	___
Was any sample result higher than the highest calibration standard for non-ICP parameters?	___	[✓]	___
If yes for any of the above, was the sample diluted to obtain the result on Form I?	[___]	___	✓
ACTION: If no, flag the result reported on Form I as estimated(J).			
A.1.9.18 Percent Solids of Sediments			
Is soil content in sediment(s) less than 50%?	___	[✓]	___
ACTION: If yes, qualify as estimated all data not previously rejected or flagged due to other QC criteria.			

Title: Evaluation of Metals Data for the Contract Laboratory Program
Appendix A.2: Data Assessment Narrative

Date: Feb. 1990
Number: HW-2
Revision: 10

Case# 15941 Site Flags Inc. Matrix: Soil 10

SDG# MBFQ01 Lab NFT Water 3

Contractor FTT2 Reviewer J. Leahy Other —

A.2.1 The case description and exceptions, if any, are noted below with reason(s) for rejection or qualification as estimated value(s) J.

1. Sodium is not expected to be present in the ICS solution, therefore it is a false positive value (≥IDL) those positive associated samples were flagged est "J"

NA: MBFQ01

2. The soil matrix spike recovery for Arsenic fell between 30-14%R and Mercury + Selenium fell between 126-200%R therefore those associated results for As were flagged est "J" and Hg + Se associated positive results were flagged J.

As: MBFQ01-10
Hg- MBFQ06,10
Se MBFQ09

3. MSF should have been run on MBFQ01 for Arsenic 2nd run because the sample concentration (8.4) is >50% of spike concentration $\frac{24-8.2}{2} = 7.8$ therefore

A.2.1 (continuation)

MBFQ01 As was flagge est "J" ("W" flag removed from form 1)
* Note MBFQ01 As was previously flagged as per statement 2.

* Read IDL > CRDL therefore these [illegible] samples < 5x IDL are flagged est "J"
Pb MBFQ ~~01-10~~ 01, 02, 06, 08-10
8/14/91

* Note: As, Pb, Tl + Se used a non-linear method to achieve concentration.

A.2.1 (continuation)

A.2.2 Contract-Problems/Non-Compliance

~~1) As, Jeb~~ 6/27/91

1) Pb1 CCV+CCB 2-6 not noted Hg1 CCV+CCB2 not noted
Tl1 CCV+CCB 2-3 " " Hg2 CCV + CCB2+3 not noted.

2) As2 LCSS+LCSSA 200 x dilution factor
Tl2 LCSS+LCSSA 10 x dilution factor

3) MBFQ 11-13 No "W" flag needed on Pb % R is w/i 85-115 criteria

4) Hg IDL should be reported as 2 not 1 in MBFQ 11-13
4.2 IDL should be used to calc. soil IDL's for MBFQ01-05, 07-09.

5) MBFQ11-13 REMOVE "N" flags since aqueous spike results for these analytes are in range of 75-125% R.

MMB Reviewer: _____ Date: _____
Signature

Contractor Reviewer: Jennifer Leahy Date: 6/27/91
Signature

Verified by: Karen Taylor (ESAT) Date: 7/22/91

CONTRACT NON-COMPLIANCE
(SMO REPORT)

Regional Review of Uncontrolled Hazardous Waste
Site Contract Laboratory Data Package

CASE NO. 15941

The hardcopied (laboratory name) NFT
Inorganic data package received at Region II has been reviewed and the quality assurance and performance data summarized. The data reviewed included:
SMO Sample No.: _____

Conc. & Matrix: _____

Contract No. WA87-K025,K026,K027(SOW787) requires that specific analytical work be done and that associated reports be provided by the contractor to the Regions, EMSL-LV, and SMO. The general criteria used to determine the performance were based on an examination of:

- Data Completeness
- Matrix Spike Results
- Calibration Standards Results
- Duplicate Analysis Results
- Blank Analysis Results
- MSA Results

Items of non-compliance with the above contract are described below.

Comments: _____

NA

[signature]
Reviewer's Initial

6/27/91
Date

INFO/MAILING LIST FOR DATA REVIEWERS

1. USEPA Region I (ESD)
60 Westview Street
Lexington, MA 02173
Deb Szaro
(617) 861-4312
CT, ME, MA, NH, RI, VT
CAA, Resource Analysts, York, EDI, Skinner, TMA

2. USEPA Region II (ESD)
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Lisa Gatton Vidulich
(201) 321-6676
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Century, Chemtech, US Test, Nanco, ETC, Gadson, EMS, Galson, ICM

3. USEPA Region III (CRL)
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4. USEPA Region IV (ESD)
Analytical Support Branch
College Station Road
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Tom Bennett, Jr.
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5. USEPA Region V (ESD)
536 South Clark Street
Tenth Floor, CRL
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Pat Churilla
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NLE, TAI/ERG

6. USEPA Region VI (ESD)
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7. USEPA Region VII Laboratory
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Debra Morey
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8. USEPA Region VIII Laboratory
BOX 25366
Denver Federal Center
Lakewood, CO 80225
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ACCU, CSMRI, RMAL, Data Chem, Cenref

9. USEPA Region IX (ESD)
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215 Fremont Street
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Kent Kitchingman
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AZ, CA, HI, NV, American Samoa, Guam Trust Territories of Pacific Islands, Wake Island
ALI, CAL Weston, S-Cubed, IT-CA, Vegas

10. USEPA Region X Laboratory
P.O. BOX 549
Manchester, WA 98353
Gerald Muth
(206) 442-0370
AK, ID, OR, WA
Lauchs Testing Labs, Century Testing Labs (For VOA Only), Weyerheuser Co. Columbia Testing, Silver Valley

11. Carla Dempsey - (OS-230)
USEPA
401 "M" Street, S.W.
Washington, DC 20460
FTS 382-5746

12. Edward Kantor
USEPA
EMSL-LV
944 E. Harmon Avenue
BOX 93478
Las Vegas, NV 89119

13. Sample Management Office
Mear and Company
P.O. BOX 818
Alexandria, VA 22313

CLP DATA ASSESSMENT SUMMARY FORM (INORGANICS)

Type of Review: Inorganic Date: 6/27/91 Case #: 15941

Site: Hans Inc. Lab Name: NFT

Reviewer's Initials: JS Number of Samples: 0 soil, 2 water

Analytes Rejected Due to Exceeding Review Criteria:*

	Holding Times	Calibration	Prep Blank	Field Blank	Inter-ferences	Spike Recovery	Duplicates Lab	Duplicates Field	Detection Limits	LCS	Serial Dilution	MSA	Total Analytes	Rejection
ICP														
Flame AA														
Furnace AA														
Mercury														
Total														
Other														

Analytes Flagged as Estimated (J) Due to Exceeding Criteria For:*

ICP													1	
Flame AA														
Furnace AA						11			6				17	
Mercury		11				2							13	
Total									6				31	
Other														

Note:
Asterisk (*) Indicates additional exceedances of review criteria.

Title: Evaluation of Metals Data for the Contract Laboratory Program
Appendix A.7: CLP Data Assessment Checklist
Inorganic Analysis

Date: Feb. 1990
Number: HW-2
Revision: 10

INORGANIC REGIONAL DATA ASSESSMENT

Region 2

CASE NO. 5941

SITE Flagys Inc

LABORATORY UFT

NO. OF SAMPLES/ MATRIX 10 soil, 3 water

SDG# MBFQ01

REVIEWER (IF NOT ESD) J Leahy

SOW# 3190

REVIEWER'S NAME Jennifer Leahy

DPO: ACTION _____ FYI _____

COMPLETION DATE 6/27/91

DATA ASSESSMENT SUMMARY

		ICP	AA	Hg	CYANIDE
1.	HOLDING TIMES	O	O	O	NA
2.	CALIBRATIONS	O	O	M	NA
3.	BLANKS	O	O	O	NA
4.	ICS	O			
5.	LCS	O	O		
6.	DUPLICATE ANALYSIS	O	O	O	NA
7.	MATRIX SPIKE	O	M	M	NA
8.	MSA		O		
9.	SERIAL DILUTION	O			
10.	SAMPLE VERIFICATION	O	O	O	NA
11.	OTHER QC	O	O	O	NA
12.	OVERALL ASSESSMENT	O	O	O	NA

O = Data has no problems/or qualified due to minor problems.
M = Data qualified due to major problems.
Z = Data unacceptable.
X = Problems, but do not affect data.

ACTION ITEMS: _____

AREAS OF CONCERN: _____

NOTABLE PERFORMANCE: _____

U.S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ01

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-1

Level (low/med): LOW Date Received: 2/28/91

% Solids: 92.1

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	4700.00			P
7440-36-0	Antimony	5.20	U		P
7440-38-2	Arsenic	1.80	B	WN	F
7440-39-3	Barium	17.50	B		P
7440-41-7	Beryllium	.41	B		P
7440-43-9	Cadmium	1.50			P
7440-70-2	Calcium	1210.00			P
7440-47-3	Chromium	19.90			P
7440-48-4	Cobalt	2.00	B		P
7440-50-8	Copper	260.00			P
7439-89-6	Iron	9150.00			P
7439-92-1	Lead	68.40			P
7439-95-4	Magnesium	1460.00			P
7439-96-5	Manganese	72.20			P
7439-97-6	Mercury	~~.05~~	U	N	CV
7440-02-0	Nickel	19.90			P
7440-09-7	Potassium	353.00	B		P
7782-49-2	Selenium	.43	U	N	F
7440-22-4	Silver	173.00			P
7440-23-5	Sodium	45.70	B		P
7440-28-0	Thallium	.22	U		F
7440-62-2	Vanadium	19.50			P
7440-66-6	Zinc	97.80			P
	Cyanide				NR

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: BROWN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

003
EPA SAMPLE NO.

1
INORGANIC ANALYSIS DATA SHEET

MBFQ02

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-2

Level (low/med): LOW Date Received: 2/28/91

% Solids: 84.4

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	11900.00			P
7440-36-0	Antimony	5.70	U		P
7440-38-2	Arsenic	7.40		N J	F
7440-39-3	Barium	67.40			P
7440-41-7	Beryllium	1.10	B		P
7440-43-9	Cadmium	.95	U		P
7440-70-2	Calcium	835.00	B		P
7440-47-3	Chromium	21.00			P
7440-48-4	Cobalt	4.00	B		P
7440-50-8	Copper	29.50			P
7439-89-6	Iron	16000.00			P
7439-92-1	Lead	60.20		J	P
7439-95-4	Magnesium	958.00	B		P
7439-96-5	Manganese	159.00			P
7439-97-6	Mercury	~~.06~~	U	N J	CV
7440-02-0	Nickel	11.60			P
7440-09-7	Potassium	1070.00	B		P
7782-49-2	Selenium	.47	U	WN	F
7440-22-4	Silver	7.40			P
7440-23-5	Sodium	43.80	U		P
7440-28-0	Thallium	.24	U		F
7440-62-2	Vanadium	26.30			P
7440-66-6	Zinc	67.80			P
	Cyanide				NR

Color Before: BROWN Clarity Before: Texture: MED

Color After: BROWN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ03

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-3

Level (low/med): LOW Date Received: 2/28/91

% Solids: 85.9

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	14100.00			P
7440-36-0	Antimony	5.60	U		P
7440-38-2	Arsenic	6.00		N J	F
7440-39-3	Barium	72.30			P
7440-41-7	Beryllium	1.00	B		P
7440-43-9	Cadmium	.93	U		P
7440-70-2	Calcium	587.00	B		P
7440-47-3	Chromium	24.00			P
7440-48-4	Cobalt	4.30	B		P
7440-50-8	Copper	20.60			P
7439-89-6	Iron	21800.00			P
7439-92-1	Lead	10.70			F
7439-95-4	Magnesium	1460.00			P
7439-96-5	Manganese	146.00			P
7439-97-6	Mercury	.06	U	N J	CV
7440-02-0	Nickel	8.90	B		P
7440-09-7	Potassium	944.00	B		P
7782-49-2	Selenium	.47	U	WN	F
7440-22-4	Silver	.98	B		P
7440-23-5	Sodium	43.10	U		P
7440-28-0	Thallium	.23	U		F
7440-62-2	Vanadium	33.10			P
7440-66-6	Zinc	37.60			P
	Cyanide				NR

Color Before: TAN Clarity Before: Texture: MED

Color After: TAN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ04

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-4

Level (low/med): LOW Date Received: 2/28/91

% Solids: 84.8

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	14900.00			P
7440-36-0	Antimony	5.70	U		P
7440-38-2	Arsenic	6.20		N	F
7440-39-3	Barium	81.20			P
7440-41-7	Beryllium	.95	B		P
7440-43-9	Cadmium	.94	U		P
7440-70-2	Calcium	483.00	B		P
7440-47-3	Chromium	23.30			P
7440-48-4	Cobalt	4.80	B		P
7440-50-8	Copper	23.30			P
7439-89-6	Iron	19300.00			P
7439-92-1	Lead	9.40			F
7439-95-4	Magnesium	1520.00			P
7439-96-5	Manganese	191.00			P
7439-97-6	Mercury	.06	U	N	CV
7440-02-0	Nickel	10.20			P
7440-09-7	Potassium	1040.00	B		P
7782-49-2	Selenium	.47	U	WN	F
7440-22-4	Silver	1.10	B		P
7440-23-5	Sodium	43.60	U		P
7440-28-0	Thallium	.26	B		F
7440-62-2	Vanadium	30.90			P
7440-66-6	Zinc	41.80			P
	Cyanide				NR

Color Before: TAN Clarity Before: Texture: MED

Color After: TAN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ05

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-5

Level (low/med): LOW Date Received: 2/28/91

% Solids: 87.2

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	11100.00			P
7440-36-0	Antimony	5.50	U		P
7440-38-2	Arsenic	5.30		N	F
7440-39-3	Barium	23.50	B		P
7440-41-7	Beryllium	.56	B		P
7440-43-9	Cadmium	.92	U		P
7440-70-2	Calcium	413.00	B		P
7440-47-3	Chromium	22.60			P
7440-48-4	Cobalt	2.20	B		P
7440-50-8	Copper	4.10	B		P
7439-89-6	Iron	17800.00			P
7439-92-1	Lead	5.30			F
7439-95-4	Magnesium	1310.00			P
7439-96-5	Manganese	71.10			P
7439-97-6	Mercury	.06	U	N	CV
7440-02-0	Nickel	5.00	B		P
7440-09-7	Potassium	1740.00			P
7782-49-2	Selenium	.46	U	WN	F
7440-22-4	Silver	.92	U		P
7440-23-5	Sodium	42.40	U		P
7440-28-0	Thallium	.23	U		F
7440-62-2	Vanadium	29.50			P
7440-66-6	Zinc	17.40			P
	Cyanide				NR

Color Before: TAN Clarity Before: Texture: MED

Color After: TAN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

007

EPA SAMPLE NO.

1

INORGANIC ANALYSIS DATA SHEET

MBFQ06

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-6

Level (low/med): LOW Date Received: 2/28/91

% Solids: 84.3

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	9270.00			P
7440-36-0	Antimony	5.70	U		P
7440-38-2	Arsenic	7.80		NJ	F
7440-39-3	Barium	50.70			P
7440-41-7	Beryllium	.83	B		P
7440-43-9	Cadmium	.95	U		P
7440-70-2	Calcium	328.00	B		P
7440-47-3	Chromium	17.80			P
7440-48-4	Cobalt	2.70	B		P
7440-50-8	Copper	16.00			P
7439-89-6	Iron	12200.00			P
7439-92-1	Lead	31.20		J	P
7439-95-4	Magnesium	986.00	B		P
7439-96-5	Manganese	204.00			P
7439-97-6	Mercury	.13		NJ	CV
7440-02-0	Nickel	6.00	B		P
7440-09-7	Potassium	958.00	B		P
7782-49-2	Selenium	.47	U	WN	F
7440-22-4	Silver	2.70			P
7440-23-5	Sodium	43.90	U		P
7440-28-0	Thallium	.24	U		F
7440-62-2	Vanadium	21.70			P
7440-66-6	Zinc	32.10			P
	Cyanide				NR

Color Before: BROWN Clarity Before: Texture: MED

Color After: TAN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

EPA SAMPLE NO.

1

INORGANIC ANALYSIS DATA SHEET

MBFQ07

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-7

Level (low/med): LOW Date Received: 2/28/91

% Solids: 87.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	11800.00			P
7440-36-0	Antimony	5.50	U		P
7440-38-2	Arsenic	6.80		NJ	F
7440-39-3	Barium	26.80	B		P
7440-41-7	Beryllium	.74	B		P
7440-43-9	Cadmium	.91	U		P
7440-70-2	Calcium	552.00	B		P
7440-47-3	Chromium	24.40			P
7440-48-4	Cobalt	4.10	B		P
7440-50-8	Copper	3.40	B		P
7439-89-6	Iron	19700.00			P
7439-92-1	Lead	5.10			F
7439-95-4	Magnesium	1290.00			P
7439-96-5	Manganese	111.00			P
7439-97-6	Mercury	.12 ~~.06~~	U	NJ	CV
7440-02-0	Nickel	5.50	B		P
7440-09-7	Potassium	1870.00			P
7782-49-2	Selenium	.46	U	WN	F
7440-22-4	Silver	.91	U		P
7440-23-5	Sodium	42.30	U		P
7440-28-0	Thallium	.23	U		F
7440-62-2	Vanadium	31.60			P
7440-66-6	Zinc	18.00			P
	Cyanide				NR

Color Before: TAN Clarity Before: Texture: MED

Color After: TAN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

EPA SAMPLE NO.

1

INORGANIC ANALYSIS DATA SHEET

MBFQ08

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-8

Level (low/med): LOW Date Received: 2/28/91

% Solids: 93.2

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	2420.00			P
7440-36-0	Antimony	5.20	U		P
7440-38-2	Arsenic	2.70		N J	F
7440-39-3	Barium	41.00	B		P
7440-41-7	Beryllium	.31	B		P
7440-43-9	Cadmium	4.70			P
7440-70-2	Calcium	1450.00			P
7440-47-3	Chromium	28.80			P
7440-48-4	Cobalt	1.10	U		P
7440-50-8	Copper	688.00			P
7439-89-6	Iron	5430.00			P
7439-92-1	Lead	37.80		J	P
7439-95-4	Magnesium	831.00	B		P
7439-96-5	Manganese	32.80			P
7439-97-6	Mercury	.11 ~~.05~~	U	N	CV
7440-02-0	Nickel	34.40			P
7440-09-7	Potassium	208.00	B		P
7782-49-2	Selenium	.43	U	WN	F
7440-22-4	Silver	193.00			P
7440-23-5	Sodium	39.70	U		P
7440-28-0	Thallium	.21	U		F
7440-62-2	Vanadium	7.60	B		P
7440-66-6	Zinc	206.00			P
	Cyanide				NR

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: TAN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ09

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-9

Level (low/med): LOW Date Received: 2/28/91

% Solids: 80.4

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	10200.00			P
7440-36-0	Antimony	6.00	U		P
7440-38-2	Arsenic	7.10		N J	F
7440-39-3	Barium	77.30			P
7440-41-7	Beryllium	.85	B		P
7440-43-9	Cadmium	1.70			P
7440-70-2	Calcium	1290.00			P
7440-47-3	Chromium	21.60			P
7440-48-4	Cobalt	2.80	B		P
7440-50-8	Copper	82.30			P
7439-89-6	Iron	14200.00			P
7439-92-1	Lead	134.00		J	P
7439-95-4	Magnesium	1170.00	B		P
7439-96-5	Manganese	196.00			P
7439-97-6	Mercury	.06	U	N J	CV
7440-02-0	Nickel	12.70			P
7440-09-7	Potassium	1190.00	B		P
7782-49-2	Selenium	.70	B	N J	F
7440-22-4	Silver	73.10			P
7440-23-5	Sodium	46.00	U		P
7440-28-0	Thallium	.32	B	W	F
7440-62-2	Vanadium	25.30			P
7440-66-6	Zinc	147.00			P
	Cyanide				NR

Color Before: BROWN Clarity Before: Texture: MED

Color After: BROWN Clarity After: Artifacts:

Comments:

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1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ10

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): SOIL Lab Sample ID: 1B13-10

Level (low/med): LOW Date Received: 2/28/91

% Solids: 84.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	7800.00			P
7440-36-0	Antimony	5.70	U		P
7440-38-2	Arsenic	11.30		NJ	F
7440-39-3	Barium	47.00	B		P
7440-41-7	Beryllium	.73	B		P
7440-43-9	Cadmium	.95	U		P
7440-70-2	Calcium	1060.00	B		P
7440-47-3	Chromium	19.30			P
7440-48-4	Cobalt	1.80	B		P
7440-50-8	Copper	17.20			P
7439-89-6	Iron	12500.00			P
7439-92-1	Lead	58.50		J	P
7439-95-4	Magnesium	1020.00	B		P
7439-96-5	Manganese	158.00			P
7439-97-6	Mercury	.13		NJ	CV
7440-02-0	Nickel	4.60	B		P
7440-09-7	Potassium	1340.00			P
7782-49-2	Selenium	.47	U	WN	F
7440-22-4	Silver	3.00			P
7440-23-5	Sodium	43.80	U		P
7440-28-0	Thallium	.24	U		F
7440-62-2	Vanadium	22.30			P
7440-66-6	Zinc	71.80			P
	Cyanide				NR

Color Before: BROWN Clarity Before: Texture: MED

Color After: BROWN Clarity After: Artifacts:

Comments:

U.S. EPA - CLP

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INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ11

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): WATER Lab Sample ID: 1B13-11

Level (low/med): LOW Date Received: 2/28/91

% Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	22.00	U		P
7440-36-0	Antimony	24.00	U		P
7440-38-2	Arsenic	1.00	U	N	F
7440-39-3	Barium	1.00	U		P
7440-41-7	Beryllium	1.00	U		P
7440-43-9	Cadmium	4.00	U		P
7440-70-2	Calcium	24.00	U		P
7440-47-3	Chromium	6.00	U		P
7440-48-4	Cobalt	5.00	U		P
7440-50-8	Copper	3.00	U		P
7439-89-6	Iron	7.00	U		P
7439-92-1	Lead	1.00	U	W	F
7439-95-4	Magnesium	24.00	U		P
7439-96-5	Manganese	1.00	U		P
7439-97-6	Mercury	.20	U	N	CV
7440-02-0	Nickel	10.00	U		P
7440-09-7	Potassium	620.00	U		P
7782-49-2	Selenium	2.00	U	W	F
7440-22-4	Silver	4.00	U		P
7440-23-5	Sodium	185.00	U		P
7440-28-0	Thallium	1.50	B		F
7440-62-2	Vanadium	6.00	U		P
7440-66-6	Zinc	5.00	U		P
	Cyanide				NR

Color Before: COLORLESS Clarity Before: CLEAR Texture:

Color After: COLORLESS Clarity After: CLEAR Artifacts:

Comments:

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INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ12

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): WATER Lab Sample ID: 1B13-12

Level (low/med): LOW Date Received: 2/28/91

% Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	22.00	U		P
7440-36-0	Antimony	24.00	U		P
7440-38-2	Arsenic	1.00	U	N	F
7440-39-3	Barium	1.00	U		P
7440-41-7	Beryllium	1.00	U		P
7440-43-9	Cadmium	4.00	U		P
7440-70-2	Calcium	24.00	U		P
7440-47-3	Chromium	6.00	U		P
7440-48-4	Cobalt	5.00	U		P
7440-50-8	Copper	3.00	U		P
7439-89-6	Iron	14.10	B		P
7439-92-1	Lead	1.00	U	N	F
7439-95-4	Magnesium	24.00	U		P
7439-96-5	Manganese	1.00	U		P
7439-97-6	Mercury	.10	U	N	CV
7440-02-0	Nickel	10.00	U		P
7440-09-7	Potassium	620.00	U		P
7782-49-2	Selenium	2.00	U	WN	F
7440-22-4	Silver	4.00	U		P
7440-23-5	Sodium	185.00	U		P
7440-28-0	Thallium	1.00	U		F
7440-62-2	Vanadium	6.00	U		P
7440-66-6	Zinc	5.00	U		P
	Cyanide				NR

Color Before: COLORLESS Clarity Before: CLEAR Texture:

Color After: COLORLESS Clarity After: CLEAR Artifacts:

Comments:

U.S. EPA - CLP

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INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBFQ13

Lab Name: N.F.T. INC. Contract: 68-D0-0145

Lab Code: NFT Case No.: 15941 SAS No.: SDG No.: MBFQ01

Matrix (soil/water): WATER Lab Sample ID: 1B13-13

Level (low/med): LOW Date Received: 2/28/91

% Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	22.00	U		P
7440-36-0	Antimony	24.00	U		P
7440-38-2	Arsenic	1.00	U	N	F
7440-39-3	Barium	1.00	U		P
7440-41-7	Beryllium	1.00	U		P
7440-43-9	Cadmium	4.00	U		P
7440-70-2	Calcium	24.00	U		P
7440-47-3	Chromium	6.00	U		P
7440-48-4	Cobalt	5.00	U		P
7440-50-8	Copper	3.00	U		P
7439-89-6	Iron	7.00	U		P
7439-92-1	Lead	1.00	U	W	F
7439-95-4	Magnesium	24.00	U		P
7439-96-5	Manganese	1.00	U		P
7439-97-6	Mercury	.10	U	N	CV
7440-02-0	Nickel	10.00	U		P
7440-09-7	Potassium	620.00	U		P
7782-49-2	Selenium	2.00	U	WN	F
7440-22-4	Silver	4.00	U		P
7440-23-5	Sodium	185.00	U		P
7440-28-0	Thallium	1.00	U		F
7440-62-2	Vanadium	6.00	U		P
7440-66-6	Zinc	5.00	U		P
	Cyanide				NR

Color Before: COLORLESS Clarity Before: CLEAR Texture:

Color After: COLORLESS Clarity After: CLEAR Artifacts:

Comments: