2.4 WETLANDS

2.4.1 INTRODUCTION

Among the most productive ecosystems on earth, wetlands are transitional areas between terrestrial and open-water habitats. Wetlands are characterized by fluctuating water tables at or near the surface, wet soils, and plants adapted to wet conditions.

A wetland organism that rises from a nesting spot, waddles across a soggy shoreline, tramps through cattails, paddles through floating plants, and eventually floats into an open pond may have traversed no fewer than five different, if not readily distinct, habitats. While the ecological functioning of wetlands is sufficient to have biologists, ecologists, chemists, hydrologists, and countless other scientists mired in the complexity of these habitats, the cultural valuation of wetlands invites the involvement of a myriad of Basin stakeholders — including foresters and farmers, landowners and developers, sportsmen and naturalists, artists and poets. While the behavior of wetland organisms is dictated by their biology, the behavior of humans is dictated by innumerable societal and cultural influences, including constraints.

While wetland organisms act of their own accord, the actions of humans inevitably require at least a rudimentary knowledge about the what, the where, the when, the how, and why of wetlands (and associated deep-water habitats). This section includes definitions, characteristics, locations, trends, and issues concerning the existence and longevity of these components of the Basin environment.

2.4.1.1 Overview

Wetlands are often described, studied, and considered together with associated deep-water habitats — that is, habitats that are essentially wetlands, but which occur at depths exceeding 6 feet. Such association is logical, since these two very general ecosystem types are often inextricably linked in the context of their function in the ecology of a Basin. In other instances, differentiating between wetlands and deep-water habitats can be extremely important, as can be differentiating between wetlands themselves. For this reason, deep-water habitats, defined as wetlands with open water exceeding depths of 6 feet, are included in this section wherever the interdependence with non-deep-water wetlands is crucial.

Wetlands and associated deep-water habitats for the Inland Bays/Atlantic Ocean Basin are depicted on *Map 2.4-1 Wetland Types.* Covering some 17 percent of Delaware, and over 39 percent of the Basin, wetlands support rich freshwater, brackish, and saltwater ecological communities. Saline and brackish (“estuarine”) marshes,

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which may be in excess of 7,000 acres, may be most recognizable to the beachgoer, boater, or casual observer. However, the Inland Bays portion of the Basin contains more than four times as much non-tidal, freshwater wetlands (including arguably the rarest and most diverse freshwater wetlands in the state: acidic sea-level fen wetlands). Similarly, the Atlantic Ocean portion of the Basin contains virtually unrecognizable, yet imperiled, freshwater wetlands, nestled between the familiar beach dunes, referred to as interdunal wetlands.

Historically, the Inland Bays portion of the Basin has lost substantial wetland acreage due to development and/or agricultural land conversion. Although the rate of wetland destruction Basin and statewide has slowed in recent years, an estimated 54 percent of Delaware wetlands has been lost since 1780 (Dahl, 1990). The increasing population and associated infrastructure and amenities suggest further wetlands degradation for the foreseeable future.

2.4.1.2 Wetland Importance

Basin wetlands have a multitude of biological, chemical, and physical functions. Principally, they trap waterborne sediments, nutrients, and toxic chemicals through water filtration and transformation. Coastal and floodplain wetlands minimize both storm and tidal flooding effects by reducing the velocity of the water, by temporarily storing volumes of water, and by gradually releasing the water to the surrounding (or underlying) recipient water bodies. Riparian wetland vegetation stabilizes the land surface and helps maintain stream channels. Tidal wetlands impede erosion by buffering against storm tides and waves. Perhaps the most recognizable function of wetlands is their role in providing habitat for waterfowl, terrestrial and aquatic animals, and the variety of plant life. Wetlands provide food, shelter, resting, and feeding places on migration routes, breeding areas, and nurseries for many animals including species of particular economic interest in Delaware such as muskrat, fish, ducks, and geese. Many rare and endangered plant species are adapted to hydrologic conditions present only in wetlands, especially freshwater wetlands.

Delaware's wetlands also have considerable recreational and economic value. They provide outdoor educational and recreational opportunities, including activities such as bird-watching, hiking, and canoeing. In addition, wetlands in Delaware support the hunting, fur trapping, commercial and sport fishing, lumbering, and tourist industries.

Wetlands are composed of physical, chemical, and biological components. In the landscape, wetlands may be juxtaposed between uplands and aquatic habitats, may occur as isolated depressions within uplands, may occur on slopes, or may be adjacent to tidal or non-tidal waters. In wetlands, the water table is at or near the surface of the soil during all or part of the year, creating conditions favorable for life adapted to inundated or saturated soil conditions (Cowardin et al., 1979). A regulatory, as well as an ecological, definition developed in response to Section 404 of the Clean Water Act of 1972 defines wetlands as:

> "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and 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."

Thus, wetlands generally have three ecological characteristics:

- ◆ Wetland vegetation (hydrophytes);
- ◆ Wetland soils (hydric soils); and,
- ◆ Wetland hydrology.

Hydrophytic vegetation consists of those plant species adapted to grow under anaerobic conditions through morphological, physiological, or reproductive mechanisms. Hydric soils are those soils that develop under reducing conditions, are associated with low oxygen, and are unmodified. Wetland hydrology implies that soils are flooded or saturated with water either periodically or permanently. These three ecological characteristics are present in most wetlands and are important in wetland identification and delineation.

2.4.2 ECOLOGICAL CLASSIFICATION

Delaware, and specifically the Inland Bays/Atlantic Ocean Basin, contains many different wetland types. Wetlands can be classified based on ecological factors such as climate, soil type, ground-water and surface-water chemistry, salinity, and the extent and duration of flooding. The U.S. Fish and Wildlife Service developed a classification system to provide national consistency for wetland concepts, terminology, and classification (i.e., the 1979 *Classification of Wetlands and Deepwater Habitats of the United States* (commonly referred to as the "Cowardin Classification System," after the authors of that publication).

The Cowardin System employs a hierarchical approach to classifying various wetland types. It first describes wetlands broadly by five systems: marine, estuarine, riverine, lacustrine, and palustrine. Each system (with the exception of the palustrine system) is further divided into subsystems based on major hydrologic characteristics. Subsystems are then subdivided into classes, describing the general vegetative types or substrate types. The classes are then delineated into subclasses, which describe either dominant substrate type in unvegetated areas (e.g., bedrock, rubble, cobble-gravel, sand, mud, or organic), or dominant vegetation type (e.g., persistent or non-persistent emergents, moss, lichen, or broad-leaved deciduous, needle-leaved deciduous, broad-leaved evergreen, needle-leaved evergreen, and dead woody plants). Additional modifiers describing hydrologic and soil properties, water chemistry, or physical modifications of the wetland are commonly used following the class or sub-class designation.

Four varieties of specific modifiers (water regime, water chemistry, soil, and special) describe particular wetland or deep-water habitats with respect to hydrologic, chemical, and edaphic (soil-related) characteristics and human impacts. These modifiers may be applied to class and lower levels of the classification hierarchy. Water regime modifiers describe soil inundation or saturation conditions and are distinguished as tidal and non-tidal. Special modifiers describe activities affecting deep-water habitats. Special modifiers include excavated, impounded (i.e., obstructed hydrology outflow), diked (i.e., obstructed hydrology inflow), partly drained, farmed, and artificial (i.e., materials deposited to create or modify a wetland or deep-water habitat) (DNREC, *Delaware Freshwater Wetlands Restoration*, 1992).

The Basin contains predominantly two wetland system types: Estuarine and Palustrine. *Estuarine wetlands* (tidally-influenced wetlands of salinities varying from seawater to fresh water) occur along the shores of the Inland Bays and behind the barrier beaches of the Atlantic Coast; such wetlands constituted approximately 4,750 acres (4.2 percent of the Basin) in 1992, according to the Department's statewide Wetlands Mapping Project. *Palustrine wetlands* (non-tidal freshwater wetlands and tidal freshwater wetlands with salinities of less than 5 parts per thousand) are dispersed throughout the Basin — from within the dune system itself, to the upper headwaters of streams; such wetlands constituted approximately 16,850 acres (14.8 percent of the Basin). Of the approximately 297 Basin wetland acres lost in the 10 years preceding 1992, some 92 percent were palustrine vegetated wetlands; agriculture was identified as the principal factor (48 percent) leading to loss, followed by residential development (24 percent) and pond construction (20 percent) (Tiner and Schaller, 1999).

Palustrine and estuarine emergent wetlands can be found in impoundments modified by constructed levees and managed by water-control structures. Salt and brackish marshes are predominantly estuarine emergent wetlands characterized by vegetation tolerant of brackish to salty water. Small scrub-shrub wetlands are commonly associated with the landward margins of salt marshes. Interdunal wetlands are topographic depressions among sand dunes on the Atlantic coast that contain palustrine emergent or scrub-shrub wetlands. Palustrine forested wetlands in Delaware include Atlantic white cedar swamps, cypress swamps, and both tidal and non-tidal floodplain forests. Delmarva bays (small, closed topographic depressions) commonly contain seasonally flooded palustrine emergent, scrub-shrub, or forested wetlands.

Palustrine forested wetlands are the most prevalent type of wetland in Delaware and in the Inland Bays/Atlantic Ocean Basin. These wetlands are dominated by trees such as *Acer rubrum* (red maple), *Fraxinus americanus (*green ash), *Liquidambar styraciflua* (sweet gum), *Nyssa sylvatica* (black gum), *Salix nigra* (black willow), and *Quercus* spp. (oaks).

Palustrine emergent marshes are a less common non-tidal wetland type in the Inland Bays/Atlantic Ocean Basin and occur along ponds, seeps, streams, and river, or in topographic depressions. Palustrine marshes may be characterized by persistent vegetation (which is biologically active year-round) such as *Typha* (cattails), or by non-persistent vegetation (which is perennial but dormant during the winter) such as *Peltandra* (arrow arum) and *Pontederia* (pickerelweed).

Palustrine scrub-shrub wetlands, a far less common type of non-tidal wetland in Delaware and in the Basin, are dominated by a number of water regimes and by woody vegetation less than 20 feet tall. Scrub-shrub wetlands may be characterized by shrub species such as *Cephalanthus occidentalis* (buttonbush), *Salix* (willow), *Viburnum* (arrowwood), and *Cornus* (dogwood), or by thickets dominated by native vines such as *Smilax* (green brier) or *Vitis* (grape), or by invasive/alien vines such as *Rosa multiflora* (multiflora rose) and *Lonicera japonica* (Japanese honeysuckle). Scrub-shrub wetlands may be early successional stages of forests characterized by scattered hydrophytic tree saplings associated with a wet meadow, or they may characterize portions of Coastal Plain ponds (refer to Section *2.4.13 Appendix A — Wetland Communities*).

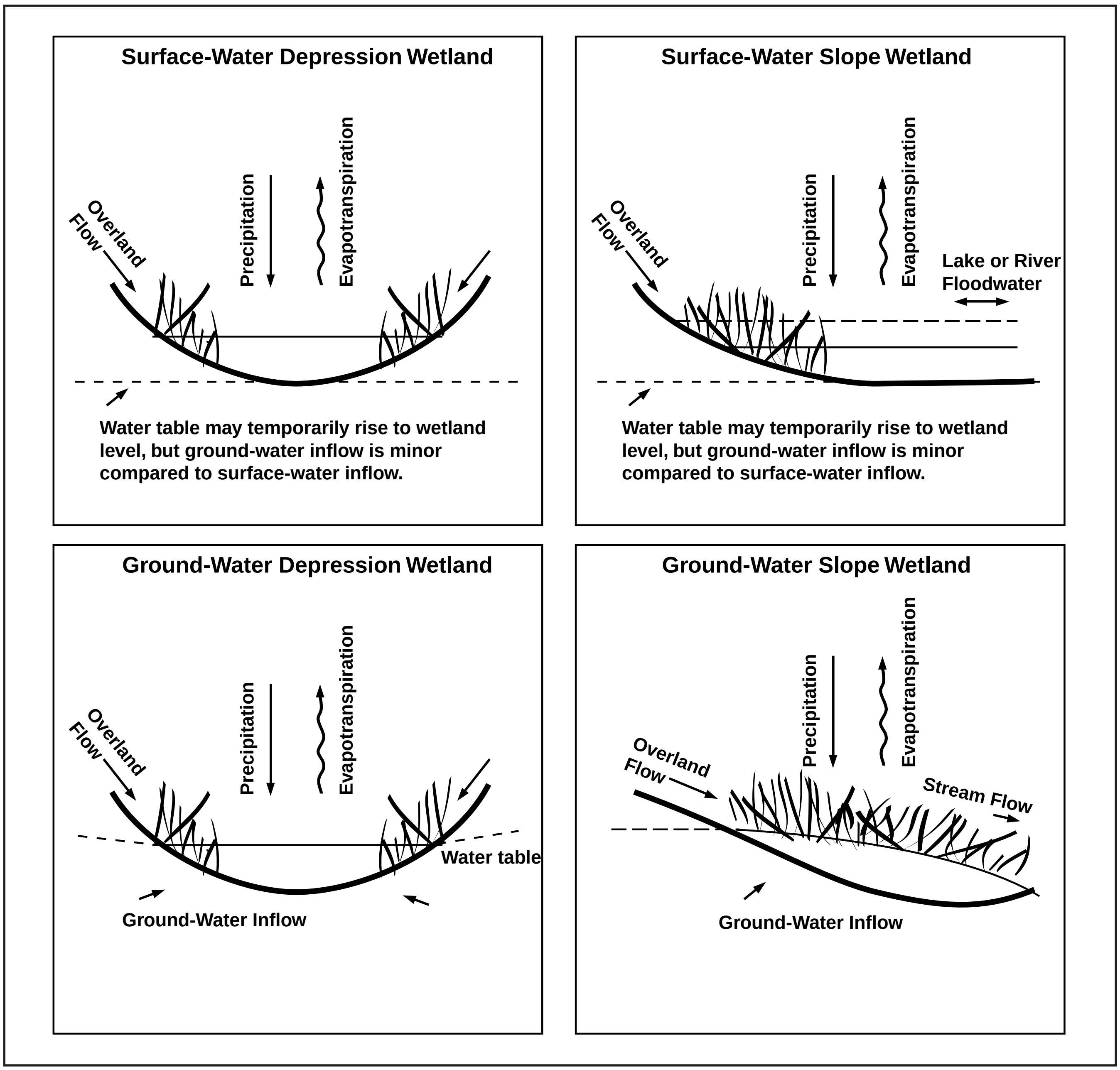
2.4.2.1 Plant Communities

Over the past decade, DNREC's Delaware Natural Heritage Program has characterized natural plant communities based primarily on vegetation collected by its biologists, community ecologists, and botanists. Section *2.4.13 Appendix A — Wetland Communities* shows specific examples of wetland plant communities occurring in the Inland Bays/Atlantic Ocean Basin. It reflects both the Delaware Natural Heritage Program database and preliminary natural community classifications (Clancy, 1993; and Rawinski, 1989).

2.4.2.2 Hydric Soils

Hydric soils are a key attribute for identifying wetlands. Hydric soils are defined as soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper soil zone. Under these saturated, anaerobic conditions, leaching of common soil constituents (such as iron and manganese) occurs. Water-table fluctuations enable visual observation of depletions (gray or yellow stains imparted to soil matrix caused by reducing conditions) and of

Figure 2.4-1
HYDROLOGY OF SURFACE-WATER AND GROUND-WATER WETLANDS
(Redrawn from Novitski 1982; in Tiner, 1985)



concentrations (red or black colors imparted to soil matrix by oxidative conditions).

A significant portion of the soils found in the Basin are poorly to very poorly drained. Many of these soils are associated with the floodplains of creeks and rivers.

2.4.3 HYDROLOGIC CLASSIFICATION

Wetland hydrologic types are important in wetland identification and delineation, restoration, and compensation efforts because hydrology is the driving force in the creation and maintenance of wetlands. The source, direction, and hydrodynamics of water are also important in understanding wetland ground-water recharge and/or discharge properties and water-quality mechanisms. In a discussion of the hydrologic characteristics and hydrologic processes that occur in wetlands, Novitski (1979) identified four simple wetland classes that have been widely accepted as applicable to most situations (refer to *Figure 2.4-1*).

Surface-water depression wetlands occur where precipitation and overland runoff collect and where water leaves primarily by infiltration and evapotranspiration. The bottoms of the depressions are above the water table most of the time. Water levels are typically high in spring (immediately after snowmelt) and decline through the rest of the year, although periodic rises may result from intense storms.

Surface-water slope wetlands occur along the margin of lakes or streams and extend to shallow but permanently flooded parts of lakes or river up-slopes to points flooded only occasionally. These wetlands receive lake or river floodwaters in addition to runoff and direct precipitation; water leaves primarily by drainage as the stage of the lake or river declines, as well as by infiltration and evapotranspiration. Water levels are controlled by the lake or river stages and are typically high in spring and decline through the rest of the year. Lake-edge wetlands differ from river-edge wetlands in that lake levels fluctuate more slowly than river stages.

Ground-water depression wetlands occur in depressions that intercept the water table and receive ground-water inflow as well as precipitation and overland flow. The amount of ground-water inflow to the wetland may be only a small percentage of its total water budget. However, since the inflow is continuous rather than seasonal, it is a determining factor in the type of plant community that develops and in the rate of soil development, in addition to other processes. Water usually leaves this wetland by evapotranspiration although it may occasionally recharge the water table. If the water table slopes toward the wetland from all sides, the wetland functions most of the time as a ground water discharge point. In spring, the wetland water level may rise briefly above the wetland bottom, resulting in the wetland recharging the local ground water.

Ground-water slope wetlands occur where ground water discharges continuously as a spring or seep at the land surface. The amount of ground-water inflow to the wetland may range from a relatively small percentage to a major portion of the total water budget, which results in wide differences among wetland plant communities and soil development rates. This type of wetland is rarely flooded because water can drain away down-slope. The water table surrounding the wetland typically is at or above (artesian) the wetland surface (Novitski, 1979).

2.4.4 LANDSCAPE CLASSIFICATION AND WETLAND FUNCTIONS

In the Inland Bays/Atlantic Ocean Basin, wetlands, which may occur inland as isolated depressions contiguous to the Atlantic Ocean (interdunal), or associated with tidal estuaries, are associated with headwaters (upper reaches) of streams and rivers.

Wetland functions include such physical mechanisms as flood flow alteration, water storage, and nutrient and sediment trapping. Biochemical processes include nutrient attenuation through denitrification and plan assimilation. Biological processes include food web support, habitat, and biodiversity. All wetlands provide functions, but wetlands in different landscape positions and with differing types and degrees of disturbance vary in their ability to perform their functions. Accordingly, one approach to classifying wetlands and describing wetland functions is based on the position of the wetland in the landscape.

Headwater riparian wetlands, for example, are important for their contribution to the maintenance of stream water quality through the removal of nonpoint source pollution. Sediment trapping and the seasonal or temporary uptake of nitrogen and phosphorus by wetlands associated with first-order streams may be as important as in riverine systems since headwater wetlands cumulatively represent an area comparable to second- or third-order stream floodplain (Brinson, 1988, 1991). Headwater wetlands provide important habitat for plants, fish, and wildlife through the maintenance of water quality for headwater streams and downstream habitats. Large tracts of headwater wetlands provide habitat for Neotropical migratory birds and over-wintering and reproductive habitat for other birds, reptiles, and mammals.

Floodplain wetlands store flood waters and buffer surface and ground water from the effects of agricultural, residential, and industrial development. Riverine floodplains are believed to interact extensively with surface water and ground water, thereby contributing to water-quality maintenance (Brinson, 1988). The water-quality functions of wetlands are of continuing concern in the agrarian landscape of the Basin, though water-storage functions may become increasingly important, as the landscape becomes increasingly suburbanized. Floodplain or riparian wetlands provide food, shelter, and migratory corridors for fur-bearing mammals including fox, otter, mink, and beaver; for Neotropical migratory songbirds; and for many other forest species (Mitsch and Gosselink, 1993).

Isolated, depressional, or Basin wetlands may be geographically located in any landscape position and are discontiguous to non-tidal streams. These wetlands may serve as ground-water recharge Basins for precipitation, as well as provide the functions of water storage and contaminant trapping (Brinson, 1988). Where surrounded by urban or rural development, these isolated wetlands may be oases of habitat for wildlife in an otherwise developed landscape.

Estuarine wetlands in the Inland Bays/Atlantic Ocean Basin are predominantly emergent wetlands found in the lower reaches of the Basin watersheds. Estuarine wetlands are highly productive wetlands, specializing in functions such as nutrient cycling and organic matter production. They may be nutrient sinks and/or export organic matter in the form of detritus to surrounding tidal water, providing primary production to the base of complex food webs. The role of the tidal marsh/estuarine ecosystem as a nursery for both nearshore and offshore fisheries has been well documented. Tidal wetlands provide feeding, resting, and nesting habitat for resident waterfowl and water birds, and resting and feeding grounds for migratory waterfowl and shorebirds.

2.4.5 TRENDS

Until recently, the most recent information regarding Delaware wetland acreage was based on the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) conducted during the late 1970s and early 1980s. The NWI used color infrared imagery from the mid-1970s to the early 1980s to map wetlands using a modified version of the Cowardin Classification System (described earlier). In 1982, Delaware had approximately 215,000 acres of wetlands, representing about 17 percent of the state's surface area. Most of this acreage (68 percent) was non-tidal wetlands, with forested wetlands being the predominant class (Tiner, 1985).

Delaware is one of 22 states that have lost approximately half their wetlands since pre-Colonial times (Dahl and others, 1991). A five-state wetlands trends study conducted by the NWI for the period between the mid-1950s and the early 1980s estimates wetland loss rate by wetland type for the Mid-Atlantic region and within each of the five states. Delaware experienced a 21 percent loss of the state's palustrine wetlands and a 6 percent loss of estuarine wetlands during the study period. A significant net loss of 42,000 acres of vegetated wetlands was experienced for the entire state during the period for a resultant average annual (statewide) loss of about 1,600 acres (Tiner and Finn, 1986).

Delaware's statewide Wetlands Mapping Project has provided updated information on the location, acreage, and type of wetlands — both statewide and within the Inland Bays/Atlantic Ocean Basin. Through a recent cooperative venture with NWI, Delaware now has available to it the most recent wetland trends data available (*see Table 2.4-1 Delaware Wetland Trends Study: 1981/82 to 1992).* In recognition of the value of Whole Basin Planning, these trend analyses were performed on a by-Basin basis, whereas previous wetland studies had relied on by-state, or by-county assessments.

Causes of inland (non-tidal) wetlands losses were attributed mainly to channelization and ditching projects (54 percent), agricultural development (28 percent), urban development (12 percent), pond and lake creations (5 percent), and change to other wetlands (1 percent). For coastal (estuarine and tidal vegetated) wetlands, losses during the period were attributed to urban development (63 percent), to coastal waters through sea-level rise and dredging (24 percent), coastal pond and impoundments (6 percent), and other factors (7 percent) (Tiner and Finn, 1986).

2.4.6 SOURCES OF IMPACT

2.4.6.1 Natural Impact

Both natural and anthropogenic threats impact wetlands. Natural threats are dynamic processes, including sea-level rise, natural succession, fluctuation of hydrologic cycles over time, sedimentation, erosion, and fire. Sea-level rise may significantly alter tidal wetland and/or estuarine ecosystems. Changes in weather and rainfall patterns may affect the hydrologic budgets of non-tidal wetlands, making them particularly sensitive to anthropogenic impacts. Erosional forces may remove wetlands, while sedimentation may result in the creation of new ones. Fire, a natural occurrence in historic times, is largely suppressed in modern-day Delaware, indirectly affecting succession and climax communities.

Other natural impacts to wetlands include flooding and wind damage from hurricanes and other severe storms. Additional impacts (which may be exacerbated by human disturbances) include such biotic effects as invasion of non-native plant species and grazing by herbivorous waterfowl (e.g., snow geese) and mammals (e.g., muskrat) (Tiner, 1985).

2.4.6.2 Human Impacts

Human-induced threats include direct effects such as filling for residential, commercial, and industrial development; discharge of point and nonpoint source pollutants; drainage for agriculture; flooding for the creation of lakes, ponds, and waterfowl impoundments; stream channelization for flood control and navigation; and ground-water removal for drinking water, irrigation, or other purposes. These impacts have both direct and indirect as well as cumulative effects. Direct impacts completely remove or alter wetland functions. Human impacts are directly related to increasing population growth and attendant land-use choices that bring about increased alterations in the natural landscape.

The Delaware Department of Transportation undertakes highway projects of potential major impact to wetlands in the Inland Bays/Atlantic Ocean Basin and elsewhere in the state. The U.S. Army Corps of Engineers leads the permit reviews for these projects, in coordination with other federal agencies and the Department's Division of Water Resources, Wetlands and Subaqueous Lands Section. Highway construction further fragments the landscape, resulting in the loss of wildlife habitat for species such as nesting Neotropical migratory birds.

2.4.6.3 Cumulative Impacts

It has become apparent that cumulative impact may threaten the integrity of wetland ecosystems within the landscape. The Council on Environmental Quality defines cumulative impact as:

> "The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

Disturbances to wetlands due to cumulative impacts are highlighted in *Table 2.4-1* (DNREC, Delaware Freshwater Wetlands Restoration, 1992).

2.4.7 CHANNELIZATION

2.4.7.1 Historical Perspective/Need

Many areas of the nation have historically made land-use decisions based on an infrastructure of man-made drainage systems. Delaware is no exception, as it has community and private drainage systems that date back to the 1700s. In the 1700s, drainage of wetlands was considered necessary for several reasons (e.g., farming and food, disease control, and timber harvests to name a few). The extensive drainage systems constructed in early times were extensions of natural drainage patterns into poorly drained upland flats. These channels were constructed to better manage soil and water resources, and for flood protection.

Without proper drainage systems, soils become over-saturated or have standing water on them. The average annual rainfall in Delaware usually exceeds plant needs and evaporation rates, creating excess water for extended periods. The result is drainage and flooding problems for agricultural areas, as well as towns, rural communities, forests, and transportation facilities. Approximately 35 percent of the soils in the Inland Bays/Atlantic Ocean Basin are poorly drained, due to low-permeable clay-type subsoil.

This over-saturated situation precludes efficient farming operations, as farmers cannot get into their fields for timely agricultural operations. Adverse effects on crop production include:

- Inability to prepare soils for planting;
- Delays beyond optimum planting dates;
- Inhibited plant growth due to excess water in the soil profile; and
- Restricted harvests and/or the inability to harvest.

In addition, crops impacted by flooding or poor drainage often underutilize nutrients, thereby creating potential excessive nutrient contamination problems in downstream areas.

Today, proper water management for optimizing farming operations has become even more vital due to increasingly complex and expensive equipment and inputs (such as fertilizers and chemicals). The existence of stable drainage systems plays a large role in determining the economic success of most farming operations within the Basin. In addition to farming concerns, many rural roads depend on proper drainage outlets to control flooding, and to minimize upkeep and maximize longevity.

For urban communities, controlling surface-water runoff is critical. Proper drainage in areas with residential and industrial development is essential for maximum utilization of related facilities. Basements, septic systems, streets, recreational areas, storm-water facilities, parking lots, schools, and businesses all depend on an effective drainage system for maximum economic utilization. Numerous programs, some dating back to the 1700s, have been implemented to address drainage and flooding issues. Nearly every volume of the Laws of Delaware has some reference to specific drainage corporations, drainage laws, or drainage incorporation laws.

The development of a drainage infrastructure in Sussex County received a large boost in 1935 when the Levy Court was authorized to sell bonds for drainage improvements. Ditch company operations for care and maintenance were also turned over to the Levy Court. Additionally, significant assistance came in the 1930s and '40s with the formation of the Works Progress Administration (WPA) and the Civilian Conservation Corps (CCC). A primary function of these two groups was to construct drainage channels. In 1944, the formation of Conservation Districts further addressed statewide drainage problems. These Districts, with help from the Soil Conservation Service, provided construction

Table 2.4-1

DELAWARE WETLAND TRENDS STUDY: 1981/82 TO 1992

CONVERSION OF VEGETATED WETLANDS

During the 1980s and early 1990s, the Inland Bays/Atlantic Ocean Basin endured net losses of both palustrine and estuarine vegetated wetlands. Most of the losses involved palustrine types, especially forested wetlands.

Overall, there was a net loss of 271.3 acres of palustrine vegetated wetlands (271.3 acres lost versus 6.1 acres gained). Forty-eight percent of the losses were attributed to agricultural operations. Residential development was responsible for about 24 percent of the losses. Pond construction was the third-ranked cause of palustrine vegetated loss, accounting for 20 percent of these lost wetlands.

Forested wetlands were most adversely affected. A total of 254.3 acres of forested wetlands were lost during the 1980s. This figure represents over 90 percent of the palustrine vegetated losses. Deciduous forested wetlands received the bulk of the negative impacts, with 178.4 acres converted to mostly non-wetlands. Agricultural operations alone were the leading cause of deciduous forested wetland loss (68.2 acres), being responsible for about 38 percent of the total losses. Residential development was a close second, accounting for 33 percent of the deciduous forested wetland losses. Pond construction was also a significant factor, causing 26 percent of the losses. Farming activities also were the major cause of loss of evergreen forested wetlands, with 56.7 acres converted to farmed wetland. This conversion alone accounted for 75 percent of the losses of this wetland type.

Small net losses of scrub-shrub wetlands were detected. About 14 acres of these wetlands were converted to non-wetlands or ponds.

Palustrine emergent wetland experiences a net gain of 0.8 acres. This was the only vegetated wetland type to increase (excluding temporary effects of timber harvest, which temporarily leads to establishment of emergent wetlands). A total of 9.6 acres of these emergent wetlands were created, whereas 8.8 acres were converted.

Wetland losses were also detected in two estuarine wetland types: emergent wetlands (salt and brackish marshes) and forested wetlands. The latter type represents former freshwater wetlands that are now periodically inundated by tidal salt water. About 20 acres of estuarine emergent wetlands were destroyed. Fifty-seven percent of that acreage was either excavated (8.1 acres) or impounded (3.1 acres). Residential development was responsible for 27 percent of these losses. During the 1980s, a total of 5.7 acres of estuarine forested wetlands became intertidal flats, presumably due to a combination of sea-level rise and Coastal Plain subsidence.

WETLAND TYPE CHANGES INDUCED BY TIMBER HARVEST

During the study decade, 484.2 acres of wetlands were impacted by forestry operations. Recently harvested forested wetlands totaled 325.3 acres. After timber cutting, this acreage became other wetland types (successional stages of forested wetlands). A total of 152.8 acres became successional emergent wetlands and 172.5 acres became successional scrub-shrub wetlands by 1992. These wetlands will likely return to forested wetlands in the next two decades.

Nearly 160 other wetland acres (158.9 acres) were affected by pre-1980 timber harvests. These wetlands represent former forested wetlands on the post-harvest successional trajectory to become forested wetlands. A total of 120 acres reverted to forested wetlands during the 1980s: 92.3 acres from successional stage shrub wetlands and 27.7 acres from successional-stage emergent wetlands. Nearly 40 acres (38.9 acres) of successional palustrine emergent wetland became scrub-shrub wetlands by 1992.

CHANGES IN FARMED WETLANDS

In the Inland Bays/Atlantic Ocean Basin, palustrine farmed wetlands experienced a net gain of 37.2 acres. This was the result of an increase of 62 acres coming from palustrine wetlands, combined with the loss of 24.8 acres. Most of this gain was at the expense of forested wetlands, as only 0.2 acres came from palustrine emergent wetlands. These losses were due to residential development (11.2 acres), pond construction (7.4 acres), feedlot construction (4.0 acres), farm buildings (2.0 acres), and palustrine emergent wetland (0.2 acres).

CHANGES ON NON-VEGETATED WETLANDS

During the study decade, there was an estimated net gain of nearly 300 acres in palustrine non-vegetated wetlands (ponds). Nearly 40 percent of the gain was from agricultural lands, with 23 percent alone coming from cropland (excluding farmed wetland). Nineteen percent of the gains came from palustrine vegetated wetlands. Only 10 acres of pre-existing ponds were filled.

Excerpted from Tiner and Schaller, 1999 equipment, cost-sharing benefits, and technical assistance for survey and design. A significant effort in the reconstruction of drainage channels took place after Public Law 566, known as "The Watershed Protection and Flood Protection Act," was passed in 1954.

Over 200 years of channel work has established a basic drainage system throughout the state. However, maintenance of these systems for most of this time was not formally addressed, and, at best, took place voluntarily. As a result, the condition of the channels has slowly deteriorated due to sediment accumulation and vegetation overgrowth in the channels, and obstruction caused by fallen trees.

2.4.7.2 Tax Ditch Organizations

In 1951, the Delaware General Assembly enacted the Delaware Drainage Law to establish ditch companies and to resolve related financial and maintenance issues. As an outgrowth of this Law, the Division of Soil and Water Conservation (the Division) is mandated to carry out a comprehensive drainage program through Title 7, *Del. Code,* Chapter 41 — Drainage of Lands: Tax Ditches.

A tax ditch is a governmental subdivision of the state. It is a watershed-based organization formed by a prescribed legal process in Superior Court. The organization is comprised of all landowners of a particular watershed or subwatershed.

Formation of a tax ditch can only be initiated by landowners that petition Superior Court to resolve drainage or flood protection concerns. Governmental agencies do not initiate the formation process. This petition action results in the Conservation District requesting an investigation by the Division to "determine whether the formation of the tax ditch is practicable and feasible, and is in the interest of the public health, safety and welfare." If so determined, the Conservation District files the petition in Superior Court, and a Board of Ditch Commissioners (as directed by the resident judge) prepares a report on the proposed tax ditch. This report contains all required information pursuant to Title 7, *Del. Code,* Chapter 41, and is the basis for a hearing held |for the affected landowners. At the conclusion of the hearing, a referendum is held for the landowners to approve or disapprove formation of the tax ditch. The Board of Ditch Commissioners files the results of the hearing and referendum in Superior Court, and the court holds a final hearing for any person to object to the formation of the tax ditch. Following the outcome of the final hearing, and if deemed appropriate, the Superior Court judge issues a court order establishing the tax ditch organization. The court order grants permanent rights-of-way to the tax ditch organization for construction and maintenance operations. It also empowers the organization with taxation authority to collect, from all affected land-owners, funds to perform this construction and maintenance. Taxation amounts (ditch assessment base) for individual properties are also established through the court order.

Ditch managers and a secretary/treasurer oversee operation of the tax ditch. These officers are landowners within the watershed and are elected at an annual meeting by the affected taxable property owners. To date, 289 individual tax ditch organizations have been formed throughout the state. These organizations range in size from the 56,000-acre Marshyhope Creek Tax Ditch to a 2-acre system in suburban Wilmington. These organizations manage over 2,000 miles of channels and provide direct or indirect benefits to approximately 100,000 people and almost one-half of the state-maintained roads. *Map 2.4-2 Drainage Ditch Areas* shows the extent of these organizations in the Inland Bays/Atlantic Ocean Basin.

Tax ditch channels range in size with an approximate width of 6 to 80 feet and depth of 2 to 14 feet. Size variation is due to the number of acres that drain to a particular site and the topography of the area. For example, channels constructed through higher areas will be deeper than those going through lower areas. Generally, the more acres served by a channel, the wider it will be. Additionally, the bottom "grade" of a channel and the degree of drainage required in an area will necessitate fluctuations in size.

Although tax ditches directly resolve many related drainage and flooding problems, their primary purpose is to establish channel outlets for drainage and flood protection. From these channel outlets, individual landowners can construct private channels for use in management of their lands, and for implementing various Best Management Practices (BMPs) for conservation.

Approximately 19 percent of the tax ditch organizations within the state are located in the Basin. Within the Basin, there are currently 44 tax ditch organizations containing approximately 920 miles of right-of-way established for tax ditch management. These channels provide drainage and flood protection for approximately 55,225 acres, or 26 percent of the Basin area. It is estimated that an additional 550 miles of private channels exist throughout the Basin.

Along with being locally managed, most of these organizations follow federally mandated operations and maintenance plans. The age of these organizations varies from 48 years old to the most recent, which is 2 years old. The older organizations routinely undergo vegetative maintenance and sediment dip-outs. The newer ones are now entering this phase. The condition of most of these channels is very good, although a few isolated organizations have not received adequate maintenance. In most of these isolated cases, negligence was mainly due to original landowners dying, and the influx of new landowners to the area. In most cases, these new landowners are simply unaware of the negative impact of a failing drainage system.

Currently, there are only several areas within the Basin where landowners have petitioned for the formation of a new tax ditch organization. Many (approximately 40) areas have been investigated to solve small individual drainage problems. These smaller problems will probably be resolved through the public ditch program.

In addition to tax ditch requests, the Division of Soil and Water Conservation's Drainage Section also responds to requests (mostly from legislators) for public ditches. Public ditches are generally smaller drainage systems that involve only a few mutually cooperative landowners. In the case of public ditches, landowners voluntarily grant temporary construction easements, usually to a conservation district or a town/city. There are no provisions for perpetual maintenance by an organized group. The public ditches are planned utilizing the same BMPs used for tax ditches, constructed, and then left to the individual landowners' responsibility for future maintenance. Many isolated drainage problems have been resolved in the Inland Bays/ Atlantic Ocean Basin utilizing this one-shot approach.

2.4.7.3 Environmental Concerns/Mitigation

The Division of Soil and Water Conservation's Drainage Section is responsible for the formation, construction, and maintenance of Group Drainage Associations' tax ditches and public ditches. Historically, the planning and construction of water management systems has been accomplished with only administrative considerations from governmental agencies. The traditional program was a single-purpose program — drainage. Little consideration was given to environmental issues such as habitat or wetlands. As Delaware addressed evident environmental concerns related to industrial and municipal discharges, development, and other areas, the environmental focus eventually progressed beyond these areas to other activities now recognized as also having potentially "significant environmental impacts." Drainage of lands through tax ditches is one such activity.

The most significant environmental impact from channel construction is the fill and drainage of forested wetlands. Fill results from clearing operations and disposal of excavated materials. Drainage occurs when wetland areas are not protected from surface flow into the channel. Loss or alteration of these wetlands is compensated through the creation or restoration of freshwater wetlands, usually in marginal agricultural fields.

The regulatory community, along with various environmental groups and affected communities, began to question the potential impacts these projects were having on natural resources. For example, interpretation of the Army Corps of Engineers and state wetland regulations became a frequent, ongoing process used by these groups in an attempt to halt or minimize projects. Regulatory exemption requirements for channel construction were tightened, and wetland/habitat mitigation was more frequently required.

In response to these environmental concerns and issues, changes in the water management program were initiated. For the past 10 years, numerous governmental agencies have performed a rigorous review process out of which comments are incorporated into related project plans. Further, Governor Castle's Executive Order No. 56 mandated that state agencies achieve projects with a no-net loss of wetlands. It is now recognized that natural resource impacts resulting from the reconstruction of drainage systems can and should be minimized. Weighing wetland concerns against drainage benefits, prior to reconstruction of deteriorated channels, has resulted in changes in procedures for selecting which channels to work on and in methods for performing such work. Ideally, these changes ensure that environmental impacts are minimized, or at least compensated for when deemed unavoidable. Implementation of this process over the last 10 years has resulted in development of a detailed list of proven environmental practices that minimize impacts. This list evolved into the Delaware Tax Ditch Best Management Practices (BMPs). Resource managers and planners on all water management projects routinely employ the BMPs. Some of the more significant practices include the following:

- Minimize clearing widths;
- Relocate channels around sensitive areas;
- Perform only one-sided construction;
- Save trees within construction zone;
- Minimize construction of downstream outlets;
- Install berm along wetlands with side inlet pipes at or above biological benchmarks; and,
- Block off old channels that drain only wetland areas.

To complement this effort, the Drainage Section has held wetland/environmental training sessions for both technical and administrative staff members. During the past 10 years, adherence to planning principles, policies and conservation management practices has minimized environmental impacts and provided long-term economic and environmental stability.

The Drainage Section also has carried out several projects to test new construction techniques and has established demonstration/education sites. Most of the channel construction techniques emphasize minimal clearing and spoil disposal. The demonstration/education sites incorporate these new construction techniques with wetland restoration in adjacent agricultural fields. Several demonstration projects have been performed statewide and have effectively shown that drainage and environmental quality do not have to be mutually exclusive. In addition, drainage channels essentially link upland farms, cities, industrial sites, and other land uses, to receiving bodies of water.

Although channels themselves produce very little nutrients or sediment, they do represent the primary transport mechanism for these parameters.

Sediment load in drainage channels usually represents a short-term problem that occurs during reconstruction or maintenance events. Once stabilized, within six months to one year after such an event, channels discharge minimal amounts of sediment and actually act as sediment traps as vegetative growth eventually covers the channel bottoms and side slopes. These short-term sediment load problems can be lessened if sediment traps and water-control structures are added. Such practices slow water flow and provide areas for sedimentation and nutrient uptake by plants.

However, when water-control structures are used, a concern exists that phosphorus tied to the sediment trapped upstream of these structures may be re-suspended through saturation. Current studies by the University of Delaware on this potential problem are nearing conclusion.

Resolution of nutrient problems within the Basin will hinge on controlling and managing the source of these nutrients through effective use of BMPs for land management in cities, agricultural fields, rural areas, and industrial sites. For drainage channels themselves, increased usage of current and new BMPs for tax ditch construction and maintenance will assist in reducing sediments delivered by drainage channels.

Once tax ditch channels are constructed, maintenance is the primary function of each individual tax ditch organization. Maintenance consists of the routine control of vegetation within the rights-of-way and the periodic removal of accumulated sediment in the channel bottom. Control of woody vegetation adjacent to and within the channel is needed to retain access to the channel for future dip-outs of sediment. Rotary mowers and boom-arm mowers have replaced the use of bush axes and other traditional hand-labor methods. Unfortunately, mowing machines are not selective, and cut all vegetation, including shrubs and grasses that are desirable for wildlife habitat. Mowing is generally performed every other year on established channels.

The Drainage Section and Conservation Districts continually search for viable alternative methods for maintenance. Several attempts have been made to establish vegetative maintenance programs utilizing herbicide application. This method, which decreases maintenance frequency and promotes growth of desirable species, has had varying degrees of success and acceptance by the tax ditch community. Recent experimental attempts include the use of a "weed wiper bar." This machine applies herbicides to targeted species by a wiping bar and leaves most desirable species untouched.

An alternative to controlling vegetation along rights-of-way for dip-out purposes is to allow trees to fully grow in the channel and along the accessway. This alternative presents a serious access problem every 15 to 20 years when sediment needs to be removed. The channel and accessway would have to be stripped of this large vegetation, with resultant significant soil disturbance and erosion. By contrast, maintaining vegetation at desired levels, specifically, at heights and densities where dip-outs can readily be performed, is a more preferred method, as minimal channel disturbance occurs during dip-out. As practicable alternative techniques for maintenance are developed, they are slowly incorporated into tax ditch maintenance plans through educational and promotional efforts.

In pursuing further innovations, the Drainage Section has become increasingly involved in David Rosgen's "Geomorphic" approach to streambank restoration and channelization. Geomorphic design concepts are based on the evaluation of local/regional streams to measure natural characteristics that promote channel stabilization. Where applicable, these natural characteristics are integrated into tax ditch channel designs. A demonstration project utilizing these concepts has been implemented as part of the Pratt Farm Water Management project. In this project, a floodplain and sinuous low-flow channel were constructed in a marginal agricultural field to replace the historic straight channel. This geomorphic approach will require special conditions and very receptive landowners to be successful. The Drainage Section will continue to develop data for use in this initiative as opportunities arise.

2.4.8 REGULATORY PROGRAMS FOR PROTECTION OF AQUATIC AND WETLAND RESOURCES

There are several federal and state laws designed to protect the water resources and wetlands of Delaware. The most significant statutes at the federal level include the Rivers and Harbors Act of 1899 and the Clean Water Act of 1976. The most significant state laws are the Wetlands Act of 1973 and Subaqueous Lands Act of 1969. The U.S. Army Corps of Engineers administers the federal laws. The Wetlands and Subaqueous Lands Section of the Department's Division of Water Resources administers the state laws. Although there are some jurisdictional differences between the federal and state programs, the Corps of Engineers and the Wetlands and Subaqueous Lands Section coordinate their programs to minimize overlapping authority. Additionally, the Wetlands and Subaqueous Lands Section has assumed authority for certain jurisdictional functions formally handled by the Corps of Engineers. Both agencies have developed expedited procedures for reviewing projects under their jurisdiction.

2.4.8.1 Wetlands Act

Since 1973, the "Wetlands Act" (7 *Del. C.* Chapter 66) has been effective in conserving Delaware's remaining tidal wetlands. The act and the regulations written pursuant to the law regulate activities in wetlands defined as:

> "Those lands above the mean low water elevation including any bank, marsh, swamp, meadow, flat or other low land subject to tidal action in the state along the Delaware Bay and Delaware River, Indian River Bay, Rehoboth Bay, Little and Big Assawoman Bays, the coastal inland waterways, or along any inlet, estuary or tributary waterway or any portion thereof, including those areas which are now or in this century have been connected to tidal waters, whose surface is at or below an elevation of 2 feet above local mean high water, and upon which may grow or is capable of growing any but not necessarily all of the following plants: [list of plants] and those lands not currently used for agricultural purposes containing 400 acres or more of contiguous non-tidal swamp, bog, muck or marsh exclusive of narrow stream valleys where fresh water stands most, if not all, of the time due to high water table, which contribute significantly to ground water recharge, and which would require intensive artificial drainage using equipment such as pumping stations, drain fields or ditches for the production of agricultural crops."

Tidal wetlands jurisdiction is determined based on aerial photo-interpretive identification of specified vegetation, and topography, and is depicted on regulatory maps. These maps are for public use to determine whether an area is a state-regulated wetland. The Wetland Act essentially regulates wetlands that have been subject to tidal inundation in the past century; hence, it is commonly referred to as the "tidal" wetlands law.

Under a concurrent review process with the U.S. Army Corps of Engineers, and regulatory oversight provided by the U.S. Environmental Protection Agency under the Clean Water Act, the state requires a permit for any non-exempt activity. A non-exempt activity may include, but is not limited to, dredging, filling, construction of a pier, jetty, breakwater, or boat ramp, mining, or drilling — in a state-mapped wetland. Proposed activities are evaluated in consideration of environmental, aesthetic, economic, and cumulative impacts. The Department's Wetlands and Subaqueous Lands Section issue permits. Any proposed permit must be consistent with the respective county zoning ordinances. State, county, and municipal comprehensive plans guiding development, conservation, and economic effect also are considered. All applications are public-noticed, and meritorious complaints are resolved prior to issuance of a permit.

Projects and activities exempted from the permit requirement include mosquito control activities authorized by the Department, construction of directional aids to navigation, duck blinds, foot bridges, boundary stakes, wildlife nesting structures, grazing of domestic animals, haying, hunting, fishing, and trapping. Although not explicitly cited in the law or regulations, the creation, restoration, or enhancement of compensatory wetlands may be required to mitigate wetland impacts due to public works projects, such as those of the Delaware Department of Transportation.

Since passage of the Wetlands Act, the loss rate of tidal wetlands has been greatly reduced. From 1995 through 1996, less than one acre of tidal wetlands was permanently displaced under the permitting process.

2.4.8.2 Freshwater Wetlands Act

Currently, the State of Delaware does not have a regulatory mechanism for protecting non-tidal wetlands. In the early 1990s, the Department developed the "Freshwater Wetlands Act" (subsequently referred to as Substitute Senate Bill 248), to enable the state to regulate non-tidal wetlands. This legislation sought to achieve no-net loss of non-tidal wetlands by acreage and function; to provide greater protection of the state's higher-value wetlands; and to reduce the regulatory burden to the public through improved predictability, flexibility, and responsiveness. This participatory legislative process gained the support of the vast majority of the state's constituent groups but did not pass the legislature. However, the process did provide the affected stakeholders with information on how to approach wetlands protection through alternative regulatory and non-regulatory means. Further protection should be supplied from the counties, which may incorporate freshwater wetland programs into their land-use planning processes and ordinances.

2.4.8.3 Clean Water Act

The federal government through Sections 404 and 401 of the Clean Water Act provides current regulatory oversight of non-tidal wetlands. The U.S. Army Corps of Engineers (the Corps), Philadelphia District, administers the federal regulatory program. Authorization is required for the placement of "dredge and fill" material in wetlands and other "waters of the state." An individual permit is required for projects involving significant potential impacts to wetlands. These types of projects involve mitigation of the impact with oversight provided by federal and state agencies. For the purposes of the 1972 Clean Water Act, *mitigation* is defined as:

- Avoiding the impact altogether by not taking a certain action or parts of an action;
- Minimizing impacts by limiting the degree or magnitude of the action and its implications;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
- Compensating for the impact by replacing or providing substitute resources or environment (40 Certified Federal Registry 1508.20).

Section 401 of the Clean Water Act allows for broadened oversight of the Corps' "dredge and fill" program by the states, as well as providing a scientific basis for permit review. This law requires states to certify that the issuance of a Corps' individual permit will not degrade "waters of the state," including wetlands. Individual states have the prerogative to deny, certify, or issue with condition, individual and nationwide Corps permits based on potential impacts of the project to water quality. Water quality, and coastal zone management consistency certificates, are issued on a case-by-case basis for individual Corps permits.

These and other provisions of the Clean Water Act of 1972 are believed to have slowed the loss rate of freshwater, non-tidal wetlands. However, cumulative losses of wetlands and wetland functions continue due to increasing development pressures, inadequate regulatory programs, gaps in the understanding of the science, and lack of resource management actions.

2.4.8.4 Rivers and Harbors Act of 1899

The Rivers and Harbors Act of 1899 regulates activities in navigable waters of the United States. *Navigable waters* are defined in Delaware as all tidal waters and their tributaries to the head of the tide. In tidal waters, the shore boundary extends to the mean high-water line. In non-tidal waters, the shore boundary extends to the ordinary high water line. The Act applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or other modifications to a navigable waterway. The Act also applies to construction of structures including, but not limited to, docks, piers, jetties, groins, weirs, breakwaters, shoreline protection structures (e.g., riprap revetments or bulkheads), pilings, aerial or subaqueous utility crossings, intake or outfall pipes, boat ramps, or navigational aids.

2.4.8.5 Subaqueous Lands Act

The Department's Division of Water Resources, Wetlands and Subaqueous Lands Section regulates subaqueous lands, which include streams, ponds, and other waterways. (7 *Del. Code,* Chapter 72). The stated purpose of the Subaqueous Lands Act, and the regulations written pursuant to the law, is to protect subaqueous lands against uses or changes which may impair the public interest in the use of tidal or navigable waters. The Regulations Governing the Use of Subaqueous Lands stipulate that no activity may be undertaken that might contribute to the pollution of public waters, adversely impact or destroy aquatic habitats, or infringe upon the rights of public or private owners.

Subaqueous lands are defined as "submerged lands and tidelands" (including the deep-water habitats mentioned earlier which often involve wetland habitats). A permit is required for the placement of a structure, or for a non-exempt regulated activity — including dredging, draining, or filling, and construction of any kind — in or over public or private subaqueous land. The regulations further specify the requirements for constructing boat-docking facilities, shoreline erosion control measures, and activities involving dredging, filling, excavating, or extracting materials in public and privately owned subaqueous lands. Applications for permits are put on public notice to solicit public input. A joint application process is coordinated with the U.S. Army Corps of Engineers to meet federal mandates.

This act provides state regulatory oversight for activities in jurisdictional Delaware waters, as depicted on U.S. Geological Survey 7.5-Minute Series (Topographic) Quadrangle maps. In addition, the Division of Fish and Wildlife manages certain mill ponds for freshwater fisheries. A "pond policy" guides the decision-making process in providing comments on subaqueous lands permit applications for structures and activities in mill ponds that may be deemed incompatible with fisheries management practices.

To expedite the permitting process, a system of statewide activity approvals has been developed by the Wetlands and Subaqueous Lands Section. The statewide activity approvals provide an abbreviated review process and authorization for relatively small projects. Applicable projects range from docks or riprap revetments in artificial lagoons, to placement of utility lines across streams. Repair and replacement of existing structures is also handled by an abbreviated review process and follow-up Letter of Authorization.

2.4.9 DELINEATION MANUALS

In 1992, the National Science Foundation recognized a dichotomy regarding wetlands. From a scientific standpoint, wetlands are transitional areas between terrestrial and open water systems. From a legal standpoint, wetlands are discrete units subject to regulatory jurisdiction. Natural wetlands diversity, nationally and within Delaware, complicates the determination of what constitutes a wetland. The federal regulatory definition of wetlands incorporates the three characteristics discussed previously as technical criteria for determining federal wetlands jurisdiction. The identification and delineation of wetlands also rely on the use of field indicators, or conditions occurring in wetlands that help in establishing technical criteria. Both the regulatory and the scientific community recognize the interdependence of hydrophytic vegetation, hydric soils, and wetland hydrology (National Research Council, 1995).

Modifications to the *1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (1989 Manual*)*, by which federal agencies identify wetlands, were proposed by the Bush Administration in 1991. The Administration stated that the *1989 Manual* erroneously expanded the scope of protected wetlands to areas that were insufficiently wet. A proposed *1991 Manual,* as published in the *Federal Register,* would have:

- ◆ Required that an area be continuously saturated with water for 21 days or inundated for 15 days to be a wetland;
- ◆ Required that saturation occur not just in the root zone of the plants but at the surface;
- ◆ Constricted the time in which this wetness is measured to the hotter, and generally drier, months;
- ◆ Required strict proof of the degree and period of wetness; and
- ◆ Excluded certain vegetation and soil types.

In cooperation with state, regional, and national scientists, the Environmental Defense Fund and the World Wildlife Fund analyzed the previous delineation manual(s) and the proposed 1991 revision. Their 1992 report assessed the environmental significance of the proposed revisions from a national perspective and also upon particular ecosystems and deduced:

> "A loss of wetlands excluded by the proposed manual would have severe environmental and economic impacts. The 1989 Manual did not, in fact, cause a large expansion in areas considered wetlands. The proposed changes are based on fundamentally inaccurate conceptions of how wetlands function and how they are identified."

An estimated 50 million acres (roughly 50 percent) of United States wetlands would have been excluded from federal protection under the proposed revisions. A key criticism of the revised manual was that many wetlands that would be excluded are flooded frequently, but not continuously for 15 days. Wetlands saturated inches below the surface throughout most of the year but rarely, if ever, flooded at the surface, and wetlands flooded consistently, but only in winter, would have been excluded. Other wetlands that are inundated for the required period would be excluded because the revised manual would not have allowed the utilization of certain indicators to prove the required inundation in most years.

The policy-versus-science controversy evidenced by the proposed revisions to the *1989 Manual* should be considered during future wetland regulation and management efforts. It is not unlikely that such policy changes could occur in the future. Therefore, it is necessary that wetland restoration and compensation guidelines development be flexible enough to incorporate changes that will not only maximize the ecological and physical nature of wetland systems, but also reflect the regulatory and jurisdictional elements likely to be charged with the protection of these systems. Such administrative changes could occur on the national level or could result from programmatic changes at the state level.

The inter-relatedness of wetland ecological characteristics is significant for wetland identification in areas where one or more hydrologic indicators is missing due to seasonal variations in surface water or ground water, or due to problematic soils or vegetation. Other floodplain soils may be hydric but lack hysoil indicators, making wetland identification and delineation problematic.

A difficulty in non-tidal wetland assessments in the Inland Bays/Atlantic Ocean Basin is determining whether wetland hydrology is still present after the substantial channelization that has taken place and which continues to take place. Areas with sufficient ground-water discharge (seeps) may lack sufficient surface-water indicators. For surface-water-driven wetlands, historical stream gauge data collected by the U.S. Geological Survey for calculating flood frequency and duration may be irrelevant in light of the rate of recent upstream watershed development. The difficulty of identifying and delineating problematic wetlands is significant given the lack of state non-tidal wetlands legislation, existing deficiencies in the federal regulatory program, and gaps in the protection of all riparian areas through county floodplain ordinances.

2.4.10 POSITIVE INITIATIVES

To preserve the integrity of Delaware's wetlands, several measures have been taken by the Department. These efforts are described below.

2.4.10.1 Identification and Characterization of Unique Wetland Ecosystems

As part of a freshwater wetlands legislative and program development initiative conducted between 1990 and 1994, the Department characterized six wetland ecosystems considered to represent wetlands of highest functions and values. They include Coastal Plain ponds (Delmarva bays), interdunal wetlands, Atlantic white cedar wetlands, bald cypress wetlands, Piedmont stream valley wetlands, and sea-level fens. These characterizations provide detailed information based on field surveys and literature review on wetland plant community profiles, associated ecological factors, and locations. Of these six rare and unique wetland ecosystems, all but the Piedmont stream valley wetlands are found in the Inland Bays/Atlantic Ocean Basin. Two of Delaware's most threatened wetland types, interdunal wetlands and acidic sea-level fens, are unique to the Basin.

2.4.10.2 Remote Sensing/GIS Methodologies of Non-Tidal Wetlands Restoration

Wetlands compensatory mitigation may include the enhancement of existing wetlands, the restoration of former wetlands that have been converted to non-wetlands, the creation of wetlands from previously non-wetland areas, or the preservation of existing wetlands. Of those mitigation procedures, wetlands restoration and wetlands creation are most consistent with stated federal and state goals of both areal no-net loss of wetlands functions and values (The Conservation Foundation, 1988). The primary difficulty in successfully creating these two types of wetland establishments is associated with the pre-identification of sites that exhibit the requisite characteristics. This study includes efforts by the Department to identify a wetlands restoration siting methodology that would advance Delaware's goal to meet federal and state wetlands compensatory mitigation mandates. Appropriately sited and successful wetlands restoration projects can protect or rehabilitate watersheds where wetlands resources are lacking due to historical degradation or conversation.

2.4.10.3 Restoration/Creation/Enhancement and Compensation Banking Criteria

This report reflects the collection, review, and evaluation of literature on the wetlands restoration science with respect to natural resources and regulatory management. Delaware's wetlands resource base continues to decline, increasing the need to initiate actions that re-establish or expand wetlands area or functions. Three general approaches to (re)establishing wetlands are recognized:

- Wetlands Creation — involves the establishment of wetlands at a site where wetlands did not historically exist;
- Wetlands Enhancement — involves the net increase of wetlands function within an existing wetland; and
- Wetlands Restoration — involves the re-establishment of wetlands at a site where wetlands historically existed but were subsequently lost.

Wetlands restoration seeks to rehabilitate damaged wetlands systems as a means to reverse historical or anticipated future losses. In principle, effective and efficient restoration ecology may:

- return functioning wetlands to sites where wetlands previously existed;
- help maintain existing genetic integrity by protecting endangered or threatened species from extinction due to habitat loss;
- reduce recreational and commercial pressure on more pristine ecosystems by providing alternative areas that my be more suitable but less sensitive;
- slow or reverse destruction processes to allow time over which societal adjustments can occur; and,
- educate the public as to the costs of restoration and the true costs of environmental destruction.

Thus, effective wetlands restoration may slow the rate of, and decrease the net impact of wetlands loss provided that sustainable-use practices can be sufficiently and expeditiously developed. Social and political recognition must be given to ecosystem services that may not be restored more quickly than those services can be expended.

Compensatory mitigation involves the creation, restoration, enhancement, and preservation of wetlands to compensate for unavoidable adverse wetlands impacts. More specifically, compensatory mitigation banking involves these practices to mitigate adverse wetlands impacts associated with anticipated regulated activities. Compensatory mitigation banking, or "compensation banking," differs from most wetlands compensation projects in that it is established by agencies, non-profit organizations, or private entities. Compensation banks usually provide a relatively large site to be used to collectively compensate, in advance, for one or more projects affecting wetlands. In contrast, individual wetlands compensation projects commonly involve restoration, creation, or enhancement activities concurrent with, or subsequent to, the permitted wetlands impacts (DNREC Delaware Freshwater Wetlands Restoration, 1992).

2.4.10.4 Legislative and Regulatory Initiatives

Despite public outreach and participatory effort with stakeholders and special interest groups, the Department has been unsuccessful in passing the Freshwater Wetlands Act. There is presently no state regulatory oversight for freshwater, non-tidal wetlands.

At the federal level, the U.S. Army Corps of Engineers general permits or nationwide permits are issued for similar classes of activities that result in impacts considered to be either individually or cumulatively minimal on wetland functions, water quality, or the aquatic environment. Nationwide Permit 26, for example, allows discharges of up to 10 acres of fill to headwater and isolated wetlands. (A predischarge notification is required for fills between 1 and 10 acres.)

Site-specific wetland functional assessment studies have been conducted to apply and compare scientific wetlands assessment techniques, including Best Professional Judgment, to wetlands within various landscape positions. These studies indicate that above-headwater wetlands may demonstrate high functionality across the scope of wetland functions. Additionally, although considered to be of minimal impact, case studies on the effects of Nationwide Permit 26 in other states have found off-site impacts to fish and wildlife habitat in most cases. In Delaware, lack of state legislation and deficiencies in the federal regulatory program pose a particular threat to unique wetland ecosystems of less than 1 acre and to headwater wetlands of high functionality.

Section 401 of the Clean Water Act allows for states to strengthen the U.S. Army Corps of Engineers' "dredge and fill" program through certifying that permit actions will not adversely impact wetlands, surface-water quality, or aquatic ecosystems. Delaware issues water-quality certifications for individual U.S. Army Corps of Engineers permits on a case-by-case basis. However, the state has, to date, chosen to waive water-quality certification for nationwide permits.

Delaware's Subaqueous Lands Act does not adequately protect non-tidal rivers, streams, and ponds/lakes. State jurisdiction is based on a legal interpretation of "navigability," which is determined by the depiction of the waterway as a blue line on a U.S. Geological Survey topographic map. This excludes many headwater streams and associated riparian wetlands that are intermittent but provide important water-quality and habitat functions, while including many ditches that were not intended to be regulated under the Act. Nonetheless, the lack of scientific and regulatory oversight for the dredging and/or channelization of streams (or ditches, for that matter) conducted for flood control may directly or indirectly adversely impact associated riparian wetlands. The Subaqueous Lands Act lacks a buffer provision, allowing indirect and cumulative impacts to aquatic systems, including wetlands, from construction projects.

2.4.10.5 Comprehensive Conservation and Management for Non-Tidal Wetlands

A parallel and requisite component of the Freshwater Wetlands Act was to be the development and implementation of a Comprehensive Conservation and Management Plan (CCMP) for non-tidal wetlands. Intended to be one component of that comprehensive legislative initiative, the absence of its enabling statute and associated regulations necessitated that this plan instead become a major umbrella under which various non-regulatory approaches could be developed and implemented.

The chief objective of the CCMP is to identify all potential tools, mechanisms, and participants available to achieve freshwater, non-tidal wetlands conservation. Major CCMP components address wetland acquisition strategies, voluntary wetland rehabilitation measures, compensatory mitigation instruments, and means by which to build community support. This approach necessarily involves coordination with other state, county, and federal agencies, as well as private non-profit entities. Currently under development by the Division of Water Resources' Watershed Assessment Section, the CCMP is organized into the following focus areas:

- Inventory of the resource/status and trends;
- Laws and regulations;
- Land protection;
- Land-use planning;
- Research initiatives/status of the science;
- Restoration/creation/enhancement and compensation banking;
- Building support/education; and
- Technical assistance.

The developing plan includes parallel projects integral to the overall planning effort, from refinement in the characterization of the wetland plant communities to mapping Delaware wetland resource base to evaluating methodologies for wetlands restoration siting.

2.4.10.6 Statewide Wetlands Mapping Project

The Statewide Wetlands Mapping Project provides recent statewide estimates of wetland acreage by wetland type. Based on the previous mapping project conducted by the National Wetlands Inventory, the Statewide Wetlands Mapping Project employs a state-modified classification scheme (modified Cowardin, et al., 1979) to further characterize wetland resources. Larger-scale, rectified aerial photography, smaller minimum mapping units, and the depiction of wetlands that possess Category I wetland characteristics more accurately detail the location, extent, and character of Delaware's wetland resources in both hard copy (mylar) and soft copy (computerized) formats. Geographic Information System analyses of the digital wetlands data allow for wetland type and acreage analyses for the Inland Bays/Atlantic Ocean, as well as statewide. Further, completion of the Statewide Wetlands Mapping Project enables projects such as the recent wetlands trends study and the wetlands aerial mapping/tracking methodology described below.

2.4.10.7 Wetland Trends Study

A wetlands trend study is being undertaken through a Memorandum of Understanding with the U.S. Fish and Wildlife Service. Using maps generated through the Statewide Wetlands Mapping Project, the recent trends study determines the type, location, and cause of lost wetland acreage by Basin from 1982 to 1992.

2.4.10.8 Reference Wetlands and Hydrogeomorphic Classification

An ongoing national research initiative is seeking to classify wetlands based on principles of hydrogeology (Brinson, 1993). A classification system based on the position of wetlands in the landscape will provide information on the source, direction, and hydrodynamics of water movement within a hydrogeomorphic class. The Hydrogeomorphic Approach to Functional Assessment identifies five wetland classes: riverine, depressional, slope, fringe, and flats.

Functional assessment models have been developed for each wetland class and for specific wetland functions. In principle, each hydrogeomorphic class and set of functional models must be modified to meet regional conditions. This is achieved through case studies to identify hydrogeomorphic subclasses and differences in regional functional variables. The models are then scaled to regional hydrogeomorphic conditions through the use of reference wetlands. An interagency federal/state work group for the riverine wetland class in the Coastal Plain Province of the Mid-Atlantic region has developed a case study. Delaware is participating in this study to identify riverine hydrogeomorphic subclasses and to select appropriate reference wetland sites within the state.

The Department's Division of Water Resources, Watershed Assessment Section, is undertaking a study to provide baseline data on the ecological integrity of non-tidal wetland functions. To coordinate with other restoration initiatives, the St. Jones watershed has been selected as the particular watershed in which reference wetlands would be chosen using a hydrogeomorphic approach. Knowledge gleaned from this pilot Coastal Plain study should be useful in the design of wetlands monitoring studies for the Inland Bays/Atlantic Ocean Basin.

2.4.10.9 Wetlands Compensatory Mitigation and Mitigation Banking

Compensatory mitigation banking remains a relatively new regulatory concept that has gained increased attention by federal, state, and local governments as a wetland management strategy due, in part, to evidence that individual wetland restoration, creation, and enhancement projects may not adequately compensate for permitted wetlands impacts. Caution is still warranted in the use of mitigation banking as a conservation measure due to the lack of quantitatively and qualitatively identifiable successes among the relatively few existing mitigation banks. However, the current difficulty in predictably establishing, monitoring, and evaluating mitigation banks should be weighed in consideration of the same difficulties associated with individual (non-banking) compensatory mitigation projects.

To date, mitigation banking program design and implementation have generally necessitated the investment of substantial expertise, financial resources, time, and property. An objective of a recent Division of Water Resources effort has been to identify the situations where mitigation banking — employing wetlands restoration, creation, enhancement, and preservation — can be used to effectuate non-tidal wetland conservation in Delaware. The Department recognizes that efficiency and expediency in the development and implementation of effective resource and compensatory mitigation programs will benefit both the regulated community and the natural resource. These sentiments are echoed by interested and involved Delaware resource management agencies such as the Department of Agriculture and the Natural Resource Conservation Service. To the greatest extent possible, compensation banking should be undertaken to meet multiple environmental objectives and should consider local, statewide, and regional goals, as well as Basin-wide goals.

2.4.10.10 Effectuation of Interagency Mitigation Banking Agreement

The Division of Water Resources has developed a draft interagency mitigation banking agreement (the Wetlands Compensatory Mitigation Banking Agreement for the State of Delaware) for the purposes of enabling wetlands banking in Delaware. The agreement effectively and efficiently expedites and encourages wetlands banking as a compensatory mitigation instrument to mitigate unavoidable impacts to waters of the United States, including wetlands, resulting from projects occurring within Delaware. The wetland banking agreement is a means of ensuring that the wetland banking program will be consistent with existing federal and state regulatory programs. The agreement will also facilitate comprehensive natural resource management by integrating wetlands compensation into other watershed protection and management programs, such as Whole Basin Management.

2.4.10.11 Wetlands Restoration in Critical Watersheds

Another facet of wetlands restoration is the identification of watersheds, or Basins, in which wetlands restoration is needed. The Watershed Assessment Section is currently undertaking a study to identify critical Basins and watersheds, based on past and current federal permit activity in non-tidal wetlands. The goal of this study is to locate critical watersheds in which restoration is needed and for which compensatory mitigation is (or will likely be) required. Thus, compensatory mitigation banks may be sited to improve the ecological health of a watershed while facilitating the compensation process. Additional information on the identification of critical watersheds or Basins may also be gained from the wetlands trends study (described above).

2.4.11 DATA GAPS AND RECOMMENDATIONS

1. Develop Best Management Practices and an accompanying manual that promotes riparian buffers to help trap nutrients and improve water quality in both channelized and natural streams.
2. Educate the agricultural community and other people affected by ditching that drainage and wetlands habitat can coexist if managed properly.

3. Finalize products of the Department's Comprehensive Tax Ditch Committee.

4. Implement environmentally friendly ditch construction and maintenance practices. Establish more cost-sharing money in Sussex County to provide incentives for environmentally friendly ditch maintenance (including wiper bar technology). Tie maintenance cost-share money to environmentally friendly maintenance practices.

5. The tax ditch program should be used for existing land uses, not land conversions. Require the inclusion of a poor drainage disclosure on real-estate transactions.

6. Provide financial incentives for water-control structures, and investigate other methods of slowing down water.

7. Implement demonstration projects to convert marginal agricultural lands to freshwater wetlands.

8. Develop a manual of environmentally friendly ditch construction and maintenance practices.

9. Implement a demonstration project on a tax ditch system utilizing riparian buffers.

10. Develop a GIS coverage of ditches utilizing environmentally friendly construction and maintenance practices.

11. Promote the acquisition and protection of wetlands and natural heritage sites.

12. Adopt department-wide comprehensive wetland plan.

13. Restrict placement of docks, piers, and ramps in dead-end canals.

14. All efforts should be made to limit further human disturbance of Delaware's remaining coastal plain ponds. Research should be initiated to gain a better understanding of the geological origins and hydrological dynamics of Delaware's coastal plain ponds. Additional inventories are needed to fully assess the presence of rare plant and animal species.

15. Adopt statewide wetland mitigation policy. Include the concept of "Land Banking."

16. Amend subaqueous land statute to go beyond high-water line by 50 feet. *Lead Agency: General Assembly.*

17. As reservoirs of rare species in Delaware, every effort should be taken protect the integrity of interdunal swale wetlands.

18. The Statewide Wetlands Mapping Project data should be compared with the Natural Heritage Inventory to identify areas where additional research and/or protection are needed.

19. Promote the establishment of forested wetlands and upland forest to supplement and/or restore natural riparian buffers.

2.4.12 REFERENCES

Andres, A. S. 1987. *Geohydrology of the Northern Coastal Area, Delaware*. Delaware Geological Survey Hydrologic Map Series No. 5, Scale 1:24,000.

Brinson, M. M. 1988. "Strategies for Assessing the Cumulative Effects of Wetland Alteration on Water Quality." *Environmental Management* 12(5):655–662.

Brinson, M. M. 1991. *Functions and Values of "Drier Wetlands*. Presentation at an invitational workshop on state wetland regulations, Wilmington, DE.

Broome, S. W. 1990. "Creation and Restoration of Tidal Wetlands of the Southeastern United States." In *Wetland Creation and Restoration: The Status of the Science,* eds. J. A. Kusler and M. E. Kentula, pp. 37–72. Washington: DC: Island Press.

Chabreck, R. H. 1990. "Creation, Restoration and Enhancement of Marshes of the Northeastern Gulf Coast." In *Wetland Creation and Restoration: The Status of the Science,* eds. J. A. Kusler and M. E. Kentula, pp. 125–142. Washington, DC: Island Press.

Clancy, K. 1993. "A Preliminary Classification of the Natural Communities of Delaware." Unpublished document. Dover, DE: DNREC Division of Parks and Recreation, Delaware Natural Heritage Inventory.

Clancy, K. 1995. *Vegetation Structure and Composition: Guidelines for Wetlands Mitigation Project Plans.* Submitted to Wetlands and Subaqueous Lands Section, Division of Water Resources, DNREC.

Clancy, K., and W. McAvoy. 1994. *Preliminary Natural Community Studies of Potential Category Wetland Types in Delaware: Sea-Level Fens and Piedmont Stream Valley Wetlands.* Submitted to the Division of Water Resources, DNREC.

Clewell, A. F., and R. Lea. 1990. Creation and Restoration of Forested Wetland Vegetation in the Southeastern United States. In *Wetland Creation and Restoration: The Status of the Science,* eds. J. A. Kusler and M. E. Kentula, pp. 195–231. Washington, DC: Island Press.

Conservation Foundation. 1988. *Protecting America's Wetlands: An Action Agenda.* Recommendations of the National Wetlands Policy Forum. Washington, DC: The Conservation Foundation.

Cowardin, L. M., Virginia Carter, F. C. Golet, and E. T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Fish and Wildlife Service Report FWS/OBS — 79/31.

Dahl, T. E. 1990. *Wetlands — Losses in the United States, 1780s to 1980s.* Washington, DC: U.S. Fish and Wildlife Service Report to Congress.

_______. 1987. *Mid-Atlantic Wetlands — A disappearing Natural Treasure.* Newton Corner, MA: U.S. Fish and Wildlife Service and U.S. EPA Cooperative Publication.

Delaware Dept. of Natural Resources and Environmental Control. 1992. *Delaware's Freshwater Wetlands: Restoration, Creation, Enhancement, and Compensation Banking.* Dover: DNREC.

Delaware Natural Heritage Program. 1995. "Unpublished Biological Database." DNREC Div. of Fish and Wildlife.

Erwin, K. L. 1990. "Freshwater Marsh Creation and Restoration in the Southeast." In *Wetland Creation and Restoration: The Status of the Science,* eds. J. A. Kusler and M. E. Kentula, pp. 233–265. Washington, DC: Island Press.

Garbisch, E. W. 1989. "Wetland Enhancement, Restoration, and Construction." In *Wetlands Ecology and Conservation: Emphasis in Pennsylvania,* eds. S. K. Majumdar, R. P. Brooks, F. J. Brenner, and R. W. Tiner, Jr., pp. 261–275. Easton: The Pennsylvania Academy of Science.

Gleason, H. A., and A. Cronquist. 1991. *Manual of the Vascular Plants of Northeastern United States and Adjacent Canada.* New York: New York Botanical Garden.

Hammer, D. A. 1992. *Creating Freshwater Wetlands.* Chelsea, MI: Lewis Publishers.

Hardisky, M. A., and V. Klemas. 1983. "Tidal Wetlands Natural and Human-Made Changes from 1973 to 1979 in Delaware." *Mapping techniques and Environmental Management* 7(4): 339–344.

Hayes, Martha A. U.S. Geological Survey Water Supply Paper 2425.

Haynes, R. J., J. A. Allen, and E. C. Pendelton. 1988. "Re-Establishment of Bottom Land Hardwood Forests on Disturbed Sites: An Annotated Bibliography." *U.S. Fish and Wildlife Service Biological Report* 88(42).

Heath, R. C. 1984. *Ground Water Regions of the United States.* U.S. Geological Survey Water Supply Paper 2242.

Hollands, G. G. 1990. "Regional Analysis of the Creation and Restoration of Kettle and Pothole Wetlands. In *Wetland Creation and Restoration: The Status of the Science,* eds. J. A. Kusler and M. E. Kentula, pp. 281–298. Washington, DC: Island Press.

Johnston, R. H. 1973. *Hydrology of the Columbia (Pleistocene) Deposits of Delaware.* Delaware Geological Survey Bulletin 14.

Kentula, M. E., R. P. Brooks, S. E. Gwin, C. C. Holland, A. D. Sherman, and J. C. Sifness. 1992. *Wetlands: An Approach to Improving Decision Making in Wetland Restoration and Creation.* Washington DC: Island Press.

Kusler, J. A., and M. E. Kentula, eds. 1990. *Wetland Creation and Restoration: The Status of the Science.* Washington, DC: Island Press.

Lesser, C. A. 1971. *Memorandum to Secretary Austin N. Heller from Charles Lesser Re: 1971 Wetland Inventory (corrected).* Dover: DNREC.

Lewis, R. R., III. 1990. "Creation and Restoration of Coastal Plain Wetlands in Florida." In *Wetland Creation and Restoration: The Status of the Science,* eds. J. A. Kusler and M. E. Kentula, pp. 73–101. Washington, DC: Island Press.

Lowry, D. J. 1990. "Restoration and Creation of Palustrine Wetlands Associated with Riverine Systems of the Glaciated Northeast." In *Wetland Creation and Restoration: The Status of the Science,* eds. J. A. Kusler and M. E. Kentula, pp. 267–280. Washington, DC: Island Press.

Ludwig, J. C. 1992. *Delaware's Sea-Level Fens: A Report on a Natural Heritage Survey.* Unpublished report submitted to the Delaware Natural Heritage Inventory, Division of Parks and Recreation, Dover.

Ludwig, J. C. 1993. *Delaware's Sea-Level Fens: Report for 1993 Natural Heritage Survey.* Unpublished report submitted to the Delaware Natural Heritage Inventory, Division of Parks and Recreation, Dover.

Marble, A. D. 1992. *A Guide to Wetland Functional Design.* Boca Raton, FL: Lewis Publishers.

McAvoy, W., and K. Clancy. 1993. *Characterization of Category I Non-Tidal Communities in Delaware: Bald Cypress,* Taxodium distichum *(L.) Richard; Atlantic White Cedar,* Chamaecyparis thyoides *(L.) Bsp.* Final Report submitted to DNREC, Division of Water Resources, by Delaware Natural Heritage Inventory.

McAvoy, W., and K. Clancy. 1994. *Community Classification and Mapping Criteria for Category I Interdunal Swales and Coastal Plain Pond Wetlands in Delaware.* Delaware Natural Heritage Inventory, Division of Parks and Recreation, Dover, DE. Final report submitted to DNREC Division of Water Resources.

Metzgar, R. G. 1973. *Wetlands in Maryland.* Maryland Department of State Planning Publication 157.

Mitsch, W. J., and J. G. Gosselink. 1993. *Wetlands.* New York: Van Nostrand Reinhold, 2nd ed. 722 pp.

National Research Council. 1995. *Wetlands: Characteristics and Boundaries.* Washington, DC: National Academy Press.

Nature Conservancy. 1994. *Rare Plant Communities of the Conterminous United States,* eds. D. H. Grossman, K. Lemon Goodin, and C. L. Reuss. Arlington, VA.

Novitski, R. P. 1979. "Wetland Hydrology." In *Wetlands Ecology and Conservation: Emphasis in Pennsylvania,* eds. S. K. Majumdar, R. P. Brooks, F. J. Brenner, and R. W. Tiner, Jr., pp. 47–64. Easton: Pennsylvania Academy of Science.

Phillips, P. J., and R. J. Shedlock. 1993. "Hydrology and Chemistry of Ground Water and Seasonal Ponds in the Atlantic Coastal Plain in Delaware, USA." *Journal of Hydrology* 141:157–778.

Rawinski, T. J. 1989. *A Classification of Delaware's Vegetated and Non-Vegetated Community Elements.* Eastern Heritage Task Force, The Nature Conservancy, Boston, MA. In cooperation with Delaware Natural Heritage Inventory, Division of Parks and Recreation, Dover, DE.

Reed, P. B. 1988. "National List of Plant Species that Occur in Wetlands: Northeast (Region 1)." *U.S. Fish and Wildlife Service Biol. Rept.* 88 (26.1).

Shedlock, R. J., P. A. Hamilton, J. M. Denver, and P. J. Phillips. 1993. "Multi-Scale Approach to Regional Ground Water Quality Assessment of the Delmarva Peninsula." In *Multi-Scale Approach to Regional Ground Water Quality Assessment,* ed. W. M. Alley, pp. 563–587. New York: Van Nostrand Reinhold.

Shisler, J. K. 1990. "Creation and Restoration of Coastal Wetlands of the Northeastern United States." In *Wetland Creation and Restoration: The Status of the Science,* eds. J. A. Kusler and M. E. Kentula, pp. 143–170. Washington, DC: Island Press.

Simmons, R. H. 1986. "Delaware Surface-Water Resources." In *U.S. Geological Survey, Natl. Water Summary 1985 — Hydrologic Events and Surface-Water Resources.* U.S. Geological Survey Water Supply Paper 2300, pp. 181–186.

Smith, G. S. 1991. *NWI Maps Made Easy: A User's Guide to National Wetlands Inventory Maps of the Northeast Region.* Newton Corner, MA.

Spoljaric, Nenad, and R. R. Jordan. 1966. *Generalized Geologic Map of Delaware.* Newark, DE, Delaware Geological Survey map, scale 1:296,075.

State of Delaware. 1994. *Procedures Manual: Development of Statewide Digital Orthophotography, Street Centerlines, and Wetlands Mapping.* Prepared for the Delaware Dept. of Transportation and DNREC by Photo Science, Inc., Dewberry & Davis, and Environmental Research, Inc.

State of Delaware. 1994. *Proposal for Digital Orthophotos, Centerline File Development and Wetlands Mapping and Data Conversion Services Statewide.* Prepared for the Delaware Dept. of Transportation and DNREC by Photo Science, Inc.

Talley, J. H. 1987. *Geohydrology of the Southern Coastal Area.* Delaware Geological Survey Hydrologic Map Series no. 7, scale 1:24,000.

Tiner, R. W., and J. T. Finn. 1986. *Status and Recent Trends of Wetlands in Five Mid-Atlantic States — Delaware, Maryland, Pennsylvania, Virginia, and West Virginia.* Newton Corner, MA, U.S. Fish and Wildlife Service, National Wetlands Inventory Project Technical Report.

Tiner, R. W., Jr. 1985. *Wetlands of Delaware.* Cooperative publication of U.S. Fish and Wildlife Service, National Wetlands Inventory, Newton Corner, MA, and DNREC Wetlands Section.

Tiner, R. J., and S. Schaller. 1999. *Wetland Trends in Delaware: 1981/2 to 1992.* Final report to DNREC.

Winter, T. C. 1992. "A Physiographic and Climactic Framework for Hydrologic Studies of Wetlands." In *Proceedings of the Symposium on Aquatic Ecosystems in Semi-Arid Regions, 1990,* eds. R. D. Robarts, and M. L. Bothwell. Environment Canada, Saskatoon, Saskatchewan. *The National Hydrology Research Institute Symposium Series* No. 7, pp. 127–147.

Zedler, J. B. 1988. "Salt Marsh Restoration: Lessons from California." In *Rehabilitating Damaged Ecosystems*, ed. J. Cairns, pp. 123–138. Vol. I. Boca Raton, FL: CRC Press.

Appendix A
WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
	FORESTED WETLANDS	
Scientific Designation: *Acer rubrum* Series **Common Designation:** Red Maple Swamp	◆ A palustrine forest dominated by *Acer rubrum* (which may approach 100% cover), with only scattered occurrences of associated tree taxa (e.g., *Fraxinus pennsylvanica, Nyssa sylvatica, Liquidambar styraciflua, Pinus taeda*). ◆ Floristically, the understory can be diverse or depauperate, and may consist of the following tree and shrub species: *Magnolia virginiana, Lindera benzoin, Cornus amomum* (only occasional), *Ilex opaca, Ilex verticillata, Clethra alnifolia, Vaccinium corymbosum, Itea virginica, Euonymus americanus, Viburnum nudum*, and *Leucothoe racemosa*, to name a few. ◆ Likewise, the herbaceous stratum can be diverse or depauperate, and may consist of a combination of the following species: *Arisaema triphyllum, Osmunda regalis, Osmunda. cinnamomea, Woodwardia areolata, Boehmeria cylindrica, Peltandra virginica* (though usually found in tidal occurrences), *Sambucus canadensis, Cicuta maculata, Saururus cernuus, Symplocarpus foetidus, Impatiens capensis, Mitchella repens, Viola cucullata, Lycopus* spp., and *Carex* spp.	Along streams, or in isolated wetlands in New Castle, Kent, Sussex counties. This series consists of the following forest community associations that are ubiquitous throughout the Coastal Plain of Delaware. Red maple is typically the conspicuous component of these communities, but occasionally may be sparse.
Scientific Designation: *Acer rubrum* Wetland Forest Association **Common Designation:** Red Maple Swamp	◆ These forests may have either a low or moderately high structural complexity: low if there appears to be a uniform, singular tree stratum (suggesting that the canopy consists of an even-aged forest stand), or high where the forest stand consists of multi-layered strata. ◆ The former may have been previously clear-cut. The latter may represent a more mature and, usually, a higher quality forest stand; such communities are less common, but *are* represented in Piedmont Basin forested wetlands (Pers. Comm. Keith Clancy, 1996).	Along streams, or in isolated wetlands in New Castle County (as well as Kent and Sussex counties).
Scientific Designation: *Acer rubrum-Liquidambar styraciflua-Nyssa sylvatica* Wetland Forest **Common Designation:** Red Maple-Sweet Gum-Black Gum Swamp	◆ This natural community type is quite abundant on the Delmarva Coastal Plain and is very similar to the previously described community, except that the canopy consists of two or more co-dominant species (e.g., red maple, sweet gum, black gum). ◆ *Nyssa* is usually less common than red maple or sweet gum. Overall species composition of this community may be nearly identical to the *Acer rubrum* wetland community above. ◆ Typical woody species include *Diospyros virginiana, Magnolia virginiana, Ilex opaca, Ilex. verticillata, Leucothoe racemosa, Lindera benzoin, Clethra alnifiolia, Vaccinium corymbosum, Viburnum dentatum* var. *lucidum, Cornus amomum,* and *Viburnum nudum*. ◆ The herbaceous layer may be sparse or well-developed, and includes many of the same species found in the red maple community association (see above).	Along palustrine streams in New Castle County (as well as in Kent and Sussex counties).

Appendix A
WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
	FORESTED WETLANDS	
Scientific Designation: *Acer rubrum-Fraxinus pennsylvanica* Streamside Forest Association **Common Designation:** Red Maple-Green Ash Streamside Swamp	◆ This natural community may consist of the red maple and ash as co-dominants, or the ash may be the only canopy species present. Rarely one finds other canopy species such as *Liquidambar, Nyssa, Quercus bicolor,* and *Fraxinus profunda*. Typically found along fresh tidal streams, above the reaches of emergent marsh or between emergent marsh and uplands. Also found along streams in non-tidal conditions. ◆ Upstream, away from the estuary, the habitats grade from salt to brackish to freshwater marsh, then to scrub-shrub marsh and finally to forested wetlands. Downstream, this pattern may be exhibited in a perpendicular fashion from the edge of the stream towards the uplands. This community association also may intergrade into a pure *Acer rubrum*, or *Chamaecyparis thyoides-Acer rubrum* wetland. ◆ This community may have either a relatively low or high floristic diversity. Tree stature also varies considerably, from low, scrubby habitat in the lower reaches and along edges of tidal streams, to trees of 40 to 60' in height in the upper reaches of this community type. ◆ In addition to the maple and ash as co-dominants, the woody understory may consist of such species as *Clethra alnifolia, Itea virginica, Leucothoe racemosa, Toxicodendron radicans, Vaccinium corymbosum, Viburnum dentatum* var. *lucidum, Magnolia virginiana, Ilex opaca, I. verticillata*, and *Rosa palustris*. ◆ Herbs present in this community type may include *Arisaema triphyllum, Boehmeria cylindrica, Saururus cernuus, Dioscorea villosa, Iris versicolor, Impatiens capensis, Cuscuta gronovii, Sium suave, Lilium superbum, Lobelia cardinalis, Mikania scandens, Leersia virginica, Osmunda regalis, Peltandra virginica, Mitchella repens, Woodwardia areolata, Sagittaria latifolia, Thalictrum pubescens, Cicuta maculata, Polygonum arifolium, Viola cucullata*, and *Sphagnum* spp.	Tidal streams in New Castle, Kent, and Sussex counties; especially abundant in the Delaware Bay drainage.
Scientific Designation: *Acer rubrum-Quercusspp./ Magnolia virginiana* Wetland Association **Common Designation:** Red Maple-Mixed Oak/ Sweet Bay Magnolia Swamp	◆ A community occurring along small feeder streams of larger creeks on the Coastal Plain. The canopy is dominated by *Acer rubrum* and several oaks (e.g., *Q. nigra, Q. palustris, Q. phellos, Q. michauxii*), with lesser amounts of *Fraxinus pennsylvanica, Liquidambar, Liriodendron, Nyssa*, and *Pinus taeda*. *Magnolia* is common in the understory. ◆ Characteristic shrub species include *Clethra alnifolia, Rhododendron viscosum, Itea virginica, Ilex opaca, I. verticillata, Rubus hispidus, Toxicodendron radicans, Euonymus americanus, Smilax rotundifolia, Viburnum dentatum* var. *lucidum, V. nudum, Vaccinium corymbosum*, and *Leucothoe racemosa*. ◆ Herbs include *Arisaema triphyllum, Boehmeria cylindrica, Carex* spp. (e.g., *C. crinita, C. intumescens, C. folliculata*), *Lilium superbum, Platanthera clavellata, Woodwardia areolata, Osmunda cinnamomea, Viola cucullata, Mitchella repens*, and *Sphagnum* spp.	Streams and isolated wetlands on the Coastal Plain of New Castle, Kent, and Sussex counties.

Appendix A
WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
FORESTED WETLANDS		
Scientific Designation: *Quercus* spp.-*Pinus taeda/Leucothoe racemosa* Wetland Association **Common Designation:** Mixed Oak-Loblolly Pine/Fetterbush Swamp	◆ A natural community that may be slightly on the dry side of National Wetlands Inventory wetland types that is dominated by a mixture of oaks such as *Q. alba, Q. bicolor, Q. falcata, Q. nigra, Q. michauxii, Q. palustris, Q. phellos*, and *Q. rubra*; frequently found as isolated wetlands. ◆ Lesser amounts of *Pinus taeda, Nyssa sylvatica, Acer rubrum*, and *Liquidambar* may also be present. The understory is composed of such species as *Clethra alnifolia, Vaccinium corymbosum, Ilex opaca, I. laevigata, Leucothoe racemosa, Itea, Rhododendron viscosum, Leersia virginica, Chasmanthium laxum, Smilax* spp., *Mitchella repens, Osmunda cinnamomea, Woodwardia virginica, Boehmeria cylindrica, Saururus cernuus*, and *Sphagnum* spp.	Kent County and Sussex counties; presence in New Castle County is uncertain, but likely.
Scientific Deignation: *Quercus phellos-Q. michauxii* Wetland Association **Common Designation:** Willow Oak-Swamp Chestnut Oak Swamp	◆ This community type is only occasionally encountered and may be characterized by the presence of *Q. phellos* and *Q. michauxii* as canopy co-dominants. ◆ The associated species of the understory may consist of *Clethra, Vaccinium corymbosum, Lindera benzoin, Magnolia virginiana, Viburnum* spp., *Ilex opaca, I. verticillata, Leucothoe racemosa, Woodwardia areolata, Osmunda cinnamomea, Viola* spp., *Carex* spp., *Impatiens capensis, Mitchella repens*, and *Sphagnum* spp. ◆ Additional species may include *Smilax rotundifolia, Toxicodendron radicans*, and *Parthenocissus quinquefolia*. The willow oak-swamp chestnut oak community is usually found in isolated wetlands rather than along streams.	Isolated wetlands in southern Kent and Sussex counties.
NARROW-LEAVED DECIDUOUS PALUSTRINE FORESTS		
Scientific Designation: *Taxodium distichum* Wetland Forest Associations **Common Designation:** Bald Cypress Swamps	◆ These forest associations are only rarely encountered in Delaware. *Taxodium distichum* is found along floodplains and may form a dense canopy cover. It generally occurs as a layer above other deciduous and coniferous trees: e.g., *Acer rubrum, Liquidambar, Nyssa sylvatica, Fraxinus pennsylvanica, Pinus taeda*, and *Chamaecyparis thyoides*. ◆ Shrub and herb layers may be very diverse, typically consisting of a recurring assemblage of species: *Clethra, Ilex opaca, I. verticillata, Itea, Magnolia virginiana, Viburnum dentatum* var. *lucidum, Lonicera japonica, Parthenocissus quinquefolia, Smilax rotundifolia, Toxicodendron radicans, Boehmeria cylindrica, Carex* spp., *Chelone glabra, Cicuta maculata, Dioscorea villosa, Impatiens capensis, Lycopus rubellus, Osmunda cinnamomea, O. regalis, Peltandra virginica, Saururus cernuus, Sphagnum* spp., *Thalictrum pubescens, Woodwardia areolata*, and *Viola* spp.	Primarily found in Sussex County in the Nanticoke drainage; scattered, remnant stands in the Great Cypress Swamp (Pocomoke drainage); frequently on Iron Branch (Inland Bays drainage); and in Kent County along the Murderkill River; planted elsewhere.

Appendix A
WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
	EVERGREEN PALUSTRINE FORESTED WETLANDS	
Scientific Designation: *Chamaecyparis thyoides* Series Atlantic White Cedar Series (and) *Chamaecyparis thyoides* Wetland Forest Association **Common Designation:** Atlantic White Cedar Swamps	◆ This series consists of the following natural community associations (additional associations may come to light after further surveys) that are primarily found along stream corridors of Sussex County. It is believed that this wetland community type was, formerly, rather abundant. These wetlands are listed as proposed Category I Freshwater Wetlands by the Division of Water Resources, DNREC, and impacts to them should be avoided at all costs. In addition, they are home to numerous rare species, including the Federally Threatened swamp pink, *Helonias bullata*. ◆ Atlantic white cedar swamps are at the wetter end of the Cowardin et al. (1979) classification and typically occur on deep peat-muck soils, with a hummock-hollow topography. Flooded conditions in hollows is frequently of long duration (especially near millpond headwaters), and herbaceous and shrubby species are usually restricted to hummocks. ◆ The rare evergreen swamp forests dominated by *Chamaecyparis thyoides* are, typically, mature remnant stands that, in some cases, may be described as "old growth." One such stand in Sussex County is estimated to be more than 200 years old. This wetland type was undoubtedly previously more abundant along southern Delaware streams. One of Delaware's most significant habitats, the *Chamaecyparis thyoides* evergreen wetland typically harbors an assemblage of rare species (e.g., *Helonias bullata, Schizaea pusilla, Alnus maritima, Carex collinsii, C. exilis, Drosera rotundifolia, Sarracenia purpurea, Trientalis borealis, Mitoura hesseli, Utricularia* spp.). ◆ Along some of Delaware's streams occurs an evergreen swamp forest association that consists of several natural community types depending on species assemblages and dominant associates. Characteristic of all these types, however, is that each contains an abundance of *Chamaecyparis thyoides* in the canopy. Frequently, these stands may consist of a nearly monospecific canopy of *Chamaecyparis thyoides* with only scattered individuals of other tree taxa (e.g., *Acer rubrum, Liquidambar styraciflua, Nyssa sylvatica, Pinus taeda*). ◆ The understory may be sparse or abundant in vegetative cover, and depauperate or diverse in species composition. Woody species found in this community include *Magnolia virginiana, Ilex glabra, I. opaca, Clethra alnifolia, Lindera benzoin, Alnus maritima, Itea virginica, Leucothoe racemosa, Rhododendron viscosum, Vaccinium corymbosum, Smilax laurifolia, S. rotundifolia*, and *Toxicodendron radicans*. Herbs present may include *Carex collinsii, C. exilis, Decodon verticillatus, Osmunda cinnamomea, O. regalis, Drosera rotundifolia, Dioscorea villosa, Iris versicolor, Orontium aquaticum, Impatiens capensis, Helonias bullata, Trientalis borealis, Selaginella apoda, Symplocarpus foetidus, Peltandra virginica, Sarracenia purpurea, Mitchella repens, Woodwardia virginica*, and *Viola cucullata*. The soils in these wetlands are peat-mucks; an abundance of *Sphagnum* is usually present, as is a hummock-hollow topography.	Remnant stands of nearly pure Atlantic white cedar occur along Sowbridge Branch, Pemberton Branch, Swan Creek, Nanticoke River, and Cedar Creek (elsewhere as well).

Appendix A

WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
EVERGREEN PALUSTRINE FORESTED WETLANDS		
Scientific Designation: *Pinus taeda* Wetland Forest Association **Common Designation:** *Loblolly Pine Wetlands*	◆ A natural community dominated by *Pinus taeda* in the canopy (generally >50%), with much lesser amounts of *Acer rubrum, Liquidambar styraciflua, Nyssa sylvatica*, and *Fraxinus pennsylvanica*. This community type may develop as a result of a prior hydrologic disturbance and/or result from human influence (e.g., forestry), and is possibly an early successional community.	Great Cypress Swamp, isolated stands along the Nanticoke River, and possibly elsewhere
MIXED EVERGREEN-DECIDUOUS FORESTED WETLANDS		
Scientific Designation: *Chamaecyparis thyoides-Acer rubrum* Wetland Associations **Common Designation:** Atlantic White Cedar-Red Maple Swamps NOTE: Several mixed evergreen-deciduous forest wetland associations are found in Delaware. Primary differences are based on dominant species and associated species. In general, the dominant evergreen species is Atlantic white cedar, *Chamaecyparis thyoides*—while the dominant deciduous species are one or more of the following: *Acer rubrum, Liquidambar styraciflua, Nyssa sylvatica*, or *Fraxinus pennsylvanica*. Although only one such association is described below, enormous variation exists in this habitat type.	◆ The primary wetland forest type of the mixed evergreen-deciduous type is mostly found along streams in the Atlantic drainage, Delaware Bay drainage of Sussex County, and the Nanticoke drainage. It may represent a successional, seral stage of the "climax" hardwood community as it develops from the evergreen Atlantic white cedar forest. ◆ The succession from evergreen to hardwood may be a natural feature of these stream systems or, may result from anthropogenic activities (e.g., wetland draining, ditching, and other hydrologic change, logging of cedars, fire suppression). ◆ *Chamaecyparis* and *Acer rubrum* are generally co-dominants, though either species may become dominant depending on the location within the site and historical conditions. Nearly all the species mentioned for *Chamaecyparis* wetlands and *Acer rubrum* Wetland Series can be found in these mixed wetlands (see above). ◆ This wetland type has been designated as a proposed Category I Freshwater Wetland by the Division of Water Resources, DNREC and it may harbor numerous rare species, including the Federally Threatened swamp pink, *Helonias bullata*.	Sussex County (Atlantic, Delaware Bay, and Nanticoke drainages) Scrub wetlands may either be evergreen-dominated, a mixture of evergreen and hardwoods, or deciduous based. These wetlands are found along the edges of freshwater tidal and non-tidal streams, in millpond headwaters, and in isolated wetlands (e.g., Coastal Plain ponds).
SCRUB WETLANDS		
Scientific Designation: *Alnus serrulata-Acer rubrum-Rosa palustris-Myrica cerifera* Scrub Associations **Common Designation:** Alder-Rose-Wax Myrtle Scrub Wetlands	◆ This wetland type is characterized by a predominance of woody taxa such as *Alnus serrulata, Acer rubrum, Rosa palustris*, and *Myrica cerifera*. ◆ Additional woody species may include *Cephalanthus occidentalis, Toxicodendron radicans, Alnus maritima, Cornus amomum, Fraxinus pennsylvanica, Clethra alnifolia, Ilex verticillatus, Viburnum dentatum* var. *lucidum*, *Lyonia ligustrina, Magnolia virginiana, Itea virginica, Aronia arbutifolia*, and *Leucothoe racemosa*. ◆ Herbs may include palustrine marsh and adjacent hardwood swamp species: *Impatiens capensis, Peltandra virginica, Boehmeria cylindrica, Saururus cernuus, Sagittaria latifolia, Nymphaea odorata, Polygonum arifolium, P. sagittatum, P. punctatum, Sium suave, Cicuta maculata, Iris versicolor, Acorus calamus, Nuphar lutea, Ptilimnium capillaceum, Osmunda regalis, Mikania scandens, Leersia oryzoides, Lobelia cardinalis, Thalictrum pubescens, Lilium superbum, Lycopus* sp., and *Cuscuta* sp.	Along the edges of tidal and non-tidal streams, or between low, emergent marsh and palustrine or terrestrial forests; Also present in the headwaters of millponds.

Appendix A

WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
SCRUB WETLANDS		
Scientific Designation: *Chamaecyparis thyoides* Scrub Wetland Associations **Common Designation:** Atlantic White Cedar Scrub-Shrub Wetlands	◆ A rather uncommon wetland found along tidal streams of Sussex County, or in the headwaters of mill ponds. These communities are either inundated for greater lengths of time, water depths are deeper, or are influenced by regular to irregular tidal regimes than are forested habitats with similar compositions. ◆ A diverse, evergreen wetland community dominated by low statured, or scrubby, *Chamaecyparis thyoides*. Additional woody species present, but in low quantities, include *Alnus maritima, A. serrulata, Rhododendron viscosum, Myrica cerifera, Magnolia virginiana, Nyssa sylvatica, Fraxinus pennsylvanica, Rosa palustris, Vaccinium corymbosum, Clethra alnifolia, Ilex glabra, Leucothoe racemosa, Toxicodendron radicans.* ◆ Herbs may be diverse and can include *Impatiens capensis, Boehmeria cylindrica, Peltandra virginica, Thalictrum pubescens, Triadenum virginicum, Osmunda regalis, Dioscorea villosa, Decodon verticillatus, Nymphaea odorata, Oxypolis rigidior, Dulichium arundinaceum, Glyceria obtusa, Carex* spp., *Cicuta maculata, Acorus calamus, Zizania aquatica, Nuphar lutea, Mikania scandens, Orontium aquaticum, Drosera rotundifolia, Calopogon tuberous, Eriocaulon* sp., *Utricularia* spp., *Sagittaria latifolia, S. engelmanniana, Brasenia schreberi*, and *Cuscuta* sp., to name a few.	Along palustrine streams of Sussex County (e.g., Cedar Creek, Sowbridge Branch, Tantrough Branch).
Scientific Designation: *Cephalanthus occidentalis* Scrub Wetland Series **Common Designation:** Buttonbush Scrub Wetlands	◆ This wetland type, characterized by an abundance of *Cephalanthus occidentalis*, is mainly found in isolated basins (i.e., Coastal Plain ponds, or Delmarva Bays), but may also be present, though less commonly, in high scrubby marsh areas. ◆ In Coastal Plain ponds, the occurrence of *Cephalanthus* may be quite variable. It may be present in large numbers throughout the pond, restricted to the central region, along the pond's perimeter, or as scattered individuals. ◆ The associated herbaceous flora may vary but will consist of at least a few of the following species: *Bidens frondosa, Cyperus strigosus, Echincohloa crusgalli, Dulichium arundinaceum, Hypericum virginicum, Lindernia dubia, Polygonum amphibium, P. punctatum, Panicum dichtomiflorum, P. spretum, P. verrucosum, Pucinellia pallida, Rhexia virginica, Scirpus cyperinus, Carex gigantea, C. lupulina, C. striata, Bidens frondosa, Proserpinaca palustris, Glyceria acutiflora, G. septentrionalis*, and *Viola lanceolata*. ◆ The *Cephalanthus occidentalis* wetland basin community is significant because it may harbor rare species, it is proposed as a Category I Freshwater Wetland by the DNREC Division of Water Resources, and (possibly more importantly) it occurs in unique geological entities known as Delmarva or Carolina bays. ◆ These wetlands are intermittently flooded (season and duration of flooding varies year to year), typically drawing down late in the growing season. Rare species known to occur in these wetlands include *Hottonia inflata, Eragrostis hypnoides, Fimbristylis perpusilla, Ambystoma maculatum, A. tigrinum, Hyla chrysoscelis*, and *H. gratiosa. F. perpusilla* is a Federal Candidate species for listing and is only known from four Delaware ponds.	Most common in central Delaware (southwestern New Castle County and northwestern Kent County) in the region known for its abundance of Delmarva bays.

Appendix A
WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
	SCRUB WETLANDS	
Scientific Designation: *Acer rubrum* Scrub Wetland Series **Common Designation:** Red Maple Scrub Wetlands	◆ Very similar to the *Acer rubrum* Wetland Forest Association (see above) but with lower statured trees (i.e., scrub size). This association may consist of many of the same species as its taller forested counterpart. ◆ This series may either represent an early successional stage to the *Acer rubrum* Wetland Forest or may, in fact, represent a more stable climax community (e.g., for those red maple scrub habitats located along fresh tidal streams). ◆ Typical species include scattered occurrences tree taxa such as *Fraxinus pennsylvanica, Nyssa sylvatica, Liquidambar styraciflua*, and *Pinus taeda*. Other species present include such species as *Magnolia virginiana, Lindera benzoin, Cornus amomum, Rosa palustris, Ilex opaca, I. Verticillata, Clethra alnifolia, Vaccinium corymbosum, Itea virginica, Viburnum nudum*, and *Leucothoe racemosa*, among woody species. ◆ The herbaceous layer may also be quite diverse consisting of a combination of species such as *Osmunda regalis, O. cinnamomea, Decodon verticillatus, Woodwardia areolata, Boehmeria cylindrica, Peltandra virginica, Sambucus canadensis, Sium suave, Cicuta maculata, Iris versicolor, Saururus cernuus, Impatiens capensis, Viola cucullata*, and *Carex* spp. ◆ Scrub communities may have low or moderately-high structural complexity. Low structural complexity if a uniform, singular tree stratum exists—suggesting the community may have developed after a recent clear-cut. High structural complexity (multiple strata) might suggest a more natural stable and mature community.	Frequently found alongside fresh tidal streams in New Castle, Kent, and Sussex counties.
	HERBACEOUS WETLANDS	
Scientific Designation: *Nuphar lutea* Emergent Wetland Association **Common Designation:** Spatterdock Marshes	◆ Located in freshwater tidal and non-tidal streams, this wetland community may be composed of pure stands of *Nuphar*. Or, conversely, it may be more diverse with scattered stands of *Acorus calamus, Zizania aquatica*, or *Pontederia cordata*. ◆ Other species present, but in much lower numbers, include *Peltandra virginica, Polygonum* spp. (*punctatum, arifolium, sagittatum*), *Impatiens capensis, Sagittaria latifolia*, and *Amaranthus cannabinus*.	Along edges of freshwater portions of tidal streams, in millponds or along non-tidal streams above millponds, in the Inland Bays/Atlantic Ocean Basin, as well as the Chesapeake Bay and Delaware Bay basins.

Appendix A
WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
	HERBACEOUS WETLANDS	
Scientific Designation: *Acorus calamus* Emergent Wetland Association **Common Designation:** Sweetflag Marshes	◆ A wetland that may be composed of large, extensive, nearly monospecific stands of *Acorus*. Or, conversely, the sweetflag may form small to medium-sized discrete colonies within other community types. ◆ Additional species, generally in low numbers, that may be found in the sweetflag marsh include *Impatiens capensis, Bidens laevis, Zizania aquatica, Typha* spp., and *Sagittaria latifolia* (some of these species may form other distinct communities).	Along edges of tidal streams, in upper freshwater portions of the Inland Bays/Atlantic Ocean Basin, as well as the Chesapeake Bay and Delaware Bay basins.
Scientific Designation: *Zizania aquatica* Wetland Series **Common Designation:** Wild Rice Marshes	◆ May form dense stands in freshwater and brackish marshes; also occurs as scattered patches along waterways. ◆ The wild rice may also be one of several co-dominant species: e.g., *Zizania aquatica-Amaranthus cannabinus* emergent marsh; *Zizania aquatica-Pontederia cordata-Impatiens capensis* emergent marsh. Other associates may include *Bidens laevis, Sagittaria latifolia, Acorus calamus, Typha* spp., and *Leersia oryzoides*.	Common in freshwater or brackish marshes along many of Delaware's tidal streams, in New Castle, Kent, and Sussex counties.
General Designation: Mixed Emergent Freshwater Marshes	◆ A wetland community whereby there are no true dominants, but rather a diverse assemblage of species. These freshwater to oligohaline wetlands occur along upper reaches of tidal streams. ◆ The following herbaceous species are typical for this marsh: *Acorus calamus, Amaranthus cannabinus, Bidens coronata, Bidens laevis, Boehmeria cylindrica, Callitriche heterophylla, Calystegia sepium, Cicuta maculata, Cuscuta* sp., *Cyperus odoratus, Decodon verticillatus, Echinochloa crusgalli, Echinochloa walteri, Erechtites hieraciifolia, Hibiscus moscheutos, Impatiens capensis, Iris pseudacorus, Iris versicolor, Lemna minor, Leersia oryzoides, Ludwigia palustris, Ludwigia peploides, Lysimachia terrestris, Lythrum salicaria, Mikania scandens, Nuphar lutea, Nymphaea odorata, Orontium aquaticum, Panicum dichotomiflorum, Peltandra virginica, Phalaris arundinacea, Phragmites australis, Polygonum arifolium, Polygonum persicaria, Polygonum punctatum, Polygonum sagittatum, Pontederia cordata, Rumex verticillatus, Sagittaria latifolia, Sambucus canadensis, Schoenoplectus tabernaemontanii, Scirpus fluviatilis, Sium suave, Thalictrum pubescens, Typha angustifolia, Typha latifolia, Typha* x *glauca*, and *Zizania aquatica*. ◆ Several of the species in the above list include exotics or weedy species that should not be considered in wetland mitigation plans (e.g., *Calystegia sepium, Erechtites hieraciifolia, Iris pseudacorus, Ludwigia peploides, Lythrum salicaria, Polygonum persicaria, Phragmites australis*).	

Appendix A

WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
	HERBACEOUS WETLANDS	
General Designation: Coastal Plain Pond Herbaceous Wetlands	◆ There is a tremendous diversity and variation in the herbaceous composition of Coastal Plain ponds (McAvoy and Clancy, 1994). The variation is most noticeable between ponds, but floristic variation within the same pond is also apparent. In addition, this variation may occur from year to year, as species may disappear for several or more years before reappearing. ◆ It is because of this variation that it becomes impractical to describe all the Coastal Plain pond herbaceous natural communities found in Delaware. Likewise, future inventories may result in the characterizations of new vegetation associations found in these ponds.	
Scientific Designation: *Cephalanthus occidentalis* Scrub Wetland Series **Common Designation:** Buttonbush Scrub Wetlands	◆ In Coastal Plain ponds, the occurrence of *Cephalanthus* may be quite variable. Cephalanthus may be densely or sparsely distributed throughout the pond or along the pond perimeter, or may be restricted to the pond center. ◆ The associated herbaceous flora may vary, but will consist of at least a few of the following species: *Bidens frondosa, Cyperus strigosus, Echincohloa crus-galli, Dulichium arundinaceum, Hypericum virginicum, Lindernia dubia, Polygonum amphibium, Polygonum punctatum, Panicum dichtomiflorum, Panicum spretum, Panicum verrucosum, Pucinellia pallida, Rhexia virginica, Scirpus cyperinus, Carex gigantea, Carex lupulina, Carex striata, Bidens frondosa, Proserpinaca palustris, Glyceria acutiflora, Glyceria septentrionalis*, and *Viola lanceolata*. ◆ The *Cephalanthus occidentalis* wetland basin community is significant because it may harbor rare species. (The Department's Division of Water Resources proposed, via the Freshwater Wetlands Act, to afford greater regulatory protection to such wetlands.) Perhaps more importantly, such wetlands occur in unique geological entities known as Delmarva or Carolina bays. These wetlands are intermittently flooded (the degree and duration of seasonal flooding varies year to year), typically drawing down late in the growing season. ◆ Rare species known to occur in these wetlands include *Hottonia inflata, Eragrostis hypnoides, Fimbristylis perpusilla, Ambystoma maculatum, Ambystoma tigrinum, Hyla chrysoscelis*, and *Hyla gratiosa*. *Fimbristylis perpusilla* is a Federal Candidate species for listing and is only known to occur in four Delaware ponds (see also, Coastal Plain Ponds).	Inland Bays/Atlantic Ocean Basin; most common in central Delaware (southwest New Castle County and northwest Kent County) in the region known for its abundance of Delmarva bays.

Appendix A
WETLAND COMMUNITIES OF THE INLAND BAYS/ATLANTIC OCEAN BASIN — CONTINUED

COMMUNITY TYPE	COMMUNITY CHARACTERISTICS	DISTRIBUTION
HERBACEOUS WETLANDS		
Scientific Designation: *Acer rubrum* Scrub Wetland Series **Common Designation:** Red Maple Scrub Wetlands	◆ Very similar to the *Acer rubrum* Wetland Forest Association (see above) but with lower-statured trees (i.e., scrub size). This association may consist of many of the same species as its taller, forested counterpart. This series may either represent an early successional stage to the *Acer rubrum* Wetland Forest or may, in fact, represent a more stable climax community (e.g., for those red maple scrub habitats located along fresh tidal streams). ◆ Typical species include scattered occurrences of small individuals of such tree taxa as *Fraxinus pennsylvanica, Nyssa sylvatica, Liquidambar styraciflua*, and *Pinus taeda*. Other species present include such species as *Magnolia virginiana, Lindera benzoin, Cornus amomum, Rosa palustris, Ilex opaca, Ilex verticillata, Clethra alnifolia, Vaccinium corymbosum, Itea virginica, Viburnum nudum*, and *Leucothoe racemosa*, among woody species. ◆ The herbaceous layer may also be quite diverse consisting of a combination of species such as *Osmunda regalis, Osmunda cinnamomea, Decodon verticillatus, Woodwardia areolata, Boehmeria cylindrica, Peltandra virginica, Sambucus canadensis, Sium suave, Cicuta maculata, Iris versicolor, Saururus cernuus, Impatiens capensis, Viola cucullata*, and *Carex* spp. ◆ Communities may have low or moderately-high structural complexity. Low structural complexity is anticipated with uniform, singular tree stratum — suggesting that community developed after a recent clear-cut; high structural complexity (multiple strata) might suggest a more natural, stable, and mature community.	Frequently found alongside fresh tidal streams in New Castle County (as well as in Kent and Sussex counties).
Scientific Designation: *Nuphar lutea* Emergent Wetlands **Common Designation:** Spatterdock Marshes	◆ Located in freshwater tidal and non-tidal streams, this wetland community may be composed of pure stands of *Nuphar*. Conversely, it may be more diverse with scattered stands of *Acorus calamus, Zizania aquatica*, or *Pontederia cordata*. ◆ Other species present, but in much lower numbers, include: *Peltandra virginica, Polygonum* spp. (*punctatum, arifolium, sagittatum*), *Impatiens capensis, Sagittaria latifolia*, and *Amaranthus cannabinus*.	Along edges of freshwater portions of tidal streams, in mill ponds or along non-tidal streams above mill ponds, in the Nanticoke River, Delaware Bay, Atlantic Ocean, and Piedmont Basins.
Scientific Designation: *Acorus calamus* Emergent Wetlands **Common Designation:** Sweetflag Marshes	◆ A wetland that may be composed of large, extensive, nearly monospecific stands of *Acorus*. Or, sweetflag may form small- to medium-sized discrete colonies within other community types. ◆ Additional species that may be found (generally in low numbers) in sweetflag marshes include *Impatiens capensis, Bidens laevis, Zizania aquatica, Typha* spp., and *Sagittaria latifolia*. (Some of these species may form other distinct communities.)	Along edges of tidal streams, in upper freshwater portions of the Nanticoke River, Delaware Bay, and Atlantic Ocean drainages (above the *Nuphar lutea* zone).

Adapted from Clancy, 1995