Wetland Characterization and Preliminary Assessment of Wetland Functions for the Delaware and Catskill Watersheds of the New York City Water Supply System

Produced by the U.S. Fish and Wildlife Service
National Wetlands Inventory Program
Ecological Services, Northeast Region
Hadley, MA

Prepared for New York City Department of Environmental Protection, Valhalla, NY

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Introduction

The New York City Water Supply System provides unfiltered drinking water to millions of residents of the City. The significance of wetlands as water sources and natural water filters makes wetland conservation a main area of concern for the New York City Department of Environmental Protection (NYCDEP).

In partnership with the NYCDEP, the U.S. Fish and Wildlife Service (Service) has been inventorying and characterizing wetlands in the NYC Water Supply System since the mid-1990s (Tiner 1997a, Tiner et al. 1999, 2002, 2004). The wetlands inventory characterized wetlands mainly by their vegetation and expected hydrology (water regime), with other modifiers used to indicate human or beaver activities (e.g., diked/impounded, excavated, partly drained, and beaver-influenced). In order to use the inventory data to predict functions (e.g., surface water detention, nutrient transformation, streamflow maintenance, and provision of fish/wildlife habitat), additional information on the hydrogeomorphic characteristics of wetlands is required. The Service has developed a set of attributes to better describe wetlands by landscape position, landform, water flow path, and waterbody type (LLWW descriptors; Tiner 2003a). When added to the National Wetlands Inventory (NWI) data, the enhanced NWI data have a predictive capability regarding wetland functions (Tiner 2003b). The NYCDEP provided funding to the Service to add LLWW descriptors to existing NWI digital data and to produce a preliminary assessment of functions for wetlands in the NYC watersheds. This report documents the findings for the Delaware and Catskill watersheds. The Croton watershed results are presented separately (Tiner et al. 2004).

Study Area

The Delaware and Catskill watersheds are located west of the Hudson River. The Delaware watershed falls largely within Delaware County, with small sections occurring in Greene, Ulster, and Sullivan Counties. This watershed covers over 1,000 square miles. Major rivers and streams draining this watershed are the East and West Branches of the Delaware River and the Neversink River. Four reservoir basins are found in this watershed: Cannonsville, Pepacton, Neversink, and Rondout. The Catskill watershed is mostly in Greene and Ulster Counties with smaller portions in Schoharie and Delaware Counties. It occupies an area about 585 square miles in size containing five major creeks (Schohaire Creek, Esopus Creek, Stony Creek, Batavia Kill, and Rondout Creek) and two reservoir basins: Schoharie and Ashokan.

Methods

Classification and Characterization

The purpose of this project was to enhance the existing NWI dataset by adding LLWW attributes to each mapped wetland and deepwater habitat, as appropriate. Existing NWI maps and digital data for the study area were the primary base data for this characterization. (Note: This project was initiated prior to updating NWI data for this area; such data are now available, but were not ready in time to use for this assessment.) NYCDEP digital data for streams and NWI linear data were used to determine linkages among wetlands and between wetlands and deepwater habitats. Intermittent stream data were derived from U.S. Geological Survey topographic maps and their digital representations. No attempt was made to improve the geospatial or classification accuracy of the original data. Matching geospatial data from a variety of sources posed some challenges regarding alignment of a wetland to a stream. Where topographic information and stream location were not in proper alignment, a wetland in the correct topographic position (i.e., drainageway) was considered to be connected to the stream.

The existing NWI database contains geospatial information on both wetlands and deepwater habitats. Since this study's focus is on wetland assessment, wetlands had to be separated from deepwater habitats. Ponds were then separated from other wetlands, so that additional descriptors could be added.

Three main descriptors (landscape position, landform, and water flow path) were applied to each wetland by interpreting available map information, and in some cases, aerial photography was consulted. "Keys to Waterbody Type and Hydrogeomorphic-type Wetland Descriptors for U.S. Waters and Wetlands (Operational Draft)" (Tiner 2000) was initally used to classify these features. These data were updated using a slight revision of the keys "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors" (Tiner 2003a: Appendix A). Other modifiers were added to depict features such as headwater, drainage-divide, and human-impacted wetlands.

Landscape position defines the relationship between a wetland and an adjacent waterbody if present. For the study watersheds, three landscape positions were possible: 1) lotic (along rivers and streams and on their active floodplains), 2) lentic (along lakes and reservoirs), and 3) terrene (typically surrounded by upland, but including wetlands serving as sources of streams). Lotic wetlands were divided in lotic river and lotic stream wetlands by their width on a 1:24,000-scale map. Watercourses mapped as linear (single-line) features on NWI maps and on a U.S. Geological Survey topographic map (1:24,000) were designated as streams, whereas two-lined channels (polygonal features on the maps) were classified as rivers. Lotic wetlands were also subdivided into gradients for perennial waters: *high* (e.g., shallow mountain streams on steep slopes), *middle* (e.g., streams on moderate slopes), and *low* (e.g., mainstem rivers with considerable floodplain development or streams in flat sections in higher terrain), and *intermittent* gradient for waters not flowing year-round. All lotic wetlands are in contact with streams or rivers. Wetlands on floodplains surrounded by upland (nonhydric soil) were classified as terrene wetlands. Lentic wetlands were divided into two categories: natural and dammed, with the latter type separating wetlands associated with reservoirs from those along other controlled lakes, when possible.

Landform is the physical form or shape of a wetland. Six landform types were recognized in the study area: 1) basin, 2) flat, 3) slope, 4) floodplain, 5) island, and 6) fringe (Table 1). The floodplain landform was restricted to wetlands bordering perennial rivers and streams. Wetlands surrounded by nonhydric soils on floodplains were classified as floodplain wetlands (Terrene), except where the floodplain was cut off from river flow by roads, railroads, or levees. The basin (former floodplain) or flat (former floodplain) landform was assigned to the latter wetlands based on expected hydrology. Wetlands along intermittent streams were classified as either fringe, basin or flat depending on their predicted hydrology (i.e., semipermanently flooded to permanently flooded = fringe, seasonally flooded = basin; and temporarily flooded = flat).

Water flow path descriptors characterize the flow of water associated with wetlands. Seven patterns of flow were recognized for inland wetlands in the Delaware and Catskill watersheds: 1) throughflow, 2) throughflow-intermittent, 3) outflow, 4) outflow-intermittent, 5) inflow, 6) bidirectional flow, and 7) isolated. Throughflow wetlands have either a perennial watercourse (e.g. stream) or another type of wetland above and below it, so water passes through them (usually by way of a river or stream, but sometimes by ditches). The water flow path of lotic wetlands associated with perennial streams is throughflow. Throughflow-intermittent was applied to identify wetlands along intermittent streams. Where a streamside wetland has intermittent inflow and perennial outflow, the water flow path was classified as throughflow and the landscape position was labeled as lotic stream intermittent gradient. Lentic wetlands crossed by streams were designated as throughflow, while those located in embayments or coves with no stream inflow were classified as bidirectional flow since fluctuating lake or reservoir water levels appear to be the primary surface water source affecting their hydrology. Outflow wetlands have water leaving them all year-long, moving downstream via a watercourse (e.g., stream) or a slope wetland. If outflow is not constant (only occurs at certain times during the year), the flow pattern is classified as outflow-intermittent. Inflow wetlands are sinks where no outlet exists, yet water enters via an intermittent stream or seepage from an upslope wetland. Isolated wetlands are essentially closed depressions (geographically isolated) where water comes from surface water runoff and/or groundwater discharge. For this project, surface water connections are emphasized, since it is not possible to determine ground water linkages (especially outflow) without hydrologic investigations. Consequently, wetlands designated as isolated may have groundwater connections.

The headwater descriptor ("hw") was applied to wetlands along intermittent streams and first- and second-order perennial streams and to terrene wetlands that are the sources of these streams.

In the upper portions of watersheds, most streamside wetlands had organic soils (Carlisle or Palms muck). While these soils may occur in on floodplains, they are not alluvial soils formed in a depositional environment. Rather they are soils that have developed in place by the slow decomposition of plant matter. Wetlands in the intermittent stream reach were classified by map interpretation as lotic intermittent basin or flat wetlands (mostly the former), whereas the "floodplain" descriptor was applied to wetlands along perennial streams and rivers as they probably receive more water-carried sediments than the former, even where soils are organic.

Care was taken to ensure that the lentic descriptor was not applied beyond the lake basin (upstream or downstream). Where a stream enters a lake through a lakeside wetland, the wetland was designated as lentic throughflow if it occurred within the lake basin. The upper limits of this wetland were determined by examining topography and the width of the stream valley. In most cases, where the stream valley narrowed, the wetland was classified as lotic, given that it is beyond significant lake influence. It should be recognized that the hydrology of some wetlands within the lake basin may be more influenced by groundwater discharge than by lake levels, but this could not be determined through map interpretation.

The pond modifer ("pd") was applied to any wetland in contact with a pond per request from NYCDEP. The pond may exert influence on the wetland vegetation or may simply have little or no influence on the wetland (e.g., where a pond represents only a small portion of the wetland such as bog eyelet pond or where an artificial pond was excavated from an existing wetland). Wetlands bordering ponds that were mapped by NWI as impounded ("h") should be significantly influenced by pond hydrology.

The floodplain modifier ("q") was applied to any pond in a floodplain. These ponds should be located on alluvial soils. Since beaver ponds are created by stream blockage, there was no need to apply the "q" modifier to these ponds. These ponds typically convert the stream channel to a standing body of water. Wetlands associated with these types of ponds were typically classified as lotic stream wetlands with a "pd" modifier.

All NWI mapped wetlands in the both major watersheds were reviewed, reclassified by landscape position, landform, water flow path, and waterbody type (LLWW descriptors), and assigned an LLWW code. NYCDEP staff reviewed the preliminary classifications as well as performed field checks on numerous wetlands throughout these watersheds. Based on this review, many wetlands initially determined to be "isolated" wetlands were found to be connected to other wetlands via an intermittent stream or small perennial stream. Edits to the database were made based on NYCDEP comments. In general, if there was a wetland on both sides of a road, the wetlands were assumed to be connected; one was usually considered outflow (e.g., through a culvert), while the receiving wetland was typically classified as throughflow.

Table 1. Definitions and examples of landform types (Tiner 2003a).

Landform Type	General Definition	Examples
Basin*	a depressional (concave) landform including artificially created ones by impoundments, causeways, and roads	lakefill bogs; wetlands in the saddle between two hills; wetlands in closed or open depressions, including narrow stream valleys; tidally restricted estuarine wetlands
Slope	a landform extending uphill (on a slope; typically crossing two or more contours on a 1:24,000 map)	seepage wetlands on hillside; wetlands along drainageways or mountain streams on slopes
Flat*	a relatively level landform, often on broad level landscapes	wetlands on flat areas with high seasonal ground-water levels; wetlands on terraces along rivers/streams; wetlands on hillside benches; wetlands at toes of slopes
Floodplain	a broad, generally flat landform occurring on a landscape shaped by fluvial or riverine processes	wetlands on alluvium; bottomland swamps
Fringe	a landform occurring within the banks of a nontidal waterbody (not on a floodplain) and often but not always subject to near permanent inundation and a landform along an estuary subject to unrestricted tidal flow or a regularly flooded landform along a tidal freshwater river or stream	buttonbush swamps; aquatic beds; semipermanently flooded marshes; river and stream gravel/sand bars; salt and brackish marshes and flats; regularly flooded tidal fresh marsh or flat
Island	a landform completely surrounded by water (including deltas)	deltaic and insular wetlands; floating bog islands

*May be applied as sub-landforms within the Floodplain landform.

General Scope and Limitations of Preliminary Functional Assessment

At the outset, it is important to emphasize that the functional assessment presented in this report is a preliminary evaluation based on wetland characteristics interpreted through remote sensing and using the best professional judgment of the senior author with input from NYCDEP personnel and others. Wetlands believed to be providing potentially significant levels of performance for a particular function were highlighted. As the focus of this report is on wetlands, the assessment of waterbodies (e.g., lakes, rivers, and streams) at providing the listed functions was not done, despite their rather obvious significant performance of functions like fish habitat and surface water detention. No attempt was made to produce a more qualitative ranking for each function or for each wetland based on multiple functions since this was beyond the scope of the current study. For a technical review of wetland functions, see Mitsch and Gosselink (2000) and for a broad overview, see Tiner (1998).

Functional assessment of wetlands can involve many parameters. Typically such assessments have been done in the field on a case-by-case basis, considering observed features relative to those required to perform certain functions or by actual measurement of performance and compared to reference standards. The present study does not seek to replace the need for such assessments as they are the ultimate assessment of the functions for individual wetlands. Yet, for a watershed analysis, basinwide field-based assessments are not practical nor cost-effective nor even possible given access considerations. For watershed planning purposes, a more generalized assessment is worthwhile for targeting wetlands that may provide certain functions, especially for those functions dependent on landscape position and vegetation lifeform. Subsequently, these results can be field-verified when it comes to actually evaluating particular wetlands for acquisition or other purposes. Current aerial photography may also be examined to aid in further evaluations (e.g., condition of wetland/stream buffers or adjacent land use) that can supplement the preliminary assessment.

This study employs a watershed assessment approach called "Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF). W-PAWF applies general knowledge about wetlands and their functions to develop a watershed overview that highlights possible wetlands of significance based on their predicted level of performance of various functions. To accomplish this objective, the relationships between wetlands and various functions must be simplified into a set of practical criteria or observable characteristics. Such assessments could also be further expanded to consider the condition of the associated waterbody and the neighboring upland or to evaluate the opportunity a wetland has to perform a particular function.

W-PAWF does not account for the opportunity that a wetland has to provide a function resulting from a certain land-use practice upstream or the presence of certain structures or land-uses downstream. For example, two wetlands of equal size and like vegetation may be in the right landscape position to retain sediments. One, however, may be downstream of a land-clearing operation that has generated considerable suspended sediments in the water column, while the other is downstream from an undisturbed forest. The first wetland is most likely actively trapping sediment, while the second wetland is not or is not accumulating as much sediment. The W-PAWF is designed to reflect the potential for a wetland to provide a function. W-PAWF also does not consider the condition of the adjacent upland (e.g., level of outside disturbance) or the actual water quality of the associated waterbody which may be regarded as important metrics for assessing the "health" of individual wetlands (not part of this study). Collection and analysis of these data were beyond the scope of the study.

This preliminary assessment does not obviate the need for more detailed assessments of the various functions. It should be viewed as a starting point for more rigorous assessments, as it attempts to cull out wetlands that may likely produce significant levels of performance for certain functions based on generally accepted principles and the source information used for this analysis. This type of assessment is most useful for regional or watershed planning purposes.

It is also important to recognize limitations derived from source data. These limitations include conservative interpretations of forested wetlands (especially evergreen types) and drier-end wetlands (e.g., wet meadows, especially those used as pastures; see Tiner 1997b for additional information), and the omission of small or narrow wetlands. Despite these limitations, the NWI dataset represents the most extensive and current database on the distribution, extent, and type of wetlands in the New York City Water Supply System. NWI data for this study were based on 1982-1987, 1:58,000 color infrared aerial photography. These data were being updated while this study was in progress and unfortunately were not available for this assessment. NYCDEP personnel found that a few of the mapped wetlands were no longer present in 2002-3 and these wetlands were removed from the database. They also noted a few classification errors that were also corrected. The U.S. Geological Survey's digital raster graphics (DRGs) were used to determine whether small isolated wetlands were within a forest matrix. This land cover data may not reflect current conditions, so more of these wetlands may have been designated as having high potential for other wildlife habitat than if current aerial photography was analyzed.

For the functional assessment, the wetlands in the drainage basin contributing to the reservoir were emphasized. Wetlands within the reservoir, such as marshes and exposed flats (i.e., unconsolidated shores) were not included in the assessment since they are not part of the contributing watershed, but are actually part of the reservoir itself.

Rationale for Preliminary Functional Assessment

Eight functions were evaluated: 1) surface water detention, 2) streamflow maintenance, 3) nutrient transformation, 4) sediment retention, 5) shoreline stabilization, 6) provision of fish habitat, 7) provision of waterfowl and waterbird habitat, and 8) provision of other wildlife habitat. The criteria used for identifying wetlands of significance for these functions were taken from Tiner (2003b) which is included as Appendix B. A list of the wetland types designated as significant for each function is presented in Table 2. This list includes only freshwater wetland types found in the Delaware and Catskill watersheds.

Table 2. List of wetlands of potential significance for eight funtions for use in the Delaware and Catskill watersheds. (Source: Adapted from Tiner 2003b).

Function/Potential Significance	Wetland Types
Surface Water Detention	
High	Lentic Basin, Lentic Fringe, Lentic Island (basin and fringe), Lentic Flat associated with reservoirs and flood control dams, Lotic Basin, Lotic Floodplain, Lotic Fringe, Lotic Island associated with Floodplain area, Lotic Island basin, Ponds Throughflow (in-stream) and associated Fringe and Basin wetlands, Ponds Bidirectional and associated wetlands
Moderate	Lotic Flat, Lotic Island flat, Lentic Flat, Other Terrene Basins, Other Ponds and associated wetlands (excluding sewage treatment ponds and similar waters)
Streamflow Maintenance	
High	Nonditched Headwater Wetlands (Terrene, Lotic, and Lentic), Headwater Ponds and Lakes (classified as PUB...on NWI) (Note: Lotic Stream Basin or Floodplain basin Wetlands along 2nd order streams should also be rated high; possibly expand to 3rd order streams in hilly or mountainous terrain.)
Moderate	Ditched Headwater Wetlands (Terrene, Lotic, and Lentic), Lotic (Nontidal) Floodplain, Throughflow Ponds and Lakes (classified as PUB on NWI) and their associated wetlands, Terrene Outflow wetlands (associated with streams not major rivers), Outflow Ponds and Lakes (classified as PUB... on NWI)

Special Note: All these wetlands should also be considered important for fish and shellfish as they are vital to sustaining streamflow necessary for the survival of these aquatic organisms.

Function/Potential Significance	Wetland Types
Nutrient Transformation	
High	Vegetated wetlands (and mixes with nonvegetated wetlands or unconsolidated bottom; even where nonvegetated predominates) with seasonally flooded (C), seasonally flooded/saturated (E), semipermanently flooded (F), and permanently flooded (H) water regimes, vegetated wetlands with permanently saturated water regime (B)
Moderate	Vegetated wetlands with temporarily flooded (A) water regime
Retention of Sediments and Other Particulates	
High	Lentic Basin, Lentic Fringe (vegetated only), Lentic Island (vegetated) Lotic Basin, Lotic Floodplain, Lotic Fringe (vegetated), Lotic Island (vegetated), Throughflow Ponds and Lakes (in-stream; designated as PUB... on NWI) and associated vegetated wetlands, Bidirectional Ponds and associated vegetated wetlands
Moderate	Lotic Island (nonvegetated), Lotic Flat (excluding bogs), Lentic Flat, Other Terrene Basins excluding bogs), Terrene wetlands associated with ponds (excluding excavated ponds; also excluding bogs and slope wetlands), Other Ponds and Lakes (classified as PUB... on NWI) and associated wetlands (excluding bogs and slope wetlands)

Note: Ponds with minimal watersheds - possibly gravel pit ponds, impoundments completely surrounded by dikes, and dug-out ponds with little surface water inflow should be excluded.

Table 3 (continued).

Function/Potential Significance	Wetland Types
Shoreline Stabilization	
High	Lotic wetlands (vegetated except island and isolated types), Lentic wetlands (vegetated except island types)
Moderate	Terrene vegetated wetlands associated with ponds (e.g., Fringe-pond, Flat-pond, and Basin-pond)
Provision of Fish Habitat	
High	Lacustrine Semipermanently Flooded (excluding wetlands along intermittent streams), Lacustrine Littoral Aquatic Bed, Lacustrine Littoral Unconsolidated Bottom/Vegetated Wetland, Lacustrine Littoral Vegetated Wetland with a Permanently Flooded water regime, Palustrine Semipermanently Flooded (excluding wetlands along intermittent streams; must be contiguous with a permanent waterbody such as PUBH, L1UBH, or R2/R3UBH), Palustrine Aquatic Bed, Palustrine Unconsolidated Bottom/Vegetated Wetland, Palustrine Vegetated Wetland with a Permanently Flooded water regime, Ponds (PUBH.. on NWI; not PUBF) associated with Semipermanently Flooded Vegetated Wetland
Moderate	Lentic wetlands that are PEM1E, Lotic River or Stream wetlands that are PEM1E (including mixtures with Scrub-Shrub or Forested wetlands), Semipermanently flooded Phragmites wetlands (PEM5F) where contiguous with a permanent waterbody, Other Ponds and associated Fringe wetlands (i.e., Terrene Fringe-pond) (excluding industrial, stormwater treatment/detention, similar ponds in highly disturbed landscapes, and ponds with K and F water regimes)
Important for Stream Shading	Lotic Stream wetlands that are Palustrine Forested or Scrub-shrub wetlands (includes mixes where one of these types predominates; excluding those along intermittent streams; also excluding shrub bogs) (Note that although forested wetlands are designated as important for stream shading, forested upland provide similar functions)

Note: Many of these habitats are also important for wetland-dependent amphibians, reptiles, and aquatic invertebrates.

Function/Potential Significance	Wetland Types
Provision of Waterfowl and Waterbird Habitat	
High	Lacustrine Semipermanently Flooded, Lacustrine Littoral Aquatic Bed, Lacustrine Littoral Vegetated wetlands with an H water regime, Lacustrine Unconsolidated Shores (F, E, or C water regimes; mudflats), Palustrine Semipermanently Flooded (excluding Phragmites stands, but including mixtures containing this species - EM5), Palustrine Aquatic Bed, Palustrine Vegetated wetlands with a H water regime, Palustrine Unconsolidated Shores (F, E, or C water regimes; mudflats), Seasonally Flooded/Saturated Palustrine wetlands impounded or beaver-influenced (all vegetation types [except PEM5Eh and PEM5Eb] and associated PUB waters), Lotic River or Stream wetlands that are PEM1E (including mixtures with Scrub-Shrub or Forested wetlands), Ponds associated with Semipermanently Flooded Vegetated wetlands, Ponds associated with all of the wetland types listed as high for this function

Table 3 (continued).

Function/Potential Significance	Wetland Types
Provison of Waterfowl and Waterbird Habitat	
Moderate	Phragmites wetlands that are Seasonally Flooded/Saturated and wetter (PEM5E; PEM5F; PEM5H) and contiguous with a waterbody, Other Lacustrine Littoral Unconsolidated Bottom, Other Palustrine Unconsolidated Bottom (excluding industrial, commercial, stormwater detention, wastewater treatment, and similar ponds), Palustrine Emergent wetlands (including mixtures with Scrub-shrub) that are Seasonally Flooded and associated with permanently flooded waterbodies
Significant for Wood Duck	Lotic wetlands (excluding those along intermittent streams) that are Forested or Scrub-shrub or mixtures of these types with C, E, F, or H water regime; Lotic wetlands that are mixed Forested/Emergent or Unconsolidated Bottom/Forested with a E, F, or H water regime
Provision of Other Wildlife Habitat	
High	Large vegetated wetlands ($\geq$20 acres, excluding open water and nonvegetated areas), small diverse wetlands (10-20 acres with 2 or more covertypes; excluding EM5 or open water as one of the covertypes), small, seasonally flooded or wetter, isolated wetlands in a cluster of two or more (within 1000-feet of one another; including small ponds that may be vernal pools) occurring within an upland forest matrix
Moderate	Other vegetated wetlands

Note: Although in general, ponds are not listed here as important as significant for other wildlife, it should be recognized that species of frogs, turtles, and some other wildlife depend on these habitats; by and large, these wetlands have already been designated as important for fish and waterbirds, so they are not listed here.

Note: Nonvegetated lacustrine wetlands and semipermanently flooded vegetated wetlands (typically emergent types) located within each NYC reservoir were considered part of the reservoir proper. Since the assessment focused on wetlands in the watershed area draining into each NYC reservoir, the assessment of within-reservoir wetlands is not reported. However, the database created for this project contains information on the predicted functions of these wetlands for use by NYCDEP.

GIS Analysis and Data Compilation

The geographic information system (GIS) used for this project was ArcInfo. Several GIS analyses were performed to produce wetland statistics (acreage summaries), a preliminary assessment of wetland functions, and maps for each reservoir basin. Tables summarizing the results of the inventory were prepared to show extent of different wetland types by NWI classifications and by LLWW descriptors. NWI and LLWW wetland acreage totals differ because palustrine open water wetlands (NWI) were treated as ponds and, in some cases, as lakes according to LLWW. For individual reservoir basins, wetlands in the reservoir were culled from the wetlands in the surrounding drainage area. This was done because NYCDEP manages the reservoirs and was more concerned about the condition and function of wetlands in the surrounding watershed than of wetlands that are part of the reservoir waterbody. Wetlands designated as within the reservoir were mostly unconsolidated shores (i.e., exposed bottoms during reservoir drawdown). Some vegetated wetlands were also included within the reservoir if they were in standing water for all of the year (i.e., semipermanently flooded or permanently flooded types). Within-reservoir wetlands are reported in the acreage summaries but were not included in the functional assessment totals since the evaluation was intended to focus on wetlands in the contributing drainage area for the reservoir; their predicted functions are recorded in the database. Eight functions were evaluated using the database: 1) surface water detention, 2) streamflow maintenance, 3) nutrient transformation, 4) sediment retention, 5) shoreline stabilization, 6) provision of fish habitat, 7) provision of waterfowl and waterbird habitat, and 8) provision of other wildlife habitat.

Maps

A series of 13 maps was produced for each reservoir basin within the Delaware and Catskill watersheds. Six reservoir basins were evaluated: Cannonsville, Pepacton, Neversink, Rondout, Schoharie, and Ashokan. Cannonsville maps were divided into two sections: Southwest (A-series) and Northeast (B-series) due to the size of this reservoir basin. All maps were produced at a scale of 1:40,000 for this report.

For each reservoir basin, the first five maps depict the results of the wetlands inventory: wetlands by NWI types and by landscape position, landform, combined landscape-landform, and water flow path. Each of the remaining maps (Maps 6 through 13) highlights wetlands in the reservoir's catchment area that may perform each of the eight selected functions at a significant level. A list of the 13 maps follows: Map 1 - Wetlands and Deepwater Habitats Classified by NWI Types, Map 2 - Wetlands Classified by Landscape Position, Map 3 - Wetlands Classified by Landform, Map 4 - Wetlands Classified by Landscape Position and Landform, Map 5 - Wetlands Classified by Water Flow Path, Map 6 – Potential Wetlands of Significance for Surface Water Detention, Map 7 - Potential Wetlands of Significance for Streamflow Maintenance, Map 8 - Potential Wetlands of Significance for Nutrient Transformation, Map 9 - Potential Wetlands of Significance for Sediment Retention, Map 10 - Potential Wetlands of Significance for Shoreline Stabilization, Map 11 - Potential Wetlands of Significance for Provision of Fish Habitat, Map 12 - Potential Wetlands of Significance for Provision of Waterfowl/Waterbird Habitat, and Map 13 - Potential Wetlands of Significance for Provision of Other Wildlife Habitat.

Results

The results are presented for the seven reservoir basins representing the study area. Data are organized by major watershed, first for the Delaware and then for the Catskill. A reservoir basin profile summarizes pertinent data for each reservoir basin. It consists of a summary of wetland types both in and out of the reservoir (wetland characterization) and a preliminary assessment of functions for wetlands in the watershed area above the reservoir (the catchment area). For the functional assessment, wetlands in the catchment area were emphasized. Wetlands within the reservoir, such as marshes and exposed flats (i.e., unconsolidated shores) were not included in the assessment totals since they are not part of the contributing watershed, but are actually part of the reservoir itself. Maps are presented in a separate folder contained on the compact disk (CD) version of the report and are hyperlinked to the report; they are not included in the hardcopy version of this report. One set of hardcopy maps were printed and given to NYCDEP.

DELAWARE WATERSHED

Four reservoir basins are contained within the Delaware watershed: Cannonsville, Pepacton, Neversink, and Rondout.

Cannonsville Reservoir Basin Profile

Wetland Characterization

Wetlands by NWI Types

According to the NWI, the Cannonsville Reservoir Basin had over 2,800 acres of wetlands (including ponds), while the reservoir itself had over 3,000 acres of exposed bottoms (unconsolidated shore) at the time of the survey (Table 3; Maps 1A & 1B). Emergent wetlands (including emergent/scrub-shrub mixed communities) were the predominant palustrine type with over 1,000 acres inventoried, accounting for 40% of the wetlands in the contributing watershed area. Nonvegetated wetlands (ponds) were next in abundance with nearly 800 acres, representing 28% of the wetlands. Scrub-shrub and forested wetlands comprised 17% and 14% of the wetlands, respectively. Deepwater habitats (e.g., lakes and reservoirs) totaled nearly 2,300 acres (1,853.6 acres of lacustrine including 1,701.7 acres in the reservoir at the time of the inventory, and 435.1 acres of riverine habitat).

Wetlands by LLWW Types

A total of 816 wetlands were identified, excluding ponds (Table 4). The wetland acreage based on LLWW classification was 2,007.9 acres. Most (79%) of the wetland acreage was lotic wetland (Maps 2A & 2B; 68% lotic stream and 11% lotic river). The remainder was mostly terrene wetland (18%). Only 3% of the wetland acreage was lentic.

From the landform perspective, floodplain and basin wetlands were most extensive, accounting for 61% and 23% of the wetland acreage, respectively (Maps 3A & 3B). Flat wetlands accounted for 9% and fringe wetlands 5%. Nearly 2% of the wetland acreage was represented by slope wetlands and less than 1% was the island type. Maps 4A & 4B show the distribution of wetlands by a combination of landscape position and landform. Considering water flow path, 81% of the wetland acreage was throughflow-(68% perennial and 13% intermittent) (Maps 5A & 5B). Outflow types accounted for 11% of the acreage (7% intermittent and 4% perennial). Isolated acreage amounted to 7% of the total. About 1% of the wetland acreage was subjected to bidirectional flow.

For the 1,081 ponds identified (677.9 acres), 45% of the acreage was throughflow (34% perennial and 11% intermittent), 34% isolated, 21% outflow (13% intermittent and 8% perennial), and about 1% inflow.

Table 3. Wetlands classified by NWI types for the Cannonsville Reservoir Basin.

NWI Wetland Type	**Acreage** (within reservoir)	**Acreage** (outside reservoir)
Lacustrine Wetlands	3,039.5	0.0
Palustrine Wetlands		
Emergent	-	1,019.3
Emergent/Scrub-Shrub	-	90.9
(subtotal Emergent)	*(0.0)*	*(1,110.2)*
Forested, Broad-leaved Deciduous	-	272.4
Forested, Mixed	-	19.4
Forested, Needle-leaved Evergreen	-	70.1
Forested, Dead	-	20.1
Forested/Scrub-Shrub	-	15.6
(subtotal Forested)	*(0.0)*	*(397.6)*
Scrub-Shrub, Deciduous	-	390.2
Scrub-Shrub, Evergreen		0.8
Scrub-Shrub, Mixed	-	2.3
Scrub-Shrub/Emergent	-	53.3
Scrub-Shrub/Forested	-	24.1
(subtotal Scrub-Shrub)	*(0.0)*	*(470.7)*
Unconsolidated Bottom	-	793.6
Palustrine Subtotal	0.0	2,772.1
Riverine Wetlands	0.0	35.8
GRAND TOTAL (ALL WETLANDS)	3,039.5	2,807.9

Table 4. Wetlands in the Cannonsville Reservoir Basin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	8	17.1
		Throughflow (TH)	7	16.6
		Throughflow-Intermittent (TI)	1	2.5
		(subtotal)	*(16)*	*(36.8)*
	Flat (FL)	Bidirectional (BI)	1	1.4
		Throughflow (TH)	2	7.0
		(subtotal)	*(3)*	*(8.4)*
	Fringe (FR)	Bidirectional (BI)	1	1.4
		Throughflow (TH)	2	3.6
		(subtotal)	*(3)*	*(5.1)*
	Island (IL)	Bidirectional (BI)	1	1.0
	(Subtotal Lentic)		*(23)*	*(51.3)*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	71	190.6
	Fringe (FR)	Throughflow (TH)	13	16.4
	Island (IL)	Throughflow (TH)	5	10.2
	(Subtotal Lotic River)		*(89)*	*(217.2)*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	12	42.1
		Throughflow-Intermittent (TI)	53	129.2
		(subtotal)	*(65)*	*(171.3)*
	Flat (FL)	Throughflow (TH)	10	22.9
		Throughflow-Intermittent (TI)	34	94.4
		(subtotal)	*(44)*	*(117.3)*
	Floodplain (FP)	Throughflow (TH)	304	1,020.0
		Throughflow-Intermittent (TI)	2	3.3
		(subtotal)	*(306)*	*(1,023.2)*
	Fringe (FR)	Throughflow (TH)	31	47.1
		Throughflow-Intermittent (TI)	3	9.0
		(subtotal)	*(34)*	*(56.1)*
	Slope (SL)	Throughflow (TH)	1	0.5
	(Subtotal Lotic Stream)		*(450)*	*(1,368.5)*

Terrene (TE)				
	Basin (BA)	Inflow (IN)	1	0.6
		Isolated (IS)	97	92.3
		Outflow (OU)	20	62.5
		Outflow Intermitttent (OI)	42	83.5
		Throughflow Intermittent (TI)	2	16.3
		(subtotal)	*(162)*	*(255.2)*
	Flat (FL)	Isolated (IS)	31	24.0
		Outflow Intermittent (OI)	14	20.7
		Outflow (OU)	5	11.8
		(subtotal)	*(50)*	*(56.5)*
	Floodplain (FP)	Isolated (IS)	3	2.1
		Outflow Intermittent (OI)	5	8.8
		(subtotal)	*(8)*	*(10.8)*
	Fringe (FR)	Isolated (IS)	4	7.3
		Outflow Intermittent (OI)	1	1.3
		Outflow (OU)	4	7.9
		(subtotal)	*(9)*	*(16.5)*
	Slope (SL)	Isolated (IS)	10	13.4
		Outflow Intermittent (OI)	11	15.0
		Outflow (OU)	4	3.5
		(subtotal)	*(25)*	*(31.9)*
	(Subtotal Terrene)		*(254)*	*(370.9)*
TOTAL LLWW Types*			816	2,007.9

*Does not include 1,081 ponds that totaled 677.9 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Preliminary Assessment of Wetland Functions

The results for each wetland function for the Cannonsville Reservoir Basin are given in Table 5. Refer to the maps for locations of these wetlands; maps are hotlinked to the table.

Ninety-three percent of the wetland acreage was predicted to be significant for surface water detention. Two functions were projected to be performed at significant levels by more than 80% of the wetland acreage: sediment retention (87%) and streamflow maintenance (84%). Other functions performed at significant levels by more than 60% of the wetland acreage were nutrient transformation (70%), provision of other wildlife habitat (68%), and shoreline stabilization (60%). Cannonsville wetlands contributed less to waterfowl and waterbird habitat and fish habitat, but over 35% of the wetland acreage was predicted to perform these functions at significant levels. For the latter, if focused solely on fish nursery and spawning grounds, only 36% of the wetlands might serve this function, with another 13% of the acreage being important for maintaining stream temperatures (i.e., stream shading by trees and shrubs). Wetlands important for streamflow maintenance (84% of the wetland acreage) are also vital to providing aquatic habitat for fish.

Table 5. Predicted wetland functions for the Cannonsville Reservoir Basin (excluding wetlands within the reservoir). Click on maps to view potential wetlands of significance for each function.

Function	**Predicted Level**	**Acreage**	**Percent of Wetlands**
Surface Water Detention	High	1,513.2	54
(Maps 6A & 6B)	Moderate	1,081.1	39
Streamflow Maintenance	High	1,923.5	69
(Maps 7A & 7B)	Moderate	435.1	15
Nutrient Transformation	High	1,236.1	44
(Maps 8A & 8B)	Moderate	741.5	26
Sediment Retention	High	1,492.7	53
(Maps 9A & 9B)	Moderate	951.7	34
Shoreline Stabilization	High	1,591.4	57
(Maps 10A & 10B)	Moderate	83.7	3
Fish Habitat	High	34.3	1
(Maps 11A & 11B)	Moderate	988.8	35
	Shading	361.2	13
Waterfowl and Waterbird			
Habitat	High	439.1	16
(Maps 12A & 12B)	Moderate	638.9	23
	Wood Duck	3.6	<1
Other Wildlife Habitat	High	502.7	18
(Maps 13A & 13B)	Moderate	1,407.1	50

Pepacton Reservoir Basin Profile

Wetland Characterization

Wetlands by NWI Types

According to the NWI, the Pepacton Reservoir Basin had over 1,550 acres of wetlands, with only 5.8 acres in the reservoir itself (Table 6; Map 1). Emergent wetlands and ponds were the predominant palustrine types, totaling more than 1,000 acres and accounting for 69% of the wetlands. The former type was slightly more abundant, representing 36% of the wetlands, whereas ponds accounted for 33%. Scrub-shrub wetlands and forested wetlands comprised 20% and 9% of the wetlands, respectively. Deepwater habitats (e.g., lakes and reservoirs) totaled over 5,700 acres (5,657.7 acres of lacustrine including 5,596.4 acres in the reservoir, and 52.3 acres of riverine habitat).

Wetlands by LLWW Types

A total of 445 wetlands were identified, excluding ponds (Table 7). The wetland acreage based on LLWW classification was 1,034.9 acres. Most (80%) of the wetland acreage was lotic wetland (Map 2; 75% lotic stream and 5% lotic river). The remainder was mostly terrene wetland (14%). Only 6% of the wetland acreage was lentic.

From the landform perspective, floodplain wetlands were most extensive, accounting for 67% of the wetland acreage (Map 3). Basin wetlands were next ranked in acreage, representing 19% of the total acreage. Fringe wetlands and flat wetlands accounted for 7% and 5%, respectively. Slope wetlands comprised nearly 3% of the acreage. Map 4 shows the distribution of wetlands by a combination of landscape position and landform. Considering water flow path, 84% of the wetland acreage was throughflow (81% perennial and 3% intermittent).(Map 5). Outflow wetlands totaled 7% of the acreage (4% intermittent and 3% perennial). Isolated types made up about 7% and bidirectional flow almost 2% of the acreage, respectively. Inflow wetlands represented less than 1% of the acreage.

For the 798 ponds identified (424.2 acres), 54% of the acreage was throughflow (47% perennial and 7% intermittent), 33% isolated, 13% outflow (9% perennial and 4% intermittent), and the remaining <1% mostly inflow.

Table 6. Wetlands classified by NWI types for the Pepacton Reservoir Basin.

NWI Wetland Type	**Acreage** (within reservoir)	**Acreage** (outside reservoir)
Lacustrine Wetlands	2.4	0.0
Palustrine Wetlands		
Aquatic Bed	-	0.1
Emergent	3.5	448.5
Emergent/Forested	-	11.6
Emergent/Scrub-Shrub	-	97.7
Emergent/Unconsolidated Bottom	-	4.5
(subtotal Emergent)	*(3.5)*	*(562.3)*
Forested, Broad-leaved Deciduous	-	82.5
Forested, Needle-leaved Evergreen	-	49.8
Forested, Dead	-	6.1
Forested/Scrub-Shrub	-	5.9
(subtotal Forested)	*(0.0)*	*(144.3)*
Scrub-Shrub, Deciduous	-	235.6
Scrub-Shrub, Evergreen	-	0.6
Scrub-Shrub/Emergent	-	62.2
Scrub-Shrub/Forested	-	5.3
(subtotal Scrub-Shrub)	*(0.0)*	*(303.7)*
Unconsolidated Bottom	-	513.1
Unconsolidated Shore	-	0.1
(subtotal nonvegetated)	*(0.0)*	*(513.2)*
Palustrine Subtotal	*0.0*	*1,523.6*
Riverine Wetlands	-	31.1
GRAND TOTAL (ALL WETLANDS)	5.9	1,554.7

Table 7. Wetlands in the Pepacton Reservoir Basin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	12	13.1
		Throughflow (TH)	8	27.1
		(subtotal)	*(20)*	*(40.3)*
	Flat (FL)	Bidirectional (BI)	3	2.4
		Throughflow (TH)	4	16.7
		(subtotal)	*(7)*	*(19.1)*
	Island (IL)	Bidirectional (BI)	1	0.8
	(Subtotal Lentic)		*(28)*	*(60.2)*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	12	41.8
	Fringe (FR)	Throughflow (TH)	8	12.8
	(Subtotal Lotic River)		*(20)*	*(54.6)*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	11	39.4
		Throughflow-Intermittent (TI)	15	18.8
		(subtotal)	*(26)*	*(58.3)*
	Flat (FL)	Throughflow (TH)	4	5.3
		Throughflow-Intermittent (TI)	11	11.4
		(subtotal)	*(15)*	*(16.6)*
	Floodplain (FP)	Throughflow (TH)	213	645.6
	Fringe (FR)	Throughflow (TH)	42	46.7
	Slope (SL)	Throughflow (TH)	5	4.2
	(Subtotal Lotic Stream)		*(301)*	*(771.4)*
Terrene (TE)				
	Basin (BA)	Inflow (IN)	1	3.7
		Isolated (IS)	36	52.9
		Outflow (OU)	8	13.6
		Outflow Intermittent (OI)	16	28.4
		(subtotal)	*(61)*	*(98.7)*
	Flat (FL)	Inflow (IN)	1	0.4
		Isolated (IS)	10	9.6
		Outflow (OU)	2	3.6
		Outflow Intermittent (OI)	3	3.2
		(subtotal)	*(16)*	*(16.7)*
	Floodplain (FP)	Isolated (IS)	2	1.5
	Fringe (FR)	Isolated (IS)	1	3.9

	Outflow (OU)	1	4.2
	Outflow Intermittent (OI)	1	0.4
	(subtotal)	*(3)*	*(8.6)*
Slope (SL)	Isolated (IS)	2	1.2
	Outflow (OU)	4	11.1
	Outflow Intermittent (OI)	8	11.0
	(subtotal)	*(14)*	*(23.3)*
(Subtotal Terrene)		*(96)*	*(148.7)*
TOTAL LLWW Types*		445	1,034.9

*Does not include 798 ponds that totaled 424.2 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Preliminary Assessment of Wetland Functions

The results for each wetland function for the Pepacton Reservoir Basin are given in Table 8. Refer to the maps for locations of these wetlands; maps are hotlinked to the table.

Two functions were predicted to be performed by more than 80% of the wetland acreage in this basin: surface water detention (89%) and sediment retention (86%). Functions performed by more than 50% of the wetland acreage were nutrient transformation (65%), provision of other wildlife habitat (64%), streamflow maintenance (58%), and shoreline stabilization (57%). Provision of habitat for waterfowl and waterbirds and for fish were predicted to be performed at significant levels by more than 40% of the wetland acreage. An additional 18% of the acreage was deemed potentially significant for shading streams, important to moderating stream temperatures for aquatic life.

Table 8. Predicted wetland functions for the Pepacton Reservoir Basin (excluding wetlands within the reservoir). Click on maps to view potential wetlands of significance for each function.

Function	**Predicted Level**	**Acreage**	**Percent of Wetlands**
Surface Water Detention	High	844.6	54
(Map 6)	Moderate	551.4	35
Streamflow Maintenance	High	632.0	41
(Map 7)	Moderate	260.3	17
Nutrient Transformation	High	706.7	45
(Map 8)	Moderate	303.5	20
Sediment Retention	High	820.0	53
(Map 9)	Moderate	516.8	33
Shoreline Stabilization	High	858.8	55
(Map 10)	Moderate	33.7	2
Fish Habitat	High	27.5	2
(Map 11)	Moderate	636.1	41
	Shading	274.8	18
Waterfowl and Waterbird			
Habitat (Map 12)	High	329.3	21
	Moderate	383.6	25
Other Wildlife Habitat	High	221.8	14
(Map 13)	Moderate	780.0	50

Neversink Reservoir Basin Profile

Wetland Characterization

Wetlands by NWI Types

According to the NWI, the Neversink Reservoir Basin had over 500 acres of wetlands including 25 acres in the reservoir (Table 9; Map 1). Forested wetlands were the predominant palustrine type with nearly 177 acres, accounting for 37% of the wetlands in the contributing watershed area. Nonvegetated wetlands (ponds and riverbanks) accounted for 35% of the wetlands. Scrub-shrub wetlands and emergent wetlands comprised 18% and 9% of the wetlands, respectively. Deepwater habitats (e.g., lakes and reservoirs) totaled about 1,500 acres (1,471.2 acres of lacustrine in the reservoir, and 29.5 acres of riverine habitat).

Wetlands by LLWW Types

A total of 157 wetlands were identified, excluding ponds (Table 10). The wetland acreage based on LLWW classification was 380.6 acres. Most (78%) of the wetland acreage was lotic wetland (Map 2; 52% lotic river and 26% lotic stream). The remainder was mostly terrene wetland (20%). Only 2% of the wetland acreage was lentic.

From the landform perspective, floodplain and basin wetlands were most extensive, accounting for 42% and 34% of the wetland acreage, respectively (Map 3). Fringe wetlands accounted for 20% and flat wetlands 3%. Map 4 shows the distribution of wetlands by a combination of landscape position and landform. Considering water flow path, 79% of the wetland acreage was throughflow-(63% perennial and 16% intermittent) (Map 5). Outflow wetlands made up 15% of the acreage (12% intermittent and 3% perennial). Isolated types accounted for 6% of the acreage. Bidirectional flow made up less than 1% of the wetland acreage.

For the 85 ponds identified (62.2 acres), 70% of the acreage was throughflow (17% perennial and 53% intermittent), 21% outflow (4% perennial and 17% intermittent), and 9% isolated.

Table 9. Wetlands classified by NWI types for the Neversink Reservoir Basin.

NWI Wetland Type	**Acreage** (within reservoir)	**Acreage** (outside reservoir)
Palustrine Wetlands		
Emergent	13.8	44.8
Forested, Broad-leaved Deciduous	-	69.9
Forested, Mixed	-	19.7
Forested, Needle-leaved Evergreen	-	81.7
Forested, Dead	-	5.4
(subtotal Forested)	*(0.0)*	*(176.7)*
Scrub-Shrub, Deciduous	-	80.9
Scrub-Shrub, Evergreen	-	1.2
Scrub-Shrub, Mixed	-	1.5
Scrub-Shrub/Emergent	-	4.4
(subtotal Scrub-Shrub)	*(0.0)*	*(88.0)*
Unconsolidated Bottom	11.6	96.9
Palustrine Subtotal	*25.4*	*406.4*
Riverine Wetland	0.0	71.0
GRAND TOTAL (ALL WETLANDS)	25.4	477.4

Table 10. Wetlands in the Neversink Reservoir Basin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands	Acreage
Lentic (LE)	Basin (BA)	Bidirectional (BI)	4	2.5
		Throughflow (TH)	2	2.3
		(subtotal)	*(6)*	*(4.8)*
	Island (IL)	Bidirectional (BI)	1	0.4
	(Subtotal Lentic)		*(7)*	*(5.2)*
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	37	127.2
	Fringe (FR)	Throughflow (TH)	42	70.8
	Island (IL)	Throughflow (TH)	1	0.2
	(Subtotal Lotic River)		*(80)*	*(198.2)*
Lotic Stream (LS)	Basin (BA)	Throughflow (TH)	1	6.4
		Throughflow-Intermittent (TI)	21	50.3
		(subtotal)	*(22)*	*(56.7)*
	Flat (FL)	Throughflow-Intermittent (TI)	4	3.5
	Floodplain (FP)	Throughflow (TH)	12	34.0
	Fringe (FR)	Throughflow-Intermittent (TI)	3	5.7
	(Subtotal Lotic Stream)		*(41)*	*(99.9)*
Terrene (TE)	Basin (BA)	Isolated (IS)	7	18.8
		Outflow (OU)	2	8.5
		Outflow Intermittent (OI)	9	39.4
		(subtotal)	*(18)*	*(66.7)*
	Flat (FL)	Isolated (IS)	1	1.1
		Outflow (OU)	1	1.0
		Outflow Intermittent (OI)	4	5.4
		(subtotal)	*(6)*	*(7.4)*
	Slope (SL)	Isolated (IS)	2	1.1
		Outflow (OU)	2	1.6
		Outflow Intermittent (OI)	1	0.5
		(subtotal)	*(5)*	*(3.2)*
	(Subtotal Terrene)		*(29)*	*(77.3)*
TOTAL LLWW Types*			157	380.6

*Does not include 85 ponds that totaled 62.2 acres.

Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Preliminary Assessment of Wetland Functions

The results for each wetland function for the Neversink Reservoir Basin are given in Table 11. Refer to the maps for locations of these wetlands; maps are hotlinked to the table.

Ninety percent of the wetland acreage in this basin was predicted to be significant for surface water detention. Functions projected to be performed at significant levels by more than 50% of the wetland acreage were sediment retention (74%), streamflow maintenance (73%), nutrient transformation (65%), provision of other wildlife habitat (65%) and shoreline stabilization (50%). The remaining functions -- provision of fish habitat and provision of waterfowl and waterbird habitat -- were expected to be performed at significant levels by 20-23% of the wetland acreage, respectively.

Table 11. Predicted wetland functions for the Neversink Reservoir Basin (excluding wetlands within the reservoir). Click on maps to view potential wetlands of significance for each function.

Function	Predicted Level	Acreage	Percent of Wetlands
Surface Water Detention	High	296.1	62
(Map 6)	Moderate	132.4	28
Streamflow Maintenance	High	211.0	44
(Map 7)	Moderate	136.2	29
Nutrient Transformation	High	181.2	38
(Map 8)	Moderate	128.4	27
Sediment Retention	High	228.7	48
(Map 9)	Moderate	125.5	26
Shoreline Stabilization	High	231.9	49
(Map 10)	Moderate	4.2	1
Fish Habitat	High	0	-
(Map 11)	Moderate	96.8	20
	Shading	17.8	4
Waterfowl and Waterbird			
Habitat (Map 12)	High	49.7	10
	Moderate	59.8	13
	Wood Duck	1.2	<1
Other Wildlife Habitat	High	105.8	22
(Map 13)	Moderate	203.7	43

Rondout Reservoir Basin Profile

Wetland Characterization

Wetlands by NWI Types

According to the NWI, the Rondout Reservoir Basin had nearly 385 acres of wetlands including 3 acres within the reservoir (Table 12; Map 1). Forested wetlands, the predominant palustrine type with almost 212 acres, accounted for 55% of the wetlands. Nearly 78 acres of emergent wetlands were inventoried; they comprised 20% of the wetlands. Nonvegetated wetlands (ponds and exposed shores of rivers and lakes) accounted for 17% of the wetlands, while scrub-shrub wetlands made up 7%. Deepwater habitats (e.g., lakes and reservoirs) totaled about 2,080 acres (2,078.9 acres of lacustrine including 2,028.8 acres in the reservoir, and 1.3 acres of riverine habitat).

Wetlands by LLWW Types

A total of 81 wetlands were identified, excluding ponds (Table 13). The wetland acreage based on LLWW classification was 326.2 acres. Most (52%) of the wetland acreage was terrene wetland (Map 2). The remainder was mostly lotic wetland (40%). Only 8% of the wetland acreage was lentic.

From the landform perspective, basin wetlands predominated, accounting for 64% of the wetland acreage. Floodplain wetlands were next occupying 26% of the acreage, followed by flats at 6% (Map 3). Fringe wetlands made up nearly 4%, while slopes comprised 1%. Island wetlands accounted for less than 1%. Map 4 shows the distribution of wetlands by a combination of landscape position and landform. Considering water flow path, throughflow wetlands represented nearly half of the acreage (38% perennial and 8% intermittent) (Map 5). Outflow wetlands comprised 32% (22% perennial and 10% intermittent). Isolated types accounted for 20% and bidirectional flow types made up nearly 3% of the acreage, respectively.

For the 105 ponds identified (54.8 acres), 40% of the acreage was isolated, 38% throughflow (30% perennial and 8% intermittent), 22% outflow (14% intermittent and 8% perennial), and the remaining <1 % inflow.

Table 12. Wetlands classified by NWI types for the Rondout Reservoir Basin.

NWI Wetland Type	**Acreage** (within reservoir)	**Acreage** (outside reservoir)
Lacustrine Wetlands	3.0	0.0
Palustrine Wetlands		
Emergent	-	64.5
Emergent/Forested	-	2.1
Emergent/Scrub-Shrub		11.3
(subtotal Emergent)	*(0.0)*	*(77.9)*
Forested, Broad-leaved Deciduous	-	30.0
Forested, Mixed	-	91.0
Forested, Needle-leaved Evergreen	-	90.9
(subtotal Forested)	*(0.0)*	*(211.9)*
Scrub-Shrub, Deciduous	-	16.6
Scrub-Shrub, Evergreen	-	0.8
Scrub-Shrub, Mixed	-	10.9
(subtotal Scrub-Shrub)	*(0.0)*	*(28.3)*
Unconsolidated Bottom	0.0	54.8
Palustrine Subtotal	*0.0*	*372.9*
Riverine Wetlands	-	8.9
GRAND TOTAL (ALL WETLANDS)	3.0	381.8

Table 13. Wetlands in the Rondout Reservoir Basin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)	Basin (BA)	Bidirectional (BI)	2	6.8
		Throughflow (TH)	1	14.8
		(subtotal)	(3)	(21.7)
	Flat (FL)	Bidirectional (BI)	2	0.7
		Throughflow (TH)	1	2.5
		(subtotal)	(3)	(3.2)
	Island (IL)	Bidirectional (BI)	1	0.5
	(Subtotal Lentic)		*(7)*	*(25.3)*
Lotic River (LR)	Fringe (FR)	Throughflow (TH)	1	0.3
	(Subtotal Lotic River)		*(1)*	*(0.3)*
Lotic Stream (LS)	Basin (BA)	Throughflow (TH)	1	11.4
		Throughflow-Intermittent (TI)	5	20.5
		(subtotal)	*(6)*	*(31.9)*
	Flat (FL)	Throughflow-Intermittent (TI)	3	2.5
	Floodplain (FP)	Throughflow (TH)	21	82.9
	Fringe (FR)	Throughflow (TH)	8	11.1
	Slope (SL)	Throughflow (TH)	1	3.2
	(Subtotal Lotic Stream)		*(39)*	*(131.5)*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	12	59.8
		Outflow (OU)	8	71.2
		Outflow Intermittent (OI)	4	23.1
		(subtotal)	*(24)*	*(154.1)*
	Flat (FL)	Isolated (IS)	4	4.2
		Outflow Intermittent (OI)	4	9.3
		(subtotal)	*(8)*	*(13.5)*
	Floodplain (FP)	Isolated (IS)	1	0.5
		Outflow (OU)	1	1.0
		(subtotal)	*(2)*	*(1.5)*
	(Subtotal Terrene)		*(34)*	*(169.1)*
TOTAL LLWW Types*			81	326.2

*Does not include 105 ponds that totaled 54.8 acres.
<u>Note</u>: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Preliminary Assessment of Wetland Functions

The results for each wetland function for the Rondout Reservoir Basin are given in Table 14. Refer to the maps for locations of these wetlands; maps are hotlinked to the table.

More than 80% of the wetland acreage was predicted to be significant for four functions: surface water detention (93%), sediment retention (92%), nutrient transformation (83%), and streamflow maintenance (81%). Sixty-four percent of the acreage was deemed potentially significant for other wildlife habitat, while 41% was predicted important for shoreline stabilization. About a quarter of the wetland acreage was predicted as significant for fish habitat and habitat for waterfowl and waterbirds. An additional 12% of the acreage provided cover for streams, thereby moderating water temperatures important for aquatic life.

Table 14. Predicted wetland functions for the Rondout Reservoir Basin (excluding wetlands within the reservoir). Click on maps to view potential wetlands of significance for each function.

Function	**Predicted Level**	**Acreage**	**Percent of Wetlands**
Surface Water Detention	High	141.0	37
(Map 6)	Moderate	214.1	56
Streamflow Maintenance	High	289.9	76
(Map 7)	Moderate	17.3	5
Nutrient Transformation	High	287.8	75
(Map 8)	Moderate	29.5	8
Sediment Retention	High	145.9	38
(Map 9)	Moderate	204.5	54
Shoreline Stabilization	High	147.8	39
(Map 10)	Moderate	8.6	2
Fish Habitat	High	2.5	1
(Map 11)	Moderate	90.3	24
	Shading	47.0	12
Waterfowl and Waterbird			
Habitat (Map 12)	High	37.6	10
	Moderate	55.2	14
Other Wildlife Habitat	High	110.7	29
(Map 13)	Moderate	133.7	35

CATSKILL WATERSHED

Two reservoir basins occur within the Catskill watershed: Schoharie and Ashokan.

Schoharie Reservoir Basin Profile

Wetland Characterization

Wetlands by NWI Types

According to the NWI, the Schoharie Reservoir Basin had over 2,500 acres of wetlands, with only 2.8 acres within the reservoir (Table 15; Map 1). Wetland types were fairly even distributed among the basic types: forested wetlands (28% of the wetlands), emergent wetlands (27%), nonvegetated wetlands (26%), and scrub-shrub wetlands (20%). Deepwater habitats (e.g., lakes and reservoirs) totaled nearly 1,500 acres (1,307.7 acres of lacustrine including 1,167.2 acres in the reservoir, and 178.2 acres of riverine habitat).

Wetlands by LLWW Types

A total of 674 wetlands were identified, excluding ponds (Table 16). The wetland acreage based on LLWW classification was 1999.8 acres. Most (64%) of the wetland acreage was lotic wetland (Map 2; 55% lotic stream and 9% lotic river). The remainder was mostly terrene wetland (27%). Only 9% of the wetland acreage was lentic.

Floodplain wetlands and basin wetlands made up more than 80% of the wetland acreage (43% floodplain and 39% basin) (Map 3). Flat and fringe types each represented about 8% of the acreage. Slope wetlands accounted for slightly more than 1% of the acreage. Map 4 shows the distribution of wetlands by a combination of landscape position and landform. Considering water flow path, nearly three-quarters of the wetland acreage was throughflow (63% perennial and 10% intermittent) (Map 5). Outflow types represented nearly 20% (13% perennial and almost 7% intermittent). Isolated wetlands comprised nearly 7% of the acreage, while bidirectional flow and inflow types accounted for the remainder (nearly 2% for the former and less than 1% for the latter).

For the 688 ponds identified (452.3 acres), 48% of the acreage was throughflow (nearly 37% perennial and almost 12% intermittent), 30% isolated, 20% outflow (13% perennial and 7% intermittent), and about 1% inflow.

Table 15. Wetlands classified by NWI types for the Schoharie Reservoir Basin.

NWI Wetland Type	**Acreage** (within reservoir)	**Acreage** (outside reservoir)
Lacustrine Wetlands	2.8	0.0
Palustrine Wetlands		
Emergent	-	615.1
Emergent/Scrub-Shrub	-	63.7
(subtotal Emergent)	*(0.0)*	*(678.8)*
Forested, Broad-leaved Deciduous	-	355.2
Forested, Mixed	-	91.7
Forested, Needle-leaved Evergreen	-	196.4
Forested, Dead	-	47.6
Forested/Emergent	-	11.9
Forested/Scrub-Shrub	-	1.8
(subtotal Forested)	*(0.0)*	*(703.6)*
Scrub-Shrub, Deciduous-	-	417.8
Scrub-Shrub, Evergreen	-	10.3
Scrub-Shrub/Emergent	-	54.3
Scrub-Shrub, Mixed	-	23.2
(subtotal Scrub-Shrub)	*(0.0)*	*(505.6)*
Unconsolidated Bottom	0.0	539.7
Unconsolidated Shore	0.0	5.6
Palustrine Subtotal	*0.0*	*2,432.3*
Riverine Wetlands	0.0	110.7
GRAND TOTAL (ALL WETLANDS)	2.8	2,543.0

Table 16. Wetlands in the Schoharie Reservoir Basin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands	Acreage
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	7	32.4
		Throughflow (TH)	11	74.9
		(subtotal)	*(18)*	*(107.3)*
	Flat (FL)	Throughflow (TH)	2	80.0
	(Subtotal Lentic)		*(20)*	*(187.4)*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	32	123.4
	Fringe (FR)	Throughflow (TH)	33	46.5
	(Subtotal Lotic River)		*(65)*	*(169.9)*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	20	80.0
		Throughflow-Intermittent (TI)	57	156.1
		(subtotal)	*(77)*	*(236.1)*
	Flat (FL)	Throughflow (TH)	1	9.4
		Throughflow-Intermittent (TI)	8	24.4
		(subtotal)	*(9)*	*(33.8)*
	Floodplain (FP)	Throughflow (TH)	206	742.5
	Fringe (FR)	Throughflow (TH)	68	88.5
		Throughflow-Intermittent (TI)	2	5.1
		(subtotal)	*(70)*	*(93.6)*
	(Subtotal Lotic Stream)		*(362)*	*(1,106.0)*
Terrene (TE)				
	Basin (BA)	Inflow (IN)	2	1.7
		Isolated (IS)	96	111.7
		Outflow (OU)	46	204.2
		Outflow Intermittent (OI)	41	115.3
		Throughflow (TH)	2	7.9
		(subtotal)	*(187)*	*(440.7)*
	Flat (FL)	Isolated (IS)	13	14.1
		Outflow (OU)	6	17.6
		Outflow Intermittent (OI)	8	11.0
		Throughflow Intermittent (TI)	1	8.6
		(subtotal)	*(28)*	*(51.2)*
	Floodplain (FP)	Isolated (IS)	1	0.1

Fringe (FR)	Outflow (OU)	1	20.1
Island (IL)	Outflow Intermittent (OI)	1	20.1
Slope (SL)	Isolated (IS)	2	6.7
	Outflow (OU)	5	13.8
	Outflow Intermittent (OI)	2	3.8
	(subtotal)	*(9)*	*(24.3)*
(Subtotal Terrene)		*(227)*	*(536.5)*
TOTAL LLWW Types*		674	1,999.8

*Does not include 688 ponds that totaled 452.3 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Preliminary Assessment of Wetland Functions

The results for each wetland function for the Schoharie Reservoir Basin are given in Table 17. Refer to the maps for locations of these wetlands; maps are hotlinked to the table.

Two functions were predicted to be performed at significant levels by more than 80% of the wetland acreage: surface water detention (89%) and sediment retention (85%). More than 50% of the wetland acreage was deemed important for five other functions: nutrient transformation (75%), provision of other wildlife habitat (68%), streamflow maintenance (62%), and shoreline stabilization (57%). The remaining functions -- provision of fish habitat and provision of waterfowl and waterbird habitat -- were projected to be performed at significant levels by roughly one-third of the wetland acreage (33% and 35%, respectively). Sixteen percent of the wetland acreage provided shading for streams potentially important for regulating water temperatures.

Table 17. Predicted wetland functions for the Schoharie Reservoir Basin (excluding wetlands within the reservoir). Click on maps to view potential wetlands of significance for each function.

Function	**Predicted Level**	**Acreage**	**Percent of Wetlands**
Surface Water Detention	High	1,322.6	52
(Map 6)	Moderate	950.5	37
Streamflow Maintenance	High	1,255.3	49
(Map 7)	Moderate	321.6	13
Nutrient Transformation	High	1,413.4	56
(Map 8)	Moderate	475.6	19
Sediment Retention	High	1,247.7	49
(Map 9)	Moderate	904.3	36
Shoreline Stabilization	High	1,352.4	53
(Map 10)	Moderate	110.4	4
Fish Habitat	High	14.3	1
(Map 11)	Moderate	805.5	32
	Shading	395.9	16
Waterfowl and Waterbird			
Habitat (Map 12)	High	416.8	16
	Moderate	490.3	19
	Wood Duck	10.0	<1
Other Wildlife Habitat	High	619.3	24
(Map 13)	Moderate	1,109.3	44

Ashokan Reservoir Basin Profile

Wetland Characterization

Wetlands by NWI Types

According to the NWI, the Ashokan Reservoir Basin had more than 1,300 acres of wetlands including 24 acres in the reservoir (Table 18; Map 1). Forested wetlands, the predominant palustrine type with almost 600 acres, accounted for 45% of the wetlands. Nonvegetated wetlands (ponds and exposed shores) accounted for 22% of the wetlands. Emergent wetlands and scrub-shrub wetlands comprised 19% and 14% of the wetlands, respectively. Deepwater habitats (e.g., lakes and reservoirs) totaled over 8,400 acres (8,199.6 acres of lacustrine including 8,054.0 acres in the reservoir, and 203.9 acres of riverine habitat).

Wetlands by LLWW Types

A total of 390 wetlands were identified, excluding ponds (Table 19). The wetland acreage based on LLWW classification was 1,115.7 acres. Most (73%) of the wetland acreage was lotic wetland (Map 2; 51% lotic stream and 22% lotic river). The remainder was mostly terrene wetland (19%). Only 8% of the wetland acreage was lentic.

From the landform perspective, floodplain and basin wetlands were most extensive, accounting for about 56% and 30% of the wetland acreage, respectively (Map 3). Fringe wetlands accounted for 11% and flat wetlands 2%. Slope and island landforms collectively represented 1% of the wetland acreage. Map 4 shows the distribution of wetlands by a combination of landscape position and landform. Considering water flow path, 77% of the wetland acreage was throughflow (69% perennial and 7% intermittent (Map 5). Outflow accounted for 10% of the acreage (7% intermittent and 3% perennial). Isolated types comprised 9% of the acreage, whereas only 4% of the acreage had bidirectional flow.

For the 209 ponds identified (155.4 acres), 61% of the acreage was throughflow (56% perennial and 5% intermittent), 18% outflow (12% intermittent and 6% perennial), and 21% isolated.

Table 18. Wetlands classified by NWI types for the Ashokan Reservoir Basin.

NWI Wetland Type	**Acreage** (within reservoir)	**Acreage** (outside reservoir)
Lacustrine Wetlands	3.2	0.0
Palustrine Wetlands		
Emergent	0.6	223.9
Emergent/Scrub-Shrub	-	32.1
(subtotal Emergent)	*(0.6)*	*(256.0)*
Forested, Broad-leaved Deciduous	-	516.5
Forested, Mixed	-	6.7
Forested, Needle-leaved Evergreen	-	40.8
Forested, Dead	-	18.4
Forested/Unconsolidated Bottom	-	2.1
Forested/Scrub-Shrub	-	15.0
(subtotal Forested)	*(0.0)*	*(599.5)*
Scrub-Shrub, Deciduous	-	160.6
Scrub-Shrub, Evergreen	-	0.8
Scrub-Shrub/Emergent	-	21.6
Scrub-Shrub/Unconsolidated Shore	-	1.9
(subtotal Scrub-Shrub)	*(0.0)*	*(184.9)*
Unconsolidated Bottom	18.6	189.2
Unconsolidated Shore	1.6	-
Palustrine Subtotal	*20.8*	*1,229.6*
Riverine Wetlands	0.0	75.5
GRAND TOTAL (ALL WETLANDS)	24.0	1,305.1

Table 19. Wetlands in the Ashokan Reservoir Basin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	18	29.6
		Throughflow Perennial (TH)	7	28.9
		(subtotal)	*(25)*	*(58.5)*
	Flat (FL)	Bidirectional (BI)	2	2.9
	Fringe (FR)	Bidirectional (BI)	2	11.1
		Throughflow (TH)	1	8.6
		(subtotal)	*(3)*	*(19.7)*
	Island (IL)	Bidirectional (BI)	5	3.2
	(Subtotal Lentic)		*(35)*	*(84.3)*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	33	217.7
	Fringe (FR)	Throughflow (TH)	22	31.3
	Island (IL)	Throughflow (TH)	3	1.5
	(Subtotal Lotic River)		*(58)*	*(250.5)*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	5	32.8
		Throughflow Intermittent (TI)	16	59.7
		(subtotal)	*(21)*	*(92.6)*
	Flat (FL)	Throughflow (TH)	1	0.8
		Throughflow Intermittent (TI)	4	3.8
		(subtotal)	*(5)*	*(4.6)*
	Floodplain (FP)	Throughflow (TH)	88	394.7
		Throughflow Intermittent (TI)	1	2.7
		(subtotal)	*(89)*	*(397.4)*
	Fringe (FR)	Throughflow (TH)	49	54.7
		Throughflow-Intermittent (TI)	1	15.1
		(subtotal)	*(50)*	*(69.7)*
	Slope (SL)	Throughflow (TH)	1	0.6
	(Subtotal Lotic Stream)		*(166)*	*(564.8)*
Terrene (TE)				
	Basin (BA)	Inflow (IN)	1	0.8
		Isolated (IS)	88	93.0
		Outflow Intemittent (OI)	16	53.7
		Outflow Perennial (OU)	5	36.1
		Throughflow Perennial (TH)	1	2.0
		(subtotal)	*(111)*	*(185.6)*

Flat (FL)	Inflow (IN)	1	1.4
	Isolated (IS)	7	7.0
	Outflow Intermittent (OI)	4	9.3
	(subtotal)	*(12)*	*(17.7)*
Floodplain (FP)	Isolated (IS)	4	3.4
Fringe (FR)	Outflow (OU)	1	3.5
Slope (SL)	Outflow Intermittent (OI)	3	5.8
(Subtotal Terrene)		*(131)*	*(216.1)*
TOTAL LLWW Types*		390	1115.7

*Does not include 209 ponds that totaled 155.4 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Preliminary Assessment of Wetland Functions

The results for each wetland function for the Ashokan Reservoir Basin are given in Table 20. Refer to the maps for locations of these wetlands; maps are hotlinked to the table.

Surface water detention was predicted to be performed at significant levels by 93% of the wetland acreage, while sediment retention was second-ranked with 89% of the acreage contributing to this function. Four other functions were performed at significant levels by more than 60% of the wetland acreage: nutrient transformation (79%), provision of other wildlife habitat (67%), streamflow maintenance (66%), and shoreline stabilization (64%). Less than 30% of the wetland acreage was deemed important for provision of fish habitat (23%) and provision of waterfowl and waterbird habitat (27%). Twenty-two percent of the acreage shaded streams and are potentially important for moderating water temperatures important for fish and other aquatic life.

Table 20. Predicted wetland functions for the Ashokan Reservoir Basin (excluding wetlands within the reservoir). Click on maps to view potential wetlands of significance for each function.

Function	Predicted Level	Acreage	Percent of Wetlands
Surface Water Detention	High	861.0	66
(Map 6)	Moderate	347.1	27
Streamflow Maintenance	High	534.3	41
(Map 7)	Moderate	324.2	25
Nutrient Transformation	High	684.0	52
(Map 8)	Moderate	356.2	27
Sediment Retention	High	818.9	63
(Map 9)	Moderate	342.3	26
Shoreline Stabilization	High	820.5	63
(Map 10)	Moderate	16.0	1
Fish Habitat	High	26.5	2
(Map 11)	Moderate	276.2	21
	Shading	291.3	22
Waterfowl and Waterbird			
Habitat (Map 12)	High	175.8	13
	Moderate	170.6	13
	Wood Duck	6.8	<1
Other Wildlife Habitat	High	387.6	30
(Map 13)	Moderate	479.9	37

Appropriate Use of this Report

The report provides a basic wetland characterization and a preliminary assessment of wetland functions for each NYC reservoir basin in the Delaware and Catskill watersheds. Keeping in mind the limitations mentioned previously, the results are an initial screening of the watershed's wetlands to designate wetlands that may have a significant potential to perform different functions. The targeted wetlands have been predicted to perform a given function at a significant level presumably important to the watershed's ability to provide that function. "Significance" is a relative term and is used in this analysis to identify wetlands that are likely to perform a given function at a level above that of wetlands not designated.

While the results are useful for gaining an overall perspective of a watershed's wetlands and their relative importance in performing certain functions, the report does not identify differences among wetlands of similar type and function. The latter information is often critical for making decisions about wetland acquisition and designating certain wetlands as more important for preservation versus others with the same classification.

The report is useful for general natural resource planning, as a screening tool for prioritization of wetlands (for acquisition or strengthened protection), as an educational tool (e.g., helping the public and nonwetland specialists better understand the functions of wetlands and the relationships between wetland characteristics and performance of individual functions), and for characterizing the differences among wetlands in terms of both form and function within a watershed.

Recommendations for Future Studies

1. <u>Floodplains</u>. While soil mapping may help identify these features, it may be worth limiting use of this landform to wetlands along higher order streams, with wetlands along lower order streams (orders 0,1, and 2) designated as lotic basins or flats depending on the duration of flooding. Alternatively, the landform could be limited to areas where broad valleys contain both wetland and upland plains or more simply to wetlands along "rivers" (polygonal streams). Streamside areas occupied solely by wetlands (no upland floodplain present) might be better classified as basins or flats rather than as floodplains. The present classification protocol described wetlands along rivers and low-gradient streams as floodplain types and those along intermittent streams as basins or flats. This should not, however, greatly effect the functional analysis as these types are accorded the same level of significance for most functions.

2. <u>Headwater wetlands</u>. It may be worth investigating whether this descriptor should be applied to wetlands along third-order streams in mountainous areas.

3. <u>Correlation between NWI water regime and landform</u>. Field work needs to be incorporated into future assessments to verify the following correlations: semipermanently flooded water regime (F) and fringe; seasonally flooded (C, E) and basin (including floodplain-basin); and temporarily flooded (A) and flat (including floodplain-flat). Some wetlands along reservoirs classified as basin wetlands (e.g., PEM1E) may be better described as fringe types if they are marshes. Relying on NWI water regimes for most landform classifications may lead to multiple

landform types within a single wetland. While this may be accurate in some cases (e.g., floodplains), it is worth looking at situations outside the floodplain to see if it is also the best way to classify these wetlands.

4. Intermittent vs. perennial streams. While the distinction is obvious given their definitions, it is often difficult to separate the two on the ground, especially in mountainous and hilly terrain without timely field inspection (e.g., multi-year field visits in late summer). We did notice possible errors in the digital data available for this study as we have on USGS topographic maps from other studies (e.g., intermittent streams designated as perennial streams). Some of the potential problems were based on perennial streams going to intermittent streams and small stretches of intermittent streams between much longer perennial streams. While these situations may be real, they do raise questions as to the classification accuracy of the source data.

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Appendices

Appendix A. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors (Tiner 2003a).

U.S. Fish and Wildlife Service

Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors

September 2003

Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors

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Section 1. Introduction

A wide variety of wetlands have formed across the United States. To describe this diversity and to inventory wetland resources, government agencies and scientists have devised various wetland classification systems (Tiner 1999). Features used to classify wetlands include vegetation, hydrology, water chemistry, origin of water, soil types, landscape position, landform (geomorphology), wetland origin, wetland size, and ecosystem form/energy sources.

The U.S. Fish and Wildlife Service's wetland and deepwater habitat classification (Cowardin et al. 1979) is the national standard for wetland classification. This classification system emphasizes vegetation, substrate, hydrology, water chemistry, and certain impacts (e.g., partly drained, excavated, impounded, and farmed). These properties are important for describing wetlands and separating them into groups for inventory and mapping purposes and for natural resource management. They do not, however, include some abiotic properties important for evaluating wetland functions (Brinson 1993). Moreover, the classification of deepwater habitats is limited mainly to general aquatic ecosystem (marine, estuarine, lacustrine, and riverine) and bottom substrate type, with a few subsystems noted for riverine deepwater habitats. The Service's classification system would benefit from the application of additional descriptors that more fully encompass the range of characteristics associated with wetlands and deepwater habitats.

In the early 1990s, Mark Brinson created a hydrogeomorphic (HGM) classification system to serve as a foundation for wetland evaluation (Brinson 1993). He described the HGM system as "a generic approach to classification and not a specific one to be used in practice" (Brinson 1993, p. 2). This system emphasized the location of a wetland in a watershed (its geomorphic setting), its sources of water, and its hydrodynamics. The system was designed for evaluating similar wetlands in a given geographic area and for developing a set of quantifiable characteristics for "reference wetlands" rather than for inventorying wetland resources (Smith et al. 1995). A series of geographically focused models or "function profiles" for various wetland types have been created and are in development for use in functional assessment (e.g., Brinson et al. 1995, Ainslie et al. 1999, Smith and Klimas 2002).

Need for New Descriptors

The Service's National Wetlands Inventory (NWI) Program has produced wetland maps for 91 percent of the coterminous United States and 35 percent of Alaska. Digital data are available for 46 percent of the former area and for 18 percent of the latter. Although these data represent a wealth of information about U.S. wetlands, they lack hydrogeomorphic and other characteristics needed to perform assessments of wetland functions over broad geographic areas. Using geographic information system (GIS) technology and geospatial databases, it is now possible to predict wetland functions for watersheds - a major natural resource planning unit. Watershed managers could make better use of NWI data if additional descriptors (e.g., hydrogeomorphic-type attributes) were added to the current NWI database. Watershed-based preliminary assessments of wetland functions could be performed. This new information would also permit more detailed characterizations of wetlands for reports and for developing scientific studies and lists of potential reference wetland sites.

Background on Development of Keys

Since the Cowardin et al. wetland classification system (1979) is the national standard and forms the basis of the most extensive wetland database for the country, it would be desirable to develop additional modifiers to enhance the current data. This would greatly increase the value of NWI digital data for natural resource planning, management, and conservation. Unfortunately, Brinson's "A Hydrogeomorphic Classification of Wetlands" (1993) was not designed for use with the Service's wetland classification. He used some terms from the Cowardin et al. system but defined them differently (e.g., Lacustrine and Riverine). Consequently, the Service needed to develop a set of hydrogeomorphic-type descriptors that would be more compatible with its system. Such descriptors would bridge the gap between these two systems, so that NWI data could be used to produce preliminary assessments of wetland functions based on characteristics identified in the NWI digital database. In addition, more descriptive information on deepwater habitats would also be beneficial. For example, identification of the extent of dammed rivers and streams in the United States is a valuable statistic, yet according to the Service's classification dammed rivers are classified as Lacustrine deepwater habitats with no provision for separating dammed rivers from dammed lacustrine waters. Differentiation of estuaries by various properties would also be useful for national or regional inventories.

Recognizing the need to better describe wetlands from the abiotic standpoint in the spirit of the HGM approach, the Service developed a set of dichotomous keys for use with NWI data (Tiner 1997b). The keys bridge the gap between the Service's wetland classification and the HGM system by providing descriptors for landscape position, landform, water flow path and waterbody type (LLWW descriptors) important for producing better characterizations of wetlands and deepwater habitats. The LLWW descriptors for wetlands can be easily correlated with the HGM types to make use of HGM profiles when they become available. The LLWW attributes were designed chiefly as descriptors for the Service's existing classification system (Cowardin et al. 1979) and to be applied to NWI digital data, but they can be used independently to describe a wetland or deepwater habitat. Consequently, there is some overlap with Cowardin et al. since some users may wish to use these descriptors without reference to Cowardin et al.

The first set of dichotomous keys was created to improve descriptions of wetlands in the northeastern United States (Tiner 1995a, b). They were initially used to enhance NWI data for predicting functions of potential wetland restoration sites in Massachusetts (Tiner 1995a, 1997a). Later, the keys were modified for use in predicting wetland functions for watersheds nationwide (Tiner 1997b, 2000). A set of keys for waterbodies was added to improve the Service's ability to characterize wetland and aquatic resources for watersheds.

The keys are periodically updated based on application in various physiographic regions. This version is an update of an earlier set of keys published in 1997 and 2000 (Tiner 1997b, 2000).

Relatively minor changes have been made, including the following: 1) added "drowned river-mouth" modifier to the Fringe and Basin landforms (for use in areas where rivers empty into large lakes such as the Great Lakes where lake influences are significant), 2) added "connecting channels" to river type (to address concerns in the Great Lakes to highlight such areas), 3) added "Throughflow-intermittent" water flow path (to separate throughflow wetlands along intermittent streams from those along perennial streams), 4) added "Throughflow-artificial" and "Outflow-artificial" to water flow path (to identify former "isolated" wetlands or fragmented wetlands that are now throughflow or outflow due to ditch construction), 5) revised the lake key to focus on permanently flooded deepwater sites (note: shallow and seasonally to intermittently flooded sites are wetlands) and added "open embayment" modifier, and 6) revised the estuary type key (consolidated some types). This version also clarifies that a terrene wetland may be associated with a stream where the stream does not periodically flood the wetland. In this case, the stream has relatively little effect on the wetland's hydrology. This is especially true for numerous flatwood wetlands. It also briefly discusses how the term "isolated" is applied relative to surface water and ground water interactions. In the near future, illustrations will be added to this document to aid users in interpretations.

Use of the Keys

Two sets of dichotomous keys (composed of pairs of contrasting statements) are provided - one for wetlands and one for waterbodies. Vegetated wetlands (e.g., marshes, swamps, bogs, flatwoods, and wet meadows) and periodically exposed nonvegetated wetlands (e.g., mudflats, beaches, and other exposed shorelines) should be classified using the wetland keys, while the waterbody keys should be used for permanent deep open water habitats (subtidal or >6.6 feet deep for nontidal waters). Some sites may qualify as both wetlands and waterbodies. A good example is a pond. Shallow ponds less than 20 acres in size meet the Service's definition of wetland, but they are also waterbodies. Such areas can be classified as both wetland and waterbody, if desirable. However, we recommend that ponds be classified using the waterbody keys. Another example would be permanently flooded aquatic beds in the shallow water zone of a lake. We have classified them using wetland hydrogeomorphic descriptors, yet they also clearly represent a section of the lake (waterbody). This approach has worked well for us in producing watershed-based wetland characterizations and preliminary assessments of wetland functions.

Uses of Enhanced Digital Database

Once they are added to existing NWI digital data, the LLWW characteristics (e.g., landscape position, landform, water flow path, and waterbody type) may be used to produce a more complete description of wetland and deepwater habitat characteristics for watersheds. The enhanced NWI digital data may then be used to predict the likely functions of individual wetlands or to estimate the capacity of an entire suite of wetlands to perform certain functions in a watershed. Such work has been done for several watersheds including Maine's Casco Bay watershed and the Nanticoke River and Coastal Bays watersheds in Maryland, the Delaware portion of the Nanticoke River, and numerous small watersheds in New York (see Tiner et al.

1999, 2000, 2001; Machung and Forgione 2002; Tiner 2002; see sample reports on the NWI website:http://wetlands.fws.gov for application of the LLWW descriptors). These characterizations are based on our current knowledge of wetland functions for specific types (Tiner 2003) and may be refined in the future, as needed, based on the applicable HGM profiles and other information. The new terms can also be used to describe wetlands for reports of various kinds including wetland permit reviews, wetland trend reports, and other reports requiring more comprehensive descriptions of individual wetlands.

Organization of this Report

The report is organized into seven sections: 1) Introduction, 2) Wetland Keys, 3) Waterbody Keys, 4) Coding System for LLWW Descriptors (codes used for classifying and mapping wetlands), 5) Acknowledgments, 6) References, and 7) Glossary.

Section 2. Wetland Keys

Three keys are provided to identify wetland landscape position and landform for individual wetlands: Key A for classifying the former and Keys B and C for the latter (for inland wetlands and coastal wetlands, respectively). A fourth key - Key D - addresses the flow of water associated with wetlands.

Users should first identify the landscape position associated with the subject wetland following Key A-1. Afterwards, using Key B-1 for inland wetlands and Key C-1 for salt and brackish wetlands, users will determine the associated landform. The landform keys include provisions for identifying specific regional wetland types such as Carolina bays, pocosins, flatwoods, cypress domes, prairie potholes, playas, woodland vernal pools, West Coast vernal pools, interdunal swales, and salt flats. Key D-1 addresses water flow path descriptors. Various other modifiers may also be applied to better describe wetlands, such as headwater areas; these are included in the four main keys.

Besides the keys provided, there are numerous other attributes that can be used to describe the condition of wetlands. Some examples are other descriptors that address resource condition could be ones that emphasize human modification, (e.g., natural vs. altered, with further subdivisions of the latter descriptor possible), the condition of wetland buffers, or levels of pollution (e.g., no pollution [pristine], low pollution, moderate pollution, and high pollution). Addressing wetland condition, however, was beyond our immediate goal of describing wetlands from a hydrogeomorphic standpoint.

Key A-1: Key to Wetland Landscape Position

This key allows characterization of wetlands based on their location in or along a waterbody, in a drainageway, or in isolation ("geographically isolated" - surrounded by upland).

1. Wetland is completely surrounded by upland (non-hydric soils)....................................**Terrene**
1. Wetland is not surrounded by upland but is connected to a waterbody of some kind................2

2. Wetland is located in or along tidal salt or brackish waters (i.e., an estuary or ocean) including its periodically inundated shoreline (excluding areas formerly under tidal influence)...................3
2. Wetland is not periodically inundated by salt or brackish tides...4

3. Wetland is located in or along the ocean..**Marine**
Go to Key C-1 for coastal landform
3. Wetland is located in or along an estuary (typically a semi-enclosed basin or tidal river where fresh water mixes with sea water)...**Estuarine**
Go to Key E-2 for Estuary Type, then to Key C-1 for coastal landform

> Note: If area was formerly connected to an estuary but now is completely cut-off from tidal flow, consider as one of inland landscape positions - Terrene, Lentic, or Lotic, depending on current site characteristics. Such areas should be designated with a modifier to identify such wetlands as "former estuarine wetland." Lands overflowed infrequently by tides such as overwash areas on barrier islands are considered Estuarine. Tidal freshwater wetlands contiguous to salt/brackish/oligohaline tidal marshes are also considered Estuarine, whereas similar wetlands just upstream along strictly fresh tidal waters are considered Lotic.

4. Wetland is located in or along a lake or reservoir (permanent waterbody where standing water is typically much deeper than 6.6 feet at low water), including streamside wetlands in a lake basin and wetlands behind barrier islands and beaches with open access to a lake............**Lentic**
Go to Key C-2 for Lake Type
Then *Go to Key B-1 for inland landform*

> Note: Lentic wetlands consist of all wetlands in a lake basin (i.e., the depression containing the lake), including lakeside wetlands intersected by streams emptying into the lake. The upstream limit of lentic wetlands is defined by the upstream influence of the lake which is usually approximated by the limits of the basin within which the lake occurs. The streamside lentic wetlands are designated as "Throughflow," thereby emphasizing the stream flow through these wetlands. Other lentic wetlands are typically classified as "Bidirectional-nontidal" since water tables rise and fall with lake levels during the year. Tidally-influenced freshwater lakes have "Bidirectional-tidal" flow.

Modifiers: Natural, Dammed River Valley, Other Dammed - see Key C-2 for others.

4. Wetland does not occur along this type of waterbody...5

5. Wetland is located in a river or stream (including in-stream ponds), within its banks, or on its active floodplain and is periodically flooded by the river or stream...6
5. Wetland is not located in a river or stream or on its active floodplain............................**Terrene**

Note: These wetlands may occur: (1) on a slope or flat, or in a depression (including ponds, potholes, and playas) lacking a stream but contiguous to a river or stream, (2) on a historic (inactive) floodplain, or (3) in a landscape position crossed by a stream (e.g., an entrenched stream), but where the stream does not periodically inundate the wetland.
Go to Key B-1 for inland landform

6. Wetland is the source of a river or stream but this watercourse does not extend through the wetland...**Terrene**

Modifiers: May include Headwater for wetlands that are sources of streams and Estuarine Discharge or Marine Discharge for wetlands whose outflow goes directly to an estuary or the ocean, respectively.

6. Wetland is located in a river or stream, within its banks, or on its active floodplain..................7

7. Wetland is associated with a river (a broad channel mapped as a polygon or 2-lined watercourse on a 1:24,000 U.S. Geological Survey topographic map) or its active floodplain........ ....**Lotic River**
Go to Couplet "a" below
(*Also see note under first couplet #3 - Lentic re: streamside wetlands in lake basins*)

7. Wetland is associated with a stream (a.linear or single-line watercourse on a 1:24,000 U.S. Geological Survey topographic map) or its active floodplain...................................**Lotic Stream**
Go to Couplet "a" below
(*Also see note under first couplet #3 - Lentic re: streamside wetlands in lake basins*)

Note: Artificial drainageways (i.e., ditches) are not considered part of the Lotic classification, whereas channelized streams are part of the Lotic landscape position.

Modifiers: Headwater (wetlands along first-order streams and possibly second-order streams and large wetlands in upper portion of watershed believed to be significant groundwater discharge sites) and Channelized (excavated stream course).

a. Water flow is under tidal influence (freshwater tidal wetlands)..............**Tidal Gradient**

Go to Key B-1 for inland landform

a. Water flow is not under tidal influence (nontidal)..b

b. Water flow is dammed, yet still flowing downstream, at least seasonally.........................
....**Dammed Reach**

Go to Key B-1 for inland landform

Modifiers: Lock and Dammed, Run-of-River Dam, Beaver Dam, and Other Dam (see Waterbody Key B-2 for further information).

b. Water flow is unrestricted..c

c. Water flow is intermittent during the year..................................**Intermittent Gradient**

Go to Key B-1 for inland landform

c. Water flow is perennial (year-round)..d

d. Water flow is generally rapid due to steep gradient; typically little or no floodplain development; watercourse is generally shallow with rock, cobbles, or gravel bottoms; first- and second-order "streams" in hilly to mountainous terrain; part of Cowardin's Upper Perennial Subsystem...**High Gradient**

Go to Key B-1 for inland landform

d. Watercourse characteristics are not so; "stream" order greater than 2 in hilly to mountainous terrain...e

e. Water flow is generally slow; typically with extensive floodplain; water course shallow or deep with mud or sand bottoms; typically fifth and higher order "streams", but includes lower order streams in nearly level landscapes such as the Great Lakes Plain (former glacial lakebed) and the Coastal Plain, and ditches; the lower order streams may lack significant floodplain development); Cowardin's Lower Perennial subsystem....................
....**Low Gradient**

Go to Key B-1 for inland landform

e. Water flow is fast to moderate; with little to some floodplain; usually third-, fourth- and higher order "streams" associated with hilly to mountainous terrain; part of Cowardin's Upper Perennial Subsystem...**Middle Gradient**

Go to Key B-1 for inland landform

Key B-1: Key to Inland Landforms

1. Wetland occurs on a noticeable slope (e.g., greater than a 2 percent slope)........**Slope Wetland**
Go to Key D-1 for water flow path

> *Modifiers* can be applied to Slope Wetlands to designate the type of inflow or outflow as Channelized Inflow or Outflow (intermittent or perennial, stream or river), Nonchannelized Inflow or Outflow (wetland lacking stream, but connected by observable surface seepage flow), or Nonchannelized-Subsurface Inflow or Outflow (suspected subsurface flow from or to a neighboring wetland upslope or downslope, respectively).

1. Wetland does not occur on a distinct slope...2

2. Wetland forms an island..**Island Wetland**
(*Go to Key D-1 for water flow path*)

> Note: Can designate an island formed in a delta at the mouth of a river or stream as a Delta Island Wetland; other islands are associated with landscape positions (e.g., lotic river island wetland, lotic stream island wetland, lentic island wetland, or terrene island pond wetland). Vegetation class and subclass from Cowardin et al. 1979 should be applied to characterize the vegetation of these wetland islands; vegetation is assumed to be rooted unless designated by a *modifier* - "Floating Mat" to indicate a floating island.

2. Wetland does not form an island...3

3. Wetland occurs within the banks of a river or stream or along the shores of a pond, lake, or island, or behind a barrier beach or island, and is either: (1) vegetated *and* typically permanently inundated, semipermanently flooded (including their tidal freshwater equivalents plus seasonally flooded-tidal palustrine emergent wetlands which tend to be flooded frequently by the tides) or otherwise flooded for most of the growing season, or permanently saturated due to this location or (2) a nonvegetated bank or shore that is temporarily or seasonally flooded ......**Fringe Wetland**

Go to Couplet "a" below for Types of Fringe Wetlands
Then *Go to Key D-1 for water flow path*

Attention: *Seasonally to temporarily flooded vegetated wetlands along rivers and streams (including tidal freshwater reaches) are classified as either Floodplain, Basin, or Flat landforms - see applicable categories.*

> a. Wetland forms along the shores of an upland island within a lake, pond, river, or stream..b
> a. Wetland does not form along the shores of an island...d

> b. Wetland forms behind a barrier island or beach spit along a lake..............Lentic Barrier Island Fringe Wetland or Lentic Barrier Beach Fringe Wetland

Modifier: Drowned River-mouth

b. Wetland forms along another type of island...c

c. Wetland forms along an upland island in a river or stream..................Lotic River Island Fringe Wetland or Lotic Stream Island Fringe Wetland

c. Wetland forms along an upland island in a lake or pond..................Lentic Island Fringe Wetland or Terrene Pond Island Fringe Wetland

d. Wetland forms in or along a river or stream.........................Lotic River Fringe Wetland or Lotic Stream Fringe Wetland

d. Wetland forms in or along a pond or lake..e

e. Wetland forms along a pond shore..f

e. Wetland forms along a lake shore..Lentic Fringe Wetland

Modifier: Drowned River-mouth

f. Wetland occurs along an in-stream pond..Lotic River or Stream Fringe Pond Wetland Throughflow

f. Wetland occurs in another type of pond............................Terrene Fringe Pond Wetland

Note: Vegetation is assumed to be rooted unless designated by a *modifier* to indicate a floating mat (Floating Mat).

3. Wetland does not exist along these shores..4

4. Wetland occurs on an active floodplain (alluvial processes in effect).......................**Floodplain Wetland*** (could specify the river system, if desirable). *Go to Key D-1 for water flow path* Sub-landforms are listed below.

a. Wetland forms along the shores of a river island...................Floodplain Island Wetland

a. Wetland is not along an island..b

b. Wetland forms in a depressional feature on a floodplain.........Floodplain Basin Wetland or Floodplain Oxbow Wetland (a special type of depression)

b. Wetland forms on a broad nearly level terrace..........................Floodplain Flat Wetland

*Note: Questionable floodplain areas may be verified by consulting soil surveys and locating the presence of alluvial soils, e.g., Fluvaquents or Fluvents, or soils with Fluvaquentic subgroups. While most Floodplain wetlands will have a Throughflow water flow path; others may be designated, e.g., Inflow, Outflow, or Isolated. Former floodplain wetlands are classified as Basins or Flats and designated as former floodplain.

Modifiers: Partly Drained; Confluence wetland - wetland at the intersection of two or more streams; River-mouth or stream-mouth wetland - wetland at point where a river and stream empties into lake; Meander scar wetland - floodplain basin wetland, the remnant of a former river meander.

4. Wetland does not occur on an active floodplain..5

5. Wetland occurs on an interstream divide (interfluve)...................................**Interfluve Wetland** or specify *regional types* of interfluve wetlands, for example: *Carolina Bay Interfluve Wetland*, *Pocosin Interfluve Wetland*, and *Flatwood Interfluve Wetland* (Southeast). Sub-landforms are listed below. *Go to Key D-1 for water flow path*

a. Wetland forms in a depressional feature................................... Interfluve Basin Wetland

a. Wetland forms on a broad nearly level terrace ....Interfluve Flat Wetland

Modifiers: Partly Drained.

5. Wetland does not occur on an interfluve..6

6. Wetland exists in a distinct depression in various positions on the landscape (i.e., surrounded by upland, along smaller rivers and streams, along in-stream ponds, along lake shores, or on former floodplains or interfluves)............ **Basin Wetland** or **Basin Wetland Former Floodplain** (including *Basin Oxbow Wetland Former Floodplain*) or **Basin Wetland Former Interfluve**. Can specify regional types: *Carolina Bay Basin Wetland* and *Pocosin Basin Wetland* (Atlantic Coastal Plain), *Cypress Dome Basin Wetland* (Florida), *Prairie Pothole Basin Wetland* (Upper Midwest), *"Salt Flat" Basin Wetland* (arid West), *Playa Basin Wetland* (Southwest), *West Coast Vernal Pool Basin Wetland* (California and Pacific Northwest), *Interdunal Basin Wetland* (sand dunes), *Woodland Vernal Pool Basin Wetland* (forests throughout the country), *Polygonal Basin Wetland* (Alaska), *Sinkhole Basin Wetland* (karst/limestone regions), *Pond Wetland Basin* (throughout country), or some type of *Island Basin Wetland* for basin wetlands on islands.

Go to Key D-1 for water flow path

Modifiers may be applied to indicate artificially created basins due to beaver activity or human actions or artificially drained basins including: Beaver (beaver-created); wetlands created for various purposes or unintentionally formed due to human activities - may want to specify purpose like Aquaculture (e.g., fish and crayfish), Wildlife management (e.g., waterfowl impoundments), and Former floodplain, or to designate former salt marsh that is now nontidal (Former estuarine wetland). Other *modifiers* may be applied to designate the type of inflow or outflow as Channelized (intermittent or perennial, stream or river), Nonchannelized-wetland (contiguous wetland lacking stream), or Nonchannelized-subsurface flow (suspected subsurface flow to neighboring wetland), or to identify a headwater basin (Headwater) or a drainage divide wetland that discharges into two or more watershed (Drainage divide), or to denote a spring-fed wetland (Spring-fed), a wetland bordering a pond (Pond basin wetland) and a wetland bordering an upland island in a pond (Pond island border). For lotic basin wetlands, consider additional modifiers such as Confluence wetland - wetland at the intersection of two or more streams; River-mouth or Stream-mouth wetland - wetland at point where a river and a stream empties into a lake. For lentic basins associated with the Great Lakes, possibly identify Drowned River-mouth wetlands where mouth extends into the lake basin. Partly drained may be used for ditched/drained wetlands.

6. Wetland exists in a relatively level area..**Flat Wetland** or specify *regional types* of flat wetlands, for example: **Salt Flat Wetland** (in the Great Basin) or flats that are fragments of once-larger interfluve flats or former floodplains: **Flat Wetland, Former Interfluve** or **Flat Wetland, Former Floodplain**.

Go to Key D-1 for water flow path

Note: If desirable, a *modifier* for drained flats can be applied (Partly drained). Other modifiers can be applied to designate the type of inflow or outflow as Channelized (intermittent or perennial, stream or river), Nonchannelized-wetland (contiguous wetland lacking stream), or Nonchannelized-subsurface flow (suspected subsurface flow to neighboring wetland). For lotic flat wetlands, consider additional modifiers such as confluence wetland - wetland at the intersection of two or more streams; river-mouth or stream-mouth wetland - wetland at point where a river and a stream empties into a lake.

Key C-1: Key to Coastal Landforms

1. Wetland forms a distinct island in an inlet, river, or embayment........................**Island Wetland**

Go to Key D-1 for water flow path

a. Occurs in a delta..Delta Island Wetland
(Could identify flood delta and ebb delta islands for tidal inlets if desirable.)
a. Occurs elsewhere either in a river or an embayment ....b

b. Occurs in a river...River Island Wetland
b. Occurs in a coastal embayment..Bay Island Wetland

1. Wetland does not form such an island, but occurs behind barrier islands and beaches, or along the shores embayments, rivers, streams, and islands..2

2. Wetland occurs along the shore, contiguous with the estuarine waterbody.......**Fringe Wetland**

Go to Key D-1 for water flow path

a. Occurs behind a barrier island or barrier beach spit...........Barrier Island Fringe Wetland or Barrier Beach Fringe Wetland [*Modifier* for overwash areas: Overwash]
a. Occurs elsewhere...b

b. Occurs along a coastal embayment or along an island in a bay.........Bay Fringe Wetland or Bay Island Fringe Wetland or Coastal Pond Fringe Wetland (a special type of embayment, typically with periodic connection to the ocean unless artificially connected by a bulkheaded inlet) or Coastal Pond Island Fringe Wetland

b. Occurs elsewhere..c

c. Occurs along a coastal river or along an island in a river................River Fringe Wetland or River Island Fringe Wetland

c. Occurs elsewhere..d

d. Occurs along an oceanic island..Ocean Island Fringe Wetland

d. Occurs along the shores of exposed rocky mainland...............Headland Fringe Wetland

2. Wetland is separated from main body of marsh by natural or artificial means; the former may be connected by a tidal stream extending through the upland or by washover channels (e.g., estuarine intertidal swales), whereas the latter occurs in an artificial impoundment or behind a road or railroad embankment where tidal flow is at least somewhat restricted........**Basin Wetland**

Go to Key D-1 for water flow path

Modifiers may be applied to separate natural from created basins (managed fish and wildlife areas; aquaculture impoundments; salt hay diked lands; tidally restricted-road, and tidally restricted-railroad), and for other situations, as needed.

Key D-1: Key to Water Flow Paths

1. Wetland is periodically flooded by tides...**Bidirectional-tidal**
   See Key F-2 for additional descriptors based on tidal ranges (i.e., macrotidal, mesotidal, and microtidal).
1. Wetland is not flooded by tides..2

2. Water levels fluctuate due to lake influences or to variable river levels, but water does not flow through this wetland..**Bidirectional-nontidal**

Note: Lentic wetlands with streams running through them are classified as Throughflow to emphasize this additional water source, while lentic wetlands located in coves or fringing the high ground would typically be classified as Bidirectional-Nontidal. Similarly, many floodplain wetlands are throughflow types, while some are connected to the river through a single channel in which water rises and falls with changing river levels. The water flow path of the latter types is best classified as bidirectional-nontidal.

2. Wetland is not subject to lake influences..3

3. Wetland is formed by paludification processes where in areas of low evapotranspiration and high rainfall, peat moss moves uphill creating wetlands on hillslopes (i.e., wetland develops upslope of primary water source)...**Paludified**
3. Wetland is not formed by paludification processes...4

4. Wetland receives surface or ground water from a stream, other waterbody or wetland (i.e., at a higher elevation) and surface or ground water passes through the subject wetland to a stream, another wetland, or other waterbody at a lower elevation; a flow-through system....**Throughflow**, **Throughflow-intermittent***, **Throughflow-entrenched***, or **Throughflow-artificial***

> *Modifiers*: Groundwater-dominated throughflow wetlands can be separated from Surface water-dominated throughflow wetlands.
>
> *Note: **Throughflow-intermittent** is to be used with throughflow wetlands along intermittent streams; **Throughflow-entrenched** indicates that stream flow is through a wetland but the stream is deeply cut and does not overflow into the wetland (therefore the stream is, for practical purposes, separate from the wetland) - this water flow path is intended to be used with Terrene wetlands in this situation; **Throughflow-artificial** is used to designate wetlands where throughflow is human-caused - usually to indicate connection of Terrene wetlands to other Terrene wetlands and waters by ditches and not by streams either natural or channelized

4. Water does not pass through this wetland to other wetlands or waters...................................5

5. There is no surface or groundwater inflow from a stream, other waterbody, or wetland (i.e., no documented surface or ground water inflow from a wetland or other waterbody at a higher elevation) and no observable or known outflow of surface or ground water to other wetlands or waters...**Isolated**

Attention: *In most applications, isolation is interpreted as "geographically isolated" since groundwater connections are typically unknown for specific wetlands. For practical purposes then," isolated" means no obvious surface water connection to other wetlands and waters. If hydrologic data exist for a locale that documents groundwater linkages, such wetlands should be identified as either outflow. inflow, or throughflow with a "Groundwater-dominated" modifier and not be identified as isolated unless the whole network of wetlands is not connected to a stream or river. In the latter case, the network is a collection of interconnected isolated wetlands.*

5. Wetland is not hydrologically or geographically isolated...6

6. Wetland receives surface or ground water inflow from a wetland or other waterbody

(perennial or intermittent) at a higher elevation <u>and</u> there is no observable or known significant outflow of surface or ground water to a stream, wetland or waterbody at a lower elevation ....**Inflow**

> *Modifiers*: <u>Groundwater-dominated</u> inflow wetlands can be separated from <u>Surface water-dominated</u> inflow wetlands; <u>Human-caused</u> (usually to indicate connection of Terrene wetlands to other Terrene wetlands and waters [e.g., Inflow human-caused] by ditches and not by streams either natural or channelized).

6. Wetland receives no surface or ground water inflow from a wetland or permanent waterbody at a higher elevation (may receive flow from intermittent streams only) <u>and</u> surface or ground water is discharged from this wetland to a stream, wetland, or other waterbody at a lower elevation...**Outflow** or **Outflow-artificial***

> *Modifiers:* <u>Groundwater-dominated</u> outflow wetlands can be separated from <u>Surface water-dominated</u> outflow wetlands. Might consider separating perennial outflow (**Outflow-perennial**) from intermitttent outflow (**Outflow-intermittent**), if interested.

> *<u>Note</u>: Outflow-artificial is usually used to indicate outflow from formerly isolated wetlands resulting by ditches.

Section 3. Waterbody Keys

These keys are designed to expand the classification of waterbodies beyond the system and subsystem levels in the Service's wetland classification system (Cowardin et al. 1979). Users are advised first to classify the waterbody in one of the five ecosystems: 1) marine (open ocean and associated coastline), 2) estuarine (mixing zone of fresh and ocean-derived salt water), 3) lacustrine (lakes, reservoirs, large impoundments, and dammed rivers), 4) riverine (undammed rivers and tributaries), and 5) palustrine (e.g., nontidal ponds) and then apply the waterbody type descriptors below.

Five sets of keys are given. Key A-2 helps describe the major waterbody type. Key B-2 identifies different stream gradients for rivers and streams. It is similar to the subsystems of Cowardin's Riverine system, but includes provisions for dammed rivers to be identified as well as a middle gradient reach similar to that of Brinson's hydrogeomorphic classification system. The third key, Key C-2, addresses lake types, while Keys D-2 and E-2 further define ocean and estuary types, respectively. Key F-2 is a key to water flow paths of waterbodies. Key G-2 is for describing general circulation patterns in estuaries. The coastal terminology applies concepts of coastal hydrogeomorphology.

Besides the keys provided, there are numerous other attributes that can be used to describe the condition of waterbodies. Some examples are other descriptors that address resource condition could be ones that emphasize human modification, (e.g., natural vs. altered, with further subdivisions of the latter descriptor possible), the condition of waterbody buffers (e.g., stream corridors), or levels of pollution (e.g., no pollution [pristine], low pollution, moderate pollution, and high pollution).

Key A-2. Key to Major Waterbody Type

1. Waterbody is predominantly flowing water...2
1. Waterbody is predominantly standing water...7

Note: Fresh waterbodies may be tidal; if so, waterbody is classified as a Tidal Lake or Tidal Pond using criteria below to separate lakes from ponds.

2. Flow is unidirectional and waterbody is a river, stream, or similar channel..............................3
2. Flow is tidal (bidirectional) at least seasonally; waterbody is an ocean, embayment, river, stream, or lake...4

3. Waterbody is a polygonal feature on a U.S. Geological Survey map or a National Wetlands Inventory Map (1:24,000/1:25,000)..**River**
3. Waterbody is a linear feature on such maps...**Stream**
Go to River/Stream Gradient Key - Key B-2 - for other modifiers

4. Waterbody is freshwater...5
4. Waterbody is salt or brackish...6

5. Waterbody is a polygonal feature on a U.S. Geological Survey map or a National Wetlands Inventory Map (1:24,000/1:25,000)..**River**
5. Waterbody is a linear feature on such maps...**Stream**
Go to River/Stream Gradient Key - Key B-2 - for other modifiers

6. Part of a major ocean or its associated embayment (Marine system of Cowardin et al. 1979) ....**Ocean**

Go to Ocean Key - Key D-2

6. Part of an estuary where fresh water mixes with salt water (Estuarine system of Cowardin et al. 1979)...**Estuary**

Go to Estuary Key - Key E-2

7. Waterbody is freshwater...8
7. Waterbody is salt or brackish and tidal...10

8. Waterbody is permanently flooded and deep (>than 6.6 ft at low water), excluding small

"kettle or bog ponds" (i.e., usually less than 5 acres in size and surrounded by bog vegetation)..**Lake**

Go to Lake Key - Key C-2

8. Waterbody is shallow (< 6.6 ft at low water) or a small "kettle or bog pond" (with deeper water)..9

9. Waterbody is small (< 20 acres)...**Pond**

Separate natural from artificial ponds, then add other modifiers like the following. Some *examples* of modifiers for ponds: beaver, alligator, marsh, swamp, vernal, Prairie Pothole, Sandhill, sinkhole/karst, Grady, interdunal, farm-cropland, farm-livestock, golf, industrial, sewage/wastewater treatment, stormwater, aquaculture-catfish, aquaculture-shrimp, aquaculture-crayfish, cranberry, irrigation, aesthetic-business, acid-mine, arctic polygonal, kettle, bog, woodland, borrow pit, Carolina bay, tundra, coastal plain, tidal, and in-stream.

Note: Wetlands associated with ponds are typically either Terrene basin wetlands, such as a Cypress dome or cypress-gum pond, or Terrene pond fringe wetlands, such as semipermanently flooded wetlands along margins of pond. In-stream ponds are in the Lotic landscape position.

9. Waterbody is large (≥20 acres)...**Lake**

Go to Lake Key - Key C-2

10. Part of a major ocean or its associated embayment (Marine system of Cowardin et al. 1979) ....**Ocean**

Go to Ocean Key - Key D-2

10. Part of an estuary where fresh water mixes with salt water (Estuarine system of Cowardin et al. 1979)...**Estuary**

Go to Estuary Key - Key E-2

Key B-2. River/Stream Gradient and Other Modifiers Key

Please note that the river/stream gradient extends from the freshwater tidal zone through the intermittent reach. The limits of the latter are typically defined by drainageways with well-defined channels that discharge water seasonally. From a practical standpoint, the limits of the lotic system are displayed on 1:24,000 U.S. Geological Survey topographic maps or similar digital data. Intermittent streams, certain dammed portions of rivers plus lock and dammed canal systems may be classified as rivers using the descriptors presented in these keys. In the Cowardin et al. system, they may be classified as Riverine Intermittent Streambed or Lacustrine Unconsolidated Bottom, respectively.

1. Water flow is under tidal influence..**Tidal Gradient**

> *Type of tidal river or stream*: 1) natural river, 2) natural stream, 3) channelized river, 4) channelized stream, 5) canal (artificial polygonal lotic feature), 6) ditch (artificial linear lotic feature), 7) restored river segment (part of river where restoration was performed), and 8) restored stream segment (part of stream where restoration was performed).

1. Water flow is not under tidal influence (nontidal)..2

2. Water flow is dammed, yet still flowing downstream at least seasonally..........**Dammed Reach**

> *Type of dammed river*: 1) lock and dammed (canalized river, a series of locks and dams are present to aid navigation), 2) run-of-river dammed (low dam allowing flow during high water periods; often used for low-head hydropower generation), and 3) other dammed (unspecified, but not major western hydropower dam as such waterbodies are considered lakes, e.g., Lake Mead and Lake Powell).

2. Water flow is unrestricted..3

3. Water flow is perennial (year-round); perennial rivers and streams...4
3. Water flow is seasonal or aperiodic (intermittent); Cowardin's Intermittent Subsystem ....
....**Intermittent Gradient***

4. Water flow is generally rapid due to steep gradient; typically little or no floodplain development; watercourse is generally shallow with rock, cobbles, or gravel bottoms; first and second order "streams"; part of Cowardin's Upper Perennial subsystem...............**High Gradient***
4. Water flow is not so; some to much floodplain development...5

5. Water flow is generally slow; typically with extensive floodplain; water course shallow or deep with mud or sand bottoms; typically fifth and higher order "streams", but includes lower order streams in nearly level landscapes such as the Great Lakes Plain (former glacial lakebed) and the Coastal Plain (the latter streams may lack significant floodplain development); Cowardin's Lower Perennial subsystem ....**Low Gradient***
5. Water flow is fast to moderate; with little to some floodplain; usually third and fourth order "streams"; part of Cowardin's Upper Perennial subsystem.................................**Middle Gradient***

**Type of river or stream* - additional modifiers that may be applied as desired: 1) natural river-single thread (one channel), 2) natural river-multiple thread (braided) (multiple, wide, shallow channels), 3) natural river-multiple thread (anastomosed) (multiple, deep narrow channels), 4) natural stream-single thread, 5) channelized river (dredged/excavated), 6) channelized stream, 7) canal (artificial polygonal lotic feature), 8) ditch (artificial linear lotic feature), 9) restored river segment (part of river where restoration was performed), 10) restored stream segment (part of stream where restoration was performed), and 11) connecting channel (joins two lakes). Other possible descriptors: 1) for perennial rivers and streams - riffles (shallow, rippling water areas), pools (deeper, quiet water areas), and waterfalls (cascades), 2) for water depth of perennial rivers - deep rivers (≥6.6 ft at low water) from shallow rivers (<6.6 ft at low water), 3) nontidal river or stream segment emptying into an estuary, ocean, or lake (estuary-discharge, marine-discharge, or lake-discharge), 4) classification by stream order (1^{st}, 2^{nd}, 3^{rd}, etc. for perennial segments), and 5) channels patterns (straight, slight meandering, moderate meandering, and high meandering).

Key C-2. Key to Lakes.

The lake designation is for permanently flooded deep waters (>6.6 feet). Some classification systems include shallow waterbodies or periodically exposed areas as "lakes." The Cowardin et al. system considers standing waterbodies larger than 20 acres to be part of the lacustrine system (regardless of water depth; shallow = wetlands; >6.6 feet = deepwater habitat), and smaller ones typically part of the palustrine wetlands. For our purposes, "shallow lakes" and "seasonal or intermittent lakes" are considered some type of terrene or lotic wetland depending on the presence and location of a stream. Lentic wetlands are associated with permanently flooded standing waterbodies deeper than 6.6 feet at low water.

1. Waterbody is not dammed or impounded..**Natural Lake**

> *Modifiers*: Main body, Open embayment, Semi-enclosed embayment, Barrier beach lagoon, Seiche-influenced, River-fed and Stream-fed descriptors. Can also use applicable modifiers listed under Pond (see Key A-2).
>
> *Can use additional modifiers listed under Pond (see Key A-2) and others (e.g., crater, lava flow, aeolian, fjord, oxbow, other floodplain, glacial, alkali, and manmade), as appropriate.

1. Waterbody is dammed, impounded, or excavated 2

2. Waterbody is dammed or impounded..3
2. Waterbody is excavated..**Excavated Lake**

3. Dammed river valley..**Dammed River Valley Lake**

> *Modifiers*: Reservoir, Hydropower, and Seiche-influenced; also River-fed and Stream-fed descriptors.

Note: When the dam inundates former floodplains and other low-lying areas, the waterbody is considered a Dammed River Valley Lake. If the dam crosses a higher gradient river and increase water depth in an channel without significant flooding of much neighboring "land," the waterbody is considered the dammed reach of a river.

3. Dammed natural lake or other landscape..**Other Dammed Lake**

Modifiers: Former natural lake, Artificial lake, River-fed and Stream-fed descriptors.

Key D-2. Ocean Key.

1. Waterbody is completely open, not protected by any feature.................................**Open Ocean**
(Can further identify open bays if desirable.)
1. Waterbody is somewhat protected...2

2. Associated with coral reef or island 3

2. Not associated with coral reef or island..4

3. Open but protected by coral reef ....**Reef-protected Waters**
3. Protected by a coral island...**Atoll Lagoon**

4. Deep embayment cut by glaciers, with an underwater sill at front end, restricting circulation; associated with rocky headlands...**Fjord**
4. Other semi-protected embayment...**Semi-protected Oceanic Bay**

Modifiers for all types above: Submerged vegetation (e.g., eelgrass or turtle-grass) or Floating vegetation (e.g., macroalgae such as kelp beds).

Key E-2. Estuary Key.

The following types should encompass most of the estuaries located in the United States. There may be estuaries that do not fit within this classification. Such types should be brought to the attention of the author.

1. Estuary is surrounded by rocky headlands and shores..2
1. Estuary is not surrounded by rocky headlands and shores...4

2. Deep embayment cut by glaciers, with an underwater sill at front end, restricting circulation

(e.g., Puget Sound)...**Fjord Estuary**
2. Not so, either open or semi-enclosed..3

3. Protected by islands......................................**Island Protected Rocky Headland Bay Estuary**
3. Not protected by islands...**Rocky Headland Bay Estuary**

Modifiers: Open or Semi-enclosed

4. Estuary is tectonically formed (e.g., San Francisco Bay), including volcanic activity..................
....**Tectonic Estuary**

Modifiers: Fault-formed and Volcanic-formed

4. Estuary is not tectonically formed or is formed by volcanic activity...5

5. Estuary is river-dominated with very little tidal range and a delta formed at the mouth of the river where it enters the sea (e.g., Mississippi River Delta)..................**River-dominated Estuary**
5. Estuary is not river-dominated...6

6. Estuary is a drowned river valley (e.g., Chesapeake Bay)........**Drowned River Valley Estuary**

Modifiers: Open Bay, River Channel, and Semi-enclosed Bay

6. Estuary is not a drowned river valley...7

7. Estuary formed behind and is protected by sandy barrier islands or barrier beaches (spits)..**Bar-built Estuary**

Modifiers: Coastal Pond (oligohaline to saline) and Hypersaline Lagoon (hypersaline)

7. Estuary is not behind sandy barrier islands or beaches...8

8. Estuary is protected by reefs or other islands......................................**Island Protected Estuary**
8. Estuary is an open or semi-enclosed embayment....................................**Shoreline Bay Estuary**

Modifiers for all estuarine waterbodies: Inlet (includes any ebb- or flood- deltas that are completed submerged), Stabilized Inlet, Shoal (shallow water area), Submerged vegetation (e.g., eelgrass or turtle-grass) or Floating vegetation (e.g., macroalgae such as kelp beds).

Key F-2. Key to Water Flow Paths

1. Water flow is tidally influenced..2
1. Water flow is not under the influence of the tides...4

2. Tide range is greater than 4m (approx. >12 feet) ....**Macrotidal**
2. Tidal range is less than 4m 3

3. Tidal range is 2-4m (approx. 6-12 feet) ....**Mesotidal**
3. Tidal range is less than 2m (approx. < 6 feet) ....**Microtidal**

4. Water flows out of the waterbody via a river, stream, or ditch, with little or no inflow (inflow could be from intermittent streams or ground water only) ....**Outflow**

> *Modifier*: Human-caused for inflow via a ditch network. Might consider separating perennial outflow (**Outflow-perennial**) from intermitttent outflow (**Outflow-intermittent**), if interested.

4. Water flow is not so...5

5. Water enters waterbody from river, stream, or ditch, flows through it, and continues to flow downstream...**Throughflow** or **Throughflow-intermittent**

> *Modifier*: Human-caused for throughflow via a ditch network
>
> Note: Throughflow intermittent is applied to intermittent streams

5. Water flow is not throughflow..6

6. Water flows in and out of the waterbody through the same channel; it does not flow through the waterbody..**Bidirectional-nontidal**

6. Water flow is not bidirectional...7

7. Water flow enters via a river, stream, or ditch, but does not exit pond, lake or reservoir; waterbody serves as a sink for water...**Inflow**

> *Modifier*: Human-caused for inflow via a ditch network.

7. No apparent channelized inflow, source of water either by precipitation or by underground sources...**Isolated**

Attention: *In most applications, isolation is interpreted as "geographically isolated" since groundwater connections are typically unknown for specific waterbodies. For practical* *purposes then," isolated" means no obvious surface water connection to other wetlands and waters. If hydrologic data exist for a locale that document groundwater linkages, such waterbodies should be identified as either outflow. inflow, or throughflow <u>with a "Groundwater-dominated" modifier added</u> and not be identified as isolated <u>unless</u> the whole network of waterbodies is not connected to a stream or river. In the latter case, the network is a collection of interconnected isolated waterbodies.*

Key G-2. Key to Estuarine Hydrologic Circulation Types

1. Estuary is river-dominated with distinct salt wedge moving seasonally up and down the river; fresh water at surface with most saline waters at bottom; low energy system with silt and clay bottoms ....**Salt-wedge Estuary**
1. Estuary is not river-dominated 2

2. Estuarine water is well-mixed, no significant salinity stratification, salinity more or less the same from top to bottom of water column; high-energy system with sand bottom...............
....**Homogeneous Estuary**
2. Estuarine water is partially mixed, salinities different from top to bottom, but not strongly stratified; low energy system ....**Partially Mixed Estuary**

Section 4. Coding System for LLWW Descriptors

The following is the coding scheme for expanding classification of wetlands and waterbodies beyond typical NWI classifications. When enhancing NWI maps/digits, codes should be applied to all mapped wetlands and deepwater habitats (including linears). At a minimum, landscape position (including lotic gradient), landform, and water flow path should be applied to wetlands, and waterbody type and water flow path to water to waterbodies. Wetland and deepwater habitat data for specific estuaries, lakes, and river systems could be added to existing digital data through use of geographic information system (GIS) technology.

Codes for Wetlands

Wetlands are typically classified by landscape position, landform, and water flow path. Landforms are grouped according to Inland types and Coastal types with the latter referring to tidal wetlands associated with marine and estuarine waters. Use of other descriptors tends to be optional. They would be used for more detailed investigations and characterizations.

<u>Landscape Position</u>

ES	Estuarine
LE	Lentic
LR	Lotic river
LS	Lotic stream
MA	Marine
TE	Terrene

<u>Lotic Gradient</u>

1	Low	
2	Middle	
3	High	
4	Intermittent	
5	Tidal	
6	Dammed	
a		lock and dammed
b		run-of-river dam
c		beaver
d		other dammed
7	Artificial (ditch)	

Lentic Type

1	Natural deep lake (see also Pond codes for possible specific types)	
a		main body
b		open empbayment
c		semi-enclosed embayment
d		barrier beach lagoon
2	Dammed river valley lake	
a		reservoir
b		hydropower
c		other
3	Other dammed lake	
a		former natural
b		artificial
4	Excavated lake	
a		quarry lake
5	Other artificial lake	

Estuary Type

1	Drowned river valley estuary	
a		open bay (fully exposed)
b		semi-enclosed bay
c		river channel
2	Bar-built estuary	
a		coastal pond-open
b		coastal pond-seasonally closed
c		coastal pond-intermittently open
d		hypersaline lagoon
3	River-dominated estuary	
4	Rocky headland bay estuary	
a		island protected
5	Island protected estuary	
6	Shoreline bay estuary	
a		open (fully exposed)
b		semi-enclosed
7	Tectonic	
a		fault-formed
b		volcanic-formed
8	Fjord	
9	Other	

Inland Landform

SL	Slope	
SLpa		Slope, paludified
IL	Island*	
ILde		Island, delta
ILrs		Island, reservoir
ILpd		Island, pond
FR	Fringe*	
FRil		Fringe, island*
FRbl		Fringe, barrier island
FRbb		Fringe, barrier beach
FRpd		Fringe, pond
FRdm		Fringe, drowned river mouth
FP	Floodplain	
FPba		Floodplain, basin
FPox		Floodplain, oxbow
FPfl		Floodplain, flat
FPil		Floodplain, island
IF	Interfluve	
IFba		Interfluve, basin
IFfl		Interfluve, flat
BA	Basin	
BAcb		Basin, Carolina bay
BApo		Basin, pocosin
BAcd		Basin, cypress dome
BApp		Basin, prairie pothole
BApl		Basin, playa
BAwc		Basin, West Coast vernal pool
BAid		Basin, interdunal
BAwv		Basin, woodland vernal
BApg		Basin, polygonal
BAsh		Basin, sinkhole
BApd		Basin, pond
BAgp		Basin, grady pond
BAsa		Basin, salt flat
BAaq		Basin, aquaculture (created)
BAcr		Basin, cranberry bog (created)
BAwm		Basin, wildlife management (created)

BAip	Basin, impoundment (created)
BAfe	Basin, former estuarine wetland
BAff	Basin, former floodplain
BAfi	Basin, former interfluve
BAfo	Basin, former floodplain oxbow
BAdm	Basin, drowned river-mouth

FL Flat

FLsa	Flat, salt flat
FLff	Flat, former floodplain
FLfi	Flat, former interfluve

*Note: Inland slope wetlands and island wetlands associated with rivers, streams, and lakes are designated as such by the landscape position classification (e.g., lotic river, lotic stream, or lentic), therefore no additional terms are needed here to convey this association.

Coastal Landform

IL Island

ILdt	Island, delta
ILde	Island, ebb-delta
ILdf	Island, flood-delta
ILrv	Island, river
ILst	Island, stream
ILby	Island, bay

DE Delta

DEr	Delta, river-dominated
DEt	Delta, tide-dominated
DEw	Delta, wave-dominated

FR Fringe

FRal	Fringe, atoll lagoon
FRbl	Fringe, barrier island
FRbb	Fringe, barrier beach
FRby	Fringe, bay
FRbi	Fringe, bay island
FRcp	Fringe, coastal pond
FRci	Fringe, coastal pond island
FRhl	Fringe, headland
FRoi	Fringe, oceanic island
FRlg	Fringe, lagoon
FRrv	Fringe, river

FRri Fringe, river island
FRst Fringe, stream
FRsi Fringe, stream island

BA Basin
BAaq Basin, aquaculture (created)
BAid Basin, interdunal (swale)
BAst Basin, stream
BAsh Basin, salt hay production (created)
BAtd Basin, tidally restricted/road (not a management area)
BAtr Basin, tidally restricted/railroad (not a management area)
BAwm Basin, wildlife management (created)
BAip Basin, impoundment (created)

Water Flow Path

PA Paludified
IS Isolated
IN Inflow
OU Outflow
OA Outflow-artificial*
OP Outflow-perennial
OI Outflow-intermittent
TH Throughflow
TA Throughflow - artificial*
TN Throughflow - entrenched
TI Throughflow - intermittent
BI Bidirectional Flow - nontidal
BT Bidirectional Flow - tidal

*Note: To be used with wetlands connected to streams by ditches.

Other Modifiers (apply at the end of the code as appropriate)

br barren
bv beaver
ch channelized flow
cl coastal island (wetland on an island in an estuary or ocean including barrier islands)
cr cranberry bog
dd drainage divide
dr partly drained
ed freshwater wetland discharging directly into an estuary
fe former estuarine wetland

fg	fragmented
fm	floating mat
gd	groundwater-dominated (apply to Water Flow Path only)
hi	severely human-induced
hw	headwater
li	lake island (wetland associated with a lake island)
md	freshwater wetland discharging directly into marine waters
ow	overwash
pi	pond island border
ri	river island (wetland associated with a river island)
sd	surface water-dominated (apply to Water Flow Path only)
sf	spring-fed
ss	subsurface flow
td	tidally restricted/road
tr	tidally restricted/railroad

(Note: "ho" was formerly used to indicate human-induced outflow brought about by ditch construction; now this is addressed by the water flow path "OA" Outflow-Artificial.)

Codes for Waterbodies

Besides Waterbody Type, waterbodies can be classified by water flow path (for lakes and ponds), estuary hydrologic type (for estuaries), and tidal range types (for estuaries and oceans).

Waterbody Type

RV	River		
	1	low gradient	
	a		connecting channel
	b		canal
	2	middle gradient	
	a		connecting channel
	3	high gradient	
	a		waterfall
	b		riffle
	c		pool
	4	intermittent gradient	
	5	tidal gradient	
	6	dammed gradient	
	a		lock and dammed
	b		run-of-river dammed
	c		other dammed

ST Stream
1 low gradient
a connecting channel
2 middle gradient
a connecting channel
3 high gradient
a waterfall
b riffle
c pool
4 intermittent gradient
5 tidal gradient
6 dammed
a lock and dammed
b run-of-river dammed
c beaver dammed
d other dammed
7 artificial
a connecting channel
b ditch

LK Lake
1 natural lake (*see also Pond codes for possible specific types*)
a main body
b open empbayment
c semi-enclosed embayment
d barrier beach lagoon
2 dammed river valley lake
a reservoir
b hydropower
c other
3 other dammed lake
a former natural
b artificial
4 other artificial lake

(Consider using a modifier to highlight specific lakes as needed, especially the Great Lakes, e.g., LK1E for Lake Erie or LK2O for Lake Ontario, and Lake Champlain, LK1C)

EY Estuary
1 drowned river valley estuary
a open bay (fully exposed)
b semi-enclosed bay
c river channel

2	bar-built estuary	
a		coastal pond-open
b		coastal pond-seasonally closed
c		coastal pond-intermittently open
d		hypersaline lagoon
3	river-dominated estuary	
4	rocky headland bay estuary	
a		island protected
5	island protected estuary	
6	shoreline bay estuary	
a		open (fully exposed)
b		semi-enclosed
7	tectonic	
a		fault-formed
b		volcanic-formed
8	fjord	
9	other	

Note: If desired, you can also designate river channel (rc), stream channel (sc),and inlet channel (ic) by modifiers. *Examples*: EY1rc = Drowned River Valley Estuary river channel; EY2ic= Bar-built estuary inlet channel. If not, simply classify all estuarine water as a single type, e.g., EY1 for Drowned River Valley or EY2 for Bar-built Estuary.

OB Ocean or Bay

1	open (fully exposed)
2	semi-protected oceanic bay
3	atoll lagoon
4	other reef-protected waters
5	fjord

PD Pond

1	natural	
a		bog
b		woodland-wetland
c		woodland-dryland
d		prairie-wetland (pothole)
e		prairie-dryland (pothole)
f		playa
g		polygonal
h		sinkhole-woodland
i		sinkhole-prairie
j		Carolina bay
k		pocosin
l		cypress dome

m		vernal-woodland
n		vernal-West Coast
o		interdunal
p		grady
q		floodplain
r		other
2	dammed/impounded	
a		agriculture
a1		cropland
a2		livestock
a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf
h		wildlife management
i		other recreational
o		other
q		floodplain
3	excavated	
a		agriculture
a1		cropland
a2		livestock
a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf

h		wildlife management
i		other recreational
j		mining
j1		sand/gravel
j2		coal
o		other
q		floodplain
4	beaver	
5	other artificial	

<u>Water Flow Path</u>

IN	Inflow
OU	Outflow
OA	Outflow-artificial*
OP	Outflow-perennial
OI	Outflow-intermittent
TH	Throughflow
TA	Throughflow-artificial*
TI	Throughflow-intermittent*
TN	Throughflow-entrenched
BI	Bidirectional-nontidal
IS	Isolated
MI	Microtidal
ME	Mesotidal
MC	Macrotidal

*<u>Note</u>: OA and TA are human-caused by ditches; TI is to be used along intermittent streams.

<u>Estuarine Hydrologic Circulation Type</u>

SW	Salt-wedge/river-dominated type
PM	Partially mixed type
HO	Homogeneous/high energy type

<u>Other Modifiers</u> (apply at end of code)

ch	Channelized or Dredged
dv	Diverted
ed	freshwater stream flowing directly into an estuary
fv	Floating vegetation (on the surface)
lv	Leveed
md	freshwater stream flowing directly into marine waters
sv	Submerged vegetation

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Section 7. Glossary

Barrier Beach -- a coastal peninsular landform extending from the mainland into the ocean or large embayment or large lake (e.g., Great Lakes), typically providing protection to waters on the backside and allowing the establishment of salt marshes; similar to the barrier island, except connected to the mainland

Barrier Island -- a coastal insular landform, an island typically between the ocean (or possibly the Great Lakes) and the mainland; its presence usually promotes the formation of salt marshes on the backside

Basin -- a depressional (concave) landform; various types are further defined by the absence of a stream (isolated), by the presence of a stream and its position relative to a wetland (throughflow, outflow, inflow), or by its occurrence on a floodplain (floodplain basins include ox-bows and sloughs, for example)

Bay -- a coastal embayment of variable size and shape that is always opens to the sea through an inlet or other features

Carolina Bay -- a wetland formed in a semicircular or egg-shaped basin with a northwest to southeast orientation, found along the Atlantic Coastal Plain from southern New Jersey to Florida, and perhaps most common in Horry County, South Carolina

Channelization -- the act or result of excavating a stream or river channel to increase downstream flow of water or to increase depth for navigational purposes

Channelized -- water flow through a conspicuous drainageway, a stream or a river

Coastal Island - an island in marine and estuarine areas

Coastal Pond - pond and its associated wetlands that form behind a barrier beach and are subjected to varying tidal influence (intermittent to daily); the tidal connection for many coastal ponds has been stabilized by jetties; the ones that are only intermittently connected have low salinities

Connecting Channel - a river or stream that connects two adjacent lakes; lakes are typically close together considering their relative size; it is not any stream that occurs between two lakes in a drainage basin; perhaps the best examples are rivers connecting the Great Lakes, such as the St. Marys River connecting Lake Superior to Lake Huron, Detroit River connecting Lake St. Clair to Lake Erie, and the Niagara River connecting Lake Erie with Lake Ontario

Cypress Dome -- a wetland dominated by bald cypress growing in a basin that may be formed by the collapse of underlying limestone, forest canopy takes on a domed appearance with tallest trees in center and becoming progressively shorter as move toward margins of basin

Delta -- a typically lobed-shaped or fan-shaped landform formed by sedimentation processes at the mouth of a river carrying heavy sediment loads

Ditch B a linear, often shallow, artificial channel created by excavation with intent to improve drainage of or to irrigate adjacent lands

Drained, Partly -- condition where a wetland has been ditched or tiled to lower the ground water table, but the area is still wet long enough and often enough to fall within the range of conditions associated with wetland hydrology

Entrenched -- condition where a stream cuts through a wetland and does not periodically overflow into the wetland; the affected wetland may be a terrene wetland cut by a stream or it could be a lotic wetland along an entrenched stream (the latter would usually have to be identified in the field)

Estuarine -- the landscape of estuaries (salt and brackish tidal waterbodies, such as bays and coastal rivers) including associated wetlands, typically occurring in sheltered or protected areas, not exposed to oceanic currents

Flat -- a relatively level landform; may be a component of a floodplain or the landform of an interfluve

Flatwood -- forest of pines, hardwoods or mixed stands growing on interfluves on the Gulf-Atlantic Coastal Plain, typically with imperfectly drained soils; some flatwoods are wetlands, while others are dryland

Floodplain -- a broad, generally flat landform occurring in a landscape shaped by fluvial or riverine processes; for purposes of this classification limited to the broad plain associated with large river systems subject to periodic flooding (once every 100 years) and typically having alluvial soils; further subdivided into several subcategories: flat (broad, nearly level to gently sloping areas) and basin (depressional features such as ox-bows and sloughs)

Floodplain, active -- floodplain that is typically inundated once every 100 years by natural events

Floodplain, inactive -- floodplain that is no longer flooded once in 100 years due to human-alterations such as leveeing, diking, or altered river flow regimes or to natural processes such as changing river courses

Fringe -- a wetland occurring along a standing or flowing waterbody, i.e., a lake, pond, river, stream, estuary, or ocean, including tidal wetlands that are inundated frequently by tides, nontidal vegetated wetlands that are flooded for most of the growing season, and nonvegetated wetlands that form the banks of these waterbodies (such as cobble-gravel bars along river bends)

Ground Water -- water below ground, held in the soil or underground aquifers

Headland -- the seaward edge of the major continental land mass (North America), commonly called the mainland; not an island

High Gradient -- the fast-flowing segment of a drainage system, typically with no floodplain development; equivalent to the Upper Perennial and Intermittent Subsystems of the Riverine System in Cowardin et al. 1979

Inflow -- water enters; an inflow wetland is one that receives surface water from a stream or other waterbody or from significant surface or ground water from a wetland or waterbody at a higher elevation and has no significant discharge

Interdunal -- occurring between sand dunes, as in interdunal swale wetlands found in dunefields behind ocean and estuarine beaches and in sand plains like the Nebraska Sandhills

Interfluve -- a broad level to imperceptibly depressional poorly drained landform occurring between two drainage systems, most typical of the Coastal Plain

Island -- a landform completely surrounded by water and not a delta; some islands are entirely wetland, while others are uplands with or without a fringe wetland

Isolated -- lacking an apparent surface water connection to other wetlands and waterbodies; typically "geographically isolated" (surrounded by upland - nonhydric soils); may be connected to other wetlands and water via groundwater, but this is not known

Karst -- a limestone region characterized by sinkholes and underground caverns

Kettle -- a glacially formed depression typically created by a block of glacial ice left on the land by a retreating glacier; melting of the ice formed a kettle pond that may be quite deep, with bog vegetation frequently established along its perimeter

Lake Island - an island in a lake

Lentic -- the landscape position associated with large, deep standing waterbodies (such as lakes and reservoirs) and contiguous wetlands formed in the lake basin (excludes seasonal and shallow lakes which are included in the *Terrene* landscape position)

Lotic -- the landscape position associated with flowing water systems (such as rivers, creeks, perennial streams, intermittent streams, and similar waterbodies) and contiguous wetlands

Low Gradient -- the slow-flowing segment of a drainage system, typically with considerable floodplain development; equivalent to the Lower Perennial Subsystem of the Riverine System in Cowardin et al. 1979 plus contiguous wetlands

Marine -- the landscape position (or seascape) associated with the ocean's shoreline

Middle Gradient -- the segment of a drainage system with characteristic intermediate between the high and low gradient reaches, typically with limited floodplain development; equivalent to areas mapped as Riverine Unknown (R5) in the Northeast Region plus contiguous wetlands

Nonchannelized -- water exits through seepage, not through a river or stream channel or ditch

Outflow -- water exits naturally or through artificial means (e.g., ditches); an outflow wetland has water leaving via a stream, seepage, or ditch (artificial) to a wetland or waterbody at a lower elevation; it lacks an inflowing surface water source like an intermittent or perennial stream

Oxbow -- a former mainstem river bend now partly or completely cut off from mainstem

Paludified -- subjected to paludification, the process by which peat moss engulfs terrains of varying elevations due to an excess of water, typically associated with cold, humid climates of northern areas (boreal/arctic regions and fog-shrouded coasts)

Playa -- a type of basin wetland in the Southwest characterized by drastic fluctuations in water levels over the normal wet-dry cycle

Pocosin -- a shrub and/or forested wetland forming on organic soils in interstream divides (interfluves) on the Atlantic Coast Plain from Virginia to Florida, mostly in North Carolina

Pond -- a natural or human-made shallow open waterbody that may be subjected to periodic drawdowns

Prairie Pothole -- a glacially formed basin wetland found in the Upper Midwest especially in the Dakotas, western Minnesota, and Iowa

Reservoir -- a large, deep waterbody formed by a dike or dam created for a water supply for drinking water or agricultural purposes or for flood control, or similar purposes

River Island - an island within a river

Salt Pond -- a coastal embayment of variable size and shape that is periodically and temporarily cut off from the sea by natural accretion processes; some may be kept permanently open by jetties and periodic maintenance dredging

Salt Flat -- a broad expanse of alkaline wetlands associated with arid regions, especially the Great Basin in the western United States

Sinkhole -- a depression formed by the collapse of underlying limestone deposits; may be wetland or nonwetland depending on drainage characteristics

Slope -- a wetland occurring on a slope; various types include those along a sloping stream (fringe), those (paludified) formed by paludification -- the process of bogging or swamping of uplands by peat moss in northern climes (humid and cold), and those not designated as one of the above and typically called seeps

Stream B a natural drainageway that contains flowing water at least seasonally; different stream types: *perennial* where water flows continously in all years except drought or extremely dry years; intermittent where water flows only seasonally in most years; channelized where stream bed has been excavated or dredged

Subsurface Flow -- water leaves via ground water

Surface Water -- water occurring above the ground as in flooded or ponded conditions

Tectonic - changes in the earth's surface caused by landslides, faulting, and volcanic activity

Terrene -- wetlands surrounded or nearly so by uplands and lacking a channelized outlet stream; a stream may enter or exit this type of wetland but it does not flow through it as a channel; includes a variety of wetlands and natural and human-made ponds

Throughflow -- water entering and exiting, passing through; a throughflow wetland receives significant surface or ground water which passes through the wetland and is discharged to a stream, wetland or other waterbody at a lower elevation; throughflow may be perennial, intermittent, or associated with an entrenched stream

Tidal Gradient -- the segment of a drainage basin that is subjected to tidal influence; essentially the freshwater tidal reach of coastal rivers; equivalent to the Tidal Subsystem of the Riverine System in Cowardin et al. 1979 plus contiguous wetlands

Vernal Pool -- a temporarily flooded basin; woodland vernal pools are found in humid temperature regions dominated by trees, these pools are surrounded by upland forests, are usually flooded from winter through mid-summer, and serve as critical breeding grounds for salamanders and woodland frogs; West Coast vernal pools occur in California, Oregon, and Washington on clayey soils, they are important habitats for many rare plants and animals
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Appendix B. Rationale for Correlating Enhanced NWI Data with Wetland Functions for Watershed-wide Assessments, With Emphasis on Northeastern U.S. Wetlands

CORRELATING ENHANCED NATIONAL WETLANDS INVENTORY DATA WITH WETLAND FUNCTIONS FOR WATERSHED ASSESSMENTS:
A RATIONALE FOR NORTHEASTERN U.S. WETLANDS

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Correlating Enhanced National Wetlands Inventory Data with Wetland Functions for Watershed Assessments: A Rationale for Northeastern U.S. Wetlands

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Background

The U.S. Fish and Wildlife Service has been conducting the National Wetlands Inventory for over 25 years. The NWI Program has produced wetland maps for 91% (78% final) of the lower 48 states, all of Hawaii, and 35% of Alaska. Wetlands are classified according to the Service's official wetland classification system (Cowardin et al. 1979). This classification describes wetlands by ecological system (Marine, Estuarine, Lacustrine, Riverine, and Palustrine), by subsystem (e.g., water depth, exposure to tides), class (vegetative life form or substrate type), subclass, water regimes (hydrology), water chemistry (pH and salinity), and special modifiers (e.g., alterations by humans). The maps have been converted to digital data for 47% of the lower 48 states and 18% of Alaska. The availability of digital data and geographic information system (GIS) technology make it possible to use NWI data for various geospatial analyses.

In the 1990s, the NWI Program for the Northeast Region recognized the potential application of NWI data for watershed assessments, but realized that other attributes would have to be added to the data to facilitate functional analysis. Dr. Mark Brinson had recently developed a hydrogeomorphic (hgm) approach to wetland functional assessment (Brinson 1993a). This approach provided the impetus for developing other attributes to expand the NWI database and make it more useful for functional assessment.

In the mid-1990s, a set of hgm-type descriptors were developed to describe a wetland's landscape position, landform, and water flow path (Tiner 1995, 1996a,b). Use of the initial set of keys for pilot watershed projects lead to a refinement and expansion of the keys in subsequent years (Tiner 1997a, 2000, 2002, 2003). These projects were watershed characterizations that included a preliminary assessment of wetland functions as a main component or the prime component of the study. The reports addressed the following watersheds: Casco Bay (Maine; Tiner et al. 1999), Nanticoke River (Maryland and Delaware; Tiner et al. 2000, 2001), Coastal Bays (Maryland; Tiner et al. 2000), and Cannonsville and Neversink Reservoirs (New York; Tiner et al. 2002), as well as the Pennsylvania Coastal Zone (Tiner and DeAlessio 2002).

In conducting these studies, we worked with local and regional wetland experts to develop correlations between wetland characteristics recorded in the database and wetland functions (see Acknowledgments for listing). The correlations reflect our best approximation of what types of wetlands are likely to perform certain functions at significant levels based on the characteristics we have in the wetland database. Conducting wetland assessments in other areas, especially in arid, semiarid, and tropical regions, may identify other wetlands that need to be added to the significance list for various functions.

Limitations of the Preliminary Wetland Functional Assessment

Source data are a primary limiting factor. NWI digital data are used as the foundation for these assessments. In some cases, the NWI data are derived by updating more detailed state wetland data. Nonetheless, all wetland mapping has limitations due to scale, photo quality, date of the survey, and the difficulty of photointerpreting certain wetland types (especially evergreen forested wetlands and drier-end wetlands; see Tiner 1997c, 1999 for details).

Recognizing source data limitations, it is equally important to understand that this type of functional assessment is a preliminary one based on wetland characteristics interpreted through remote sensing and using the best professional judgment of various specialists to develop correlations between wetland characteristics in the database and wetland functions.
Also, no attempt is made to produce a more qualitative ranking for each function or for each wetland based on multiple functions as this would require more input from others and more data, well beyond the scope of this type of evaluation. For a technical review of wetland functions, see Mitsch and Gosselink (2000) and for a broad overview, see Tiner (1998).

Functional assessment of wetlands can involve many parameters. Typically such assessments have been done in the field on a case-by-case basis, considering observed features relative to those required to perform certain functions or by actual measurement of performance. The preliminary assessments based on remotely sensed information do not seek to replace the need for field evaluations since they represent the ultimate assessment of the functions for individual wetlands. Yet, for a watershed analysis, basin-wide field-derived assessments are not practical, cost-effective, or even possible given access considerations. For watershed planning purposes, a more generalized assessment (level 1 assessment) is worthwhile for targeting wetlands that may provide certain functions, especially for those functions dependent on landscape position, landform, hydrologic processes, and vegetative life form. Subsequently, these results can be field-verified when it comes to actually evaluating particular wetlands for acquisition purposes (e.g., for conserving biodiversity or for preserving flood storage capacity) or for project impact assessment. Current aerial photography may also be examined to aid in further evaluations (e.g., condition of wetland/stream buffers or adjacent land use) that can supplement the preliminary assessment.

The functional assessment approach -"Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF) - applies general knowledge about wetlands and their functions to develop a watershed overview that highlights possible wetlands of significance in terms of performance of various functions. To accomplish this objective, the relationships between wetlands and various functions are simplified into a set of practical criteria or observable characteristics. Such assessments may be further expanded to consider the condition of the associated waterbody and the neighboring upland or to evaluate the opportunity a wetland has to perform a particular function or service to society, for example.

W-PAWF usually does not account for the opportunity that a wetland has to provide a function resulting from a certain land-use practice upstream or the presence of certain structures or land-uses downstream. For example, two wetlands of equal size and like vegetation may be in the right landscape position to retain sediments. One, however, may be downstream of a land-clearing operation that has generated considerable suspended sediments in the water column, while the other is downstream from an undisturbed forest. The former should be actively performing sediment trapping in a major way, whereas the latter is not. Yet if land-clearing takes place in the latter area, the second wetland will likely trap sediments as well as the first wetland. The entire analysis typically tends to ignore opportunity since such opportunity may have occurred in the past or may occur in the future and the wetland is there to perform this service at higher levels when necessary.

W-PAWF also does not consider the condition of the adjacent upland (e.g., level of disturbance) or the actual water quality of the associated waterbody that may be regarded as important metrics for assessing the health of individual wetlands. Collection and analysis of these data may be done as a followup investigation, where desired.

It is important re-emphasize that the preliminary assessment does not obviate the need for more detailed assessments of the various functions. This type of assessment should be viewed as a starting point for more rigorous assessments, since it attempts to cull out wetlands that may likely provide significant functions based on generally accepted principles and the source information used for this analysis. This assessment is most useful for regional or watershed planning purposes. For site-specific evaluations, additional work will be required, especially field verification and collection of site-specific data for potential functions (e.g., following the HGM assessment approach as described by Brinson 1993a or other onsite evaluation procedures). This is particularly true for assessments of fish and wildlife habitats and biodiversity. Other sources of data may exist to help refine some of the findings of this report (e.g., state natural heritage data). Additional modeling could be done, for example, to identify habitats of likely significance to individual species of animals based on their specific life history requirements (see U.S. Fish and Wildlife Service 2003 for Gulf of Maine habitat analysis).

Also note that the criteria used for the correlations were based on regional application of the Service's wetland classification (Cowardin et al. 1979). Regional applications of this system may differ slightly depending on regional priorities, level of field effort, and knowledge of wetland ecology. Use of the correlations in other regions of the country therefore may require some adjustment based on these considerations.

Through this analysis, numerous wetlands are predicted to perform a given function at a significant level presumably important to a watershed's ability to provide that function. "Significance" is a relative term and is used in this analysis to identify wetlands that are likely to perform a given function at a level above that of wetlands not designated. It is also emphasized that the assessment is limited to wetlands (i.e., areas classified as wetlands on NWI maps or similar sources). Deepwater habitats and streams were not included in the assessment, although their inherent value to wetlands and many wetland-dependent organisms is apparent.

Rationale for Preliminary Functional Assessments

A maximum of ten functions may be evaluated: 1) surface water detention, 2) coastal storm surge detention, 3) streamflow maintenance, 4) nutrient transformation, 5) sediment and other particulate retention, 6) shoreline stabilization, 7) provision of fish and shellfish habitat, 8) provision of waterfowl and waterbird habitat, 9) provision of other wildlife habitat, and 10) conservation of biodiversity. The criteria used for identifying wetlands of significance for these functions using the digital wetland database are discussed below. The criteria were initially developed by the author of this report based on his knowledge of wetland characteristics and functions. The draft criteria were then reviewed and modified for the subject watersheds based on comments from wetland specialists working on specific watersheds in four Northeast states (Maine, New York, Delaware, and Maryland). (Note: Criteria may need to be modified for other regions of the country, although many are universally applicable.)

In developing a protocol for designating wetlands of potential significance, wetland size was generally disregarded from the criteria, with few exceptions (i.e., other wildlife habitat and biodiversity functions). This approach was followed because it was felt that individual agencies and organizations using the digital database and charged with setting priorities should make the decision on appropriate size criteria as a means of limiting the number of priority wetlands, if necessary. There is no science-based size limit to establish significance for any function. However, it is obvious that, all things being equal, a larger wetland will have a higher capacity to perform a given function than a smaller one of the same type. The W-PAWF approach is intended to produce a more expansive characterization of wetlands and their likely functions and not to develop a rapid assessment method for ranking wetlands for acquisition, protection, or other purposes.

The criteria for identifying different levels of potential significance can be modified in the future based on additional peer review, application to other watersheds and regions, and field evaluation. The proposed criteria are designed for wetlands in the Northeast, but many, if not most, should be relevant nationwide. Some of the criteria, especially those addressing fish and wildlife habitat, will need to be re-examined for individual watersheds, particularly when this approach is applied to other regions of the country. Note that palustrine farmed wetlands have not been identified as being significant for any function in the Northeast. Since they are tilled cropland or cultivated cranberry bogs, farmed wetlands were viewed as severely degraded wetlands that perform the specified functions at minimal levels. Consequently, they represented sites where substantial gains in wetland functions may be achieved through restoration projects. In other parts of the country, farmed wetlands may perform some wetland functions at significant levels (e.g., farmed pothole wetlands in the Midwest or diked former tidelands in the Sacramento River valley - important waterfowl habitat).

Surface Water Detention

This function is important for reducing downstream flooding and lowering flood heights, both of which aid in minimizing property damage and personal injury from such events. In a landmark study on the relationships between wetlands and flooding at the watershed scale, Novitzki (1979) found that watersheds with 40 percent coverage by lakes and wetlands had significantly reduced flood flows -- lowered by as much as 80 percent -- compared to similar watersheds with no or few lakes and wetlands in Wisconsin. Floodplain wetlands, other lotic wetlands (basin and flat types), estuarine fringe wetlands along coastal rivers, and estuarine island wetlands in these rivers provide this function at significant levels. At the present time, estuarine and marine rocky shores are rated as high for this function, since they are usually narrow habitats and/or intermixed with tidal flats. Perhaps this function should be limited to non-estuarine habitats, with the water storage function of estuarine wetlands listed under coastal storm surge detention and shoreline stabilization. Presently, estuarine and marine wetlands are recognized as important areas for storing surface water, recognizing that it is tidal water that ebbs and flows.

Wetlands dominated by trees and/or dense stands of shrubs could be deemed to provide a higher level of this function than emergent wetlands, since woody vegetation (with higher frictional resistance) may further aid in flood desynchronization. However, emergent wetlands along waterways provide significant flood storage, so no distinction is made regarding the type of vegetative cover. Floodplain width could also be an important factor in evaluating the significance of performance of this function by individual wetlands (e.g., for acquisition or strengthened protection), but there is no scientifically based criterion for establishing a significance threshold based on size.

Interfluve wetlands and drier-end wetlands (e.g., Lotic Flats) are rated as having moderate potential. While Interfluve basins hold more water than Interfluve flats, no distinction was made since they represent a single system that tends to be dominated by flats. Wetland size was not considered, but it is obvious that size should make a difference in the amount of water stored. Others interested in prioritizing wetlands for acquisition or protection may wish to identify a minimum threshold for importance for this function or develop other criteria for prioritization (e.g., treat small interfluve flats differently from small interfluve basins).

For this function, the following correlations are used:

High	Estuarine Fringe, Estuarine Basin, Estuarine Island, Lentic Basin, Lentic Fringe, Lentic Island (basin and fringe), Lentic Flat associated with reservoirs and flood control dams, Lotic Basin, Lotic Floodplain, Lotic Fringe, Lotic Island associated with Floodplain area, Lotic Island basin, Marine Fringe, Marine Island, Ponds Throughflow wetlands, Ponds Bidirectional and associated wetlands, Terrene Throughflow Basin
Moderate	Lotic Flat, Lotic Island flat, Lentic Flat, Terrene Interfluve, Other Terrene Basins, Other Ponds and associated wetlands (excluding sewage treatment ponds and similar waters)

Coastal Storm Surge Detention

This function is listed separately from Surface Water Detention to highlight the importance of tidal wetlands at storing tidal waters brought into estuaries by storms (e.g., Nor'easters, tropical storms, and hurricanes). Estuarine and freshwater tidal wetlands are important areas for temporary storage of this water. At the present time, estuarine and marine rocky shores that are fringe types are rated as high for this function, since they are usually narrow habitats and/or intermixed with tidal flats. Some nontidal wetlands contiguous to these wetlands (e.g., low-lying terrene outflow basins - flatwoods) may also provide this function, but it was not possible to predict the extent of such storage as this depends on storm intensity and frequency.

For this function, the following correlations are used:

High	Estuarine Basin, Estuarine Fringe, Estuarine Island, Lotic Tidal Fringe, Lotic Tidal Island, Lotic Tidal Floodplain, Marine Fringe

Streamflow Maintenance

Many wetlands are sources of groundwater discharge and some may be in a position to sustain streamflow in the watershed. Such wetlands are critically important for supporting aquatic life in streams. All wetlands classified as headwater wetlands are important for streamflow (e.g, Terrene headwater wetlands, by definition, are sources of streams). These wetlands include lotic wetlands along 1st-order streams and lentic wetlands associated with outflow lakes. Wetlands along 2nd-order streams in mountainous areas may be classified as headwater wetlands as they probably are sites of groundwater discharge. Ditched headwater wetlands are rated as "Moderate," since this alteration typically results in faster release of water, thereby reducing the period of outflow. Outflow from groundwater-fed wetlands (lacking a stream) may discharge directly into streams and thereby contribute substantial quantities of water for sustaining baseflows. These wetlands were rated as "Moderate" for this function. Lakes may also be important regulators of streamflow, so lentic wetlands may be designated as significant to streamflow, with those in headwater positions being rated "High" and others as "Moderate."

Floodplain wetlands are known to store water in the form of bank storage, later releasing this water to maintain baseflows (Whiting 1998). Among several key factors affecting bank storage are porosity and permeability of the bank material, the width of the floodplain, and the hydraulic gradient (steepness of the water table). The wider the floodplain, the more bank storage given the same soils. Gravel floodplains drain in days, sandy floodplains in a few weeks to a few years, silty floodplains in years, and clayey floodplains in decades. In good water years, wide sandy floodplains may help maintain baseflows. Despite these differences, the W-PAWF assessment treats all floodplain wetlands similarly, since it is based on remote sensing and does not include soil examinations.

For this function, the following correlations are used:

High	Nonditched Headwater Wetlands (Terrene, Lotic, and Lentic), Headwater Ponds and Lakes (classified as PUB...on NWI) (Note: Lotic Stream Basin or Floodplain basin Wetlands along 2nd order streams should also be rated high; possibly expand to 3rd order streams in hilly or mountainous terrain.)
Moderate	Ditched Headwater Wetlands (Terrene, Lotic, and Lentic), Lotic (Nontidal) Floodplain, Throughflow Ponds and Lakes (classified as PUB on NWI) and their associated wetlands, Terrene Outflow wetlands (associated with streams not major rivers), Outflow Ponds and Lakes (classified as PUB... on NWI)

Special Note: All these wetlands should be considered to also be important for fish and shellfish as they are vital to sustaining streamflow necessary for the survival of these aquatic organisms.

Nutrient Transformation

All wetlands recycle nutrients, but those having a fluctuating water table are best able to recycle nitrogen and other nutrients. Vegetation slows the flow of water causing deposition of mineral and organic particles with adsorbed nutrients (nitrogen and phosphorus), whereas hydric soils are the places where chemical transformations occur (Carter 1996). Microbial action in the soil is the driving force behind chemical transformations in wetlands. Microbes need a food source -- organic matter -- to survive, so wetlands with high amounts of organic matter should have an abundance of microflora to perform the nutrient cycling function. Wetlands are so effective at filtering and transforming nutrients that artificial wetlands are constructed for water quality renovation (e.g., Hammer 1992). Natural wetlands performing this function help improve local water quality of streams and other watercourses.

Numerous studies have demonstrated the importance of wetlands in denitrification. Simmons et al. (1992) found high nitrate removal (greater than 80%) from groundwater during both the growing season and dormant season in Rhode Island streamside (lotic) wetlands. Groundwater temperatures throughout the dormant season were between 6.5 and 8.0 degrees C, so microbial activity was not limited by temperature. Even the nearby upland, especially transitional areas with somewhat poorly drained soils, experienced an increase in nitrogen removal during the dormant season. This was attributed to a seasonal rise in the water table that exposed the upper portion of the groundwater to soil with more organic matter (nearer the ground surface), thereby supporting microbial activity and denitrification. Riparian forests dominated by wetlands have a greater proportion of groundwater (with nitrate) moving within the biologically active zone of the soil that makes nitrate susceptible to uptake by plants and microbes (Nelson et al. 1995). Riparian forests on well-drained soils are much less effective at removing nitrate. In a Rhode Island study, Nelson et al. (1995) found that November had the highest nitrate removal rate due to the highest water tables in the poorly drained soils, while June experienced the lowest removal rate when the deepest water table levels occurred. Similar results can be expected to occur elsewhere. For bottomland hardwood wetlands, DeLaune et al. (1996) reported decreases in nitrate from 59-82 percent after 40 days of flooding wetland soil cores taken from the Cache River floodplain in Arkansas. Moreover, they surmised that denitrification in these soils appeared to be carbon-limited: increased denitrification took place in soils with more organic matter in the surface layer.

Nitrogen fixation is accomplished in wetlands by microbial-driven reduction processes that convert nitrate to nitrogen gas. Nitrogen removal rates for freshwater wetlands are very high (averaging from 20-80 grams/square meter) (Bowden 1987). The following information comes from a review paper on this topic by Buresh et al. (1980). Nitrogen fixation has been attributed to blue-green algae in the photic zone at the soil-water interface and to heterotrophic bacteria associated with plant roots. In working with rice, Matsuguchi (1979) believed that the significance of heterotrophic fixation in the soil layer beyond the roots has been underrated and presented data showing that such zones were the most important sites for nitrogen fixation in a Japanese rice field. This conclusion was further supported by Wada et al. (1978). Higher fixation rates have been found in the rhizosphere of wetland plants than in dryland plants.

Phosphorus removal is largely done by plant uptake (Patrick, undated manuscript). Wetlands that accumulate peat have a great capacity for phosphorus removal. Wetland drainage can, therefore, change a wetland from a phosphorus sink to a phosphorus source. This is a significant cause of water quality degradation in many areas of the world including the United States, where wetlands are drained for agricultural production. Hydric soils with significant clay constituents fix phosphorus due to its interaction with clay and inorganic colloids. Reduced soils have more sorption sites than oxidized soils (Patrick and Khalid 1974), while the latter soils have stronger bonding energy and adsorb phosphorus more tightly.

From the water quality standpoint, wetlands associated with watercourses are probably the most noteworthy. Numerous studies have found that forested wetlands along rivers and streams ("riparian forested wetlands") are important for nutrient retention and sedimentation during floods (Whigham et al. 1988; Yarbro et al. 1984; Simpson et al. 1983; Peterjohn and Correll 1982). This function by forested riparian wetlands is especially important in agricultural areas. Brinson (1993b) suggests that riparian wetlands along low-order streams may be more important than those along higher order streams.

Wetlands with seasonally flooded and wetter water regimes (including tidal regimes - seasonally flooded-tidal, irregularly flooded, and regularly flooded) are identified as having potential to recycle nutrients at high levels of performance. The soils of these wetlands should have substantial amounts of organic matter near the surface that promote microbial activity and denitrification when wet. Based on field observations, in general, there is a positive correlation between the amount of organic matter and the degree of wetness as reflected by the NWI's water regime classification in wetlands of the Nanticoke River watershed in Delaware (Amy Jacobs, pers. comm. 2003). Periodically flooded soils also retain sediments and their adsorbed nutrients.

Seasonally saturated wetlands are also rated as having high potential for this function. Most the the groundwater flux from uplands to surface waters occurs in the non-growing season in the Northeast and reasonable denitrification rates occur in spring and fall making sites that are wet during these times important for nutrient retention (Art Gold, pers. comm. 2003). Permanently saturated wetlands in nutrient-rich sites should also be rated as high for this function, whereas wetlands with this hydrology in nutrient-poor areas are rated as moderate. The latter types are nutrient-deficient habitats, yet they may have considerable potential for nutrient uptake should more nutrients become available due to land use practices.

Wetlands with a temporarily flooded water regime including those in tidal environments (temporarily flooded-tidal) are identified as having a moderate potential for performing this function. Vegetated wetlands with a seasonally saturated water regime are also considered as moderate, since they are usually wet longer during the non-growing season and for shorter periods during the growing season.

Drainage through ditches or tiles can significantly reduce nutrient transformation by lowering the water table below the zone of highest biological activity (Art Gold, pers. comm. 2003). Partly drained wetlands that are listed as having wetter water regimes (i.e., C, E and F) should still perform this function significantly (i.e., like their nondrained counterparts) since this function appears positively correlated with water regime. Drained wetlands on the drier-end of the soil moisture gradient (i.e., A and B water regimes) likely perform this function to a less degree and are therefore rated as having moderate potential.

For this function, correlations are the following:

High	Vegetated wetlands (and mixes with nonvegetated wetlands or unconsolidated bottom; even where nonvegetated predominates) with seasonally flooded (C), seasonally flooded/saturated (E), semipermanently flooded (F), semipermanently flooded-tidal (T), seasonally flooded-tidal (R), irregularly flooded (P), regularly flooded (N), and permanently flooded (H or L) water regimes, vegetated wetlands with permanently saturated water regime (B; not on the coastal plain or glaciolacustrine plains).
Moderate	Vegetated wetlands with seasonally saturated (B on the coastal plain and on glaciolacustrine plains, e.g., Great Lakes Plain in western New York), temporarily flooded (A) or temporarily flooded-tidal (S) water regimes

Retention of Sediments and Other Particulates

Many wetlands owe their existence to being located in areas of sediment deposition. This is especially true for floodplain and estuarine wetlands. This function supports water quality maintenance by capturing sediments with bonded nutrients or heavy metals (as in and downstream of urban areas). Estuarine and floodplain wetlands plus lotic (streamside) and lentic (lakeshore) fringe and basin wetlands including lotic (in-stream) ponds are likely to trap and retain sediments and particulates at significant levels. Terrene throughflow basins should function similarly.   Vegetated wetlands will likely favor sedimentation over nonvegetated wetlands and are therefore rated higher. Lotic flat wetlands are flooded only for brief periods and less frequently than the wetlands listed above due to their elevation; they are classified as having moderate potential for sediment retention. Throughflow (in-stream) ponds are rated as "High," since they occur within the stream network. Other ponds may be locally significant in retaining such materials, and are also designated as "Moderate." Interfluve flats are not rated as potentially significant because they are level landscapes that do not appear to accumulate substantial amounts of sediment from surrounding areas, whereas Interfluve basins are depressional landscapes that likely collect sediments. The latter wetlands were rated as having moderate potential. Bogs and rocky shores are not considered significant sites for sediment retention and are therefore excluded from the list. Wetlands that are not flooded (e.g., seasonally saturated flatwoods) are also not considered to perform this function at significant levels.

For this function, the following correlations are used:

High	Estuarine Basin (vegetated), Estuarine Fringe (vegetated excluding rocky shores), Estuarine Island (vegetated), Lentic Basin, Lentic Fringe (vegetated only), Lentic Island (vegetated) Lotic Basin, Lotic Floodplain, Lotic Fringe (vegetated), Lotic Island (vegetated), Throughflow Ponds and Lakes (in-stream; designated as PUB... on NWI) and associated vegetated wetlands, Bidirectional Ponds and associated vegetated wetlands, Terrene Throughflow Basin and Interfluve Basin
Moderate	Estuarine Basin (nonvegetated), Estuarine Fringe (nonvegetated excluding rocky shore), Estuarine Island (nonvegetated, excluding rocky shore), Lotic Island (nonvegetated), Lotic Flat (excluding bogs), Lotic Tidal Fringe (nonvegetated), Lentic Flat, Marine Fringe (excluding rocky shore), Marine Island (excluding rocky shore), Other Terrene Basins (excluding bogs), Other Terrene Interfluve Basins, Terrene wetlands associated with ponds (excluding excavated ponds; also excluding bogs and slope wetlands), Other Ponds and Lakes (classified as PUB... on NWI) and associated wetlands (excluding bogs and slope wetlands) (Note: Users might want to considerremoving certain types of ponds from this category, such as ponds with minimal watersheds - possibly gravel pit ponds, impoundments completely surrounded by dikes,and dug-out ponds with little surface water inflow.)

Shoreline Stabilization

Vegetated wetlands along all waterbodies (e.g., estuaries, lakes, rivers, and streams) provide this function. Vegetation stabilizes the soil or substrate and diminishes wave action, thereby reducing shoreline erosion potential. There is less wave or erosive action along pond shores, so vegetated shoreline wetlands along ponds are designated as "Moderate." Marine and estuarine rocky shores form stable shorelines in several parts of the country. Consequently, they are rated as "High" for this function, except where these wetland types are islands that are inundated completely at times. In the latter situation, they are not shoreline features fringing an upland.

For this function, the following correlations are used:

High	Estuarine wetlands (vegetated except island types), Estuarine Rocky Shore (excluding island types), Marine Rocky Shore (excluding island types), Lotic wetlands (vegetated except island and isolated types), Lentic wetlands (vegetated except island types)
Moderate	Terrene vegetated wetlands associated with ponds (e.g., Fringe-pond, Flat-pond, and Basin-pond)

Provision of Fish and Shellfish Habitat[1]

The assessment of potential habitat for fish and shellfish is based on generalities that could be refined for particular species of interest by others at a later date if desireable. Regional and local variations will need to be accounted for on a watershed-by-watershed basis. The criteria selected below are useful for the Northeast and many may be applicable nationwide, but they should be re-examined for each project watershed to ensure accuracy and completeness. Although focused on fish and shellfish, wetlands identified as significant for these species are likely also significant for other aquatic-dependent species such as muskrat, turtles, and numerous frogs.

For tidal areas, the assessment emphasizes palustrine and riverine tidal emergent wetlands, unconsolidated shores (tidal flats), and estuarine wetlands. For nontidal regions, palustrine aquatic beds and semipermanently flooded wetlands are ranked higher than seasonally flooded types due to the longer duration of surface water. Palustrine forested wetlands along streams (lotic stream wetlands) are recognized as important for maintaining fish and shellfish habitat since their canopies help moderate water temperatures and their leaf litter provides food for aquatic organisms (e.g., aquatic invertebrates) that sustain juvenile and some adult fishes. Many ponds (excluding wastewater ponds, for example) and the shallow marsh-open water zone of impoundments are identified as wetlands having moderate potential for fish and shellfish habitat. Those associated with semipermanently flooded wetlands were listed as "High" since they are

[1] This assessment is focused on wetlands, not deepwater habitats, hence the exclusion of the latter from this analysis, despite widespread recognition that rivers, streams, ponds, and impoundments are the primary habitats for fish and shellfish.

important nursery grounds and feeding grounds for adults of some species.

Other wetlands providing significant fish habitat may exist, but are not identified. Such wetlands may be identified based on actual observations or culled out from site-specific fisheries information that may be available from other sources. Moreover, all wetlands that are significant for the streamflow maintenance function could be considered vital to sustaining the watershed's ability to provide in-stream fish and shellfish habitat. While these wetlands may not be providing significant fish and shellfish habitat themselves, they support base flows essential to keeping water in streams for aquatic life. Terrene outflow wetlands and Lotic basin wetlands along low order streams (e.g., orders 1-2 in Coastal Plain and 1-3 in hilly or mountainous terrain) often discharge cool groundwater to streams which keeps these streams cooler in summer. Such wetlands are important for providing summer refuges for trout and other coldwater species, especially in warm climate regions (Francis Brautigam, pers. comm. 2003). Other wetlands along waterbodies provide food that supports aquatic organisms that are an important part of the diet of juvenile and some adult fishes.

For this function, the following correlations are used:

High	Estuarine Emergent Wetland (including mixtures with other types where Emergent is the dominant class), Estuarine Unconsolidated Shore, Estuarine Intertidal Reef, Estuarine Aquatic Bed, Estuarine Intertidal Rocky Shore, Lacustrine Semipermanently Flooded (excluding wetlands along intermittent streams), Lacustrine Littoral Aquatic Bed, Lacustrine Littoral Unconsolidated Bottom/Vegetated Wetland, Lacustrine Littoral Vegetated Wetland with a Permanently Flooded water regime, Marine Aquatic Bed, Marine Intertidal Rocky Shore, Marine Intertidal Unconsolidated Shore, Marine Intertidal Reef, Palustrine Semipermanently Flooded (excluding wetlands along intermittent streams; must be contiguous with a permanent waterbody such as PUBH, L1UBH, or R2/R3UBH), Palustrine Aquatic Bed, Palustrine Unconsolidated Bottom/Vegetated Wetland, Palustrine Vegetated Wetland with a Permanently Flooded water regime, Palustrine Tidal Emergent Wetland with N, R, T, or L water regimes (excluding "R" wetlands where EM5 is only dominant), Ponds (PUBH.. on NWI; not PUBF) associated with Semipermanently Flooded Vegetated Wetland, Riverine Tidal Emergent Wetland, Riverine Tidal Unconsolidated Shore (excluding those with an "S" water regime)
Moderate	Estuarine Wetlands where Forested or Scrub-Shrub Wetland is mixed with Emergent Wetland, Palustrine Tidal Forested or Scrub-Shrub Wetland mixed with Emergent Wetland having a R or T water regime, Lentic wetlands that are PEM1E, Lotic River or Stream wetlands that are PEM1E (including mixtures with

	Scrub-Shrub or Forested wetlands), Semipermanently flooded Phragmites wetlands (PEM5F) where contiguous with a permanent waterbody, Other Ponds and associated Fringe wetlands (i.e., Terrene Fringe-pond) (excluding industrial, stormwater treatment/detention, similar ponds in highly disturbed landscapes, and ponds with K and F water regimes)
Important for Stream Shading	Lotic Stream wetlands that are Palustrine Forested or Scrub-shrub wetlands (includes mixes where one of these types predominates; excluding those along intermittent streams; also excluding shrub bogs) (Note that although forested wetlands are designated as important for stream shading, forested upland provide similar functions)
Local	Lake Champlain example: Seasonally flooded Lentic wetlands (along Lake Champlain - important spawning areas in spring)

Provision of Waterfowl and Waterbird Habitat

Wetlands designated as important for waterfowl (e.g., ducks, geese, mergansers, and loons) and waterbirds (e.g., wading birds, shorebirds, rails, marsh wrens, and red-winged blackbirds) are generally those used for nesting, reproduction, or feeding. The emphasis is on the wetter wetlands and ones that are frequently flooded for long periods. The criteria for selection should be re-examined for each watershed as there may be regional and local differences in habitat requirements that need to be accounted for. The criteria listed below should, however, be useful for most of the country.

The selected wetlands include estuarine wetlands (vegetated or not), riverine emergent wetlands, estuarine and riverine unconsolidated shores (excluding temporary flooded-tidal), palustrine tidal and riverine tidal emergent wetlands (including emergent/shrub mixtures), semipermanently flooded wetlands, mixed open water-emergent wetlands (palustrine and lacustrine), and aquatic beds. Marine rocky shores are rated as having "High" since sea ducks, mergansers, and loons feed extensively in such areas (George Haas, pers. comm. 2003). Phragmites-dominated wetlands are listed as "Moderate" when they are contiguous to a permanent waterbody; those that are flooded either regularly flooded (N) in tidal areas or semipermanently flooded (F) in nontidal areas are designated as "High" since they provide excellent escape cover and night roosting cover (George Haas, pers. comm. 2003). For this analysis, palustrine tidal scrub-shrub/emergent wetlands and tidal forested/emergent wetlands were designated as having moderate significance for these birds. Similar mixed wetlands dominated by emergent species, however, are listed as having high significance, since the emergents typically represent wetter conditions. Ponds were considered to have moderate potential for providing waterfowl and waterbird habitat.[2] Phragmites-dominated wetlands were listed as having moderate potential for they receive some use by waterfowl and waterbirds.

Other wetlands that may be significant principally for wood duck are identified. Since wooded streams are particularly important for them, seasonally flooded lotic wetlands that are forested or mixtures of trees and shrubs (excluding those along intermittent streams) are designated as wetlands with significant potential for use by this species. Similar seasonally flooded-tidal wetlands bordering oligohaline estuarine wetlands may also be important for wood duck as well as for providing shelter from winter storms for overwintering black ducks. Recognize that wetlands listed as having high potential for waterfowl and waterbird habitat also include some types important to wood ducks (e.g., semipermanently flooded lotic shrub/emergent wetlands); their value to wood ducks has not been highlighted given that they were already designated as having high potential for waterfowl and waterbirds.

Seasonally flooded emergent wetlands (including mixtures with shrubs) were not designated as potentially significant for waterfowl and waterbirds. Field checking of these types may reveal that some are freshwater marshes that provide significant habitat; they should then be added to database as wetlands of significance for this function. Although palustrine forested wetlands along freshwater tidal rivers and streams were designated as important for wood duck, similar wetland behind estuarine wetlands were not identified as significant. These wetlands need further evaluation by local waterfowl experts as we recognize that forested wetlands provide important shelter for overwintering black ducks during coastal storm events, but are uncertain as to the role played by this subsset of forested wetlands.

For this function, the following correlations were used:

High	Estuarine Aquatic Bed, Estuarine Emergent wetlands (excluding Phragmites-dominated wetlands; including mixtures with other vegetated types, e.g., EM/SS), Estuarine Unconsolidated Shore (except S water regime), Estuarine Intertidal Reef, Lacustrine Semipermanently Flooded, Lacustrine Littoral Aquatic Bed, Lacustrine Littoral Vegetated wetlands with an H water regime, Lacustrine Unconsolidated Shores (F, E, or C water regimes; mudflats), Marine Aquatic Bed, Marine Intertidal Reef, Marine Unconsolidated Shore, Marine Rocky Shores, Palustrine Semipermanently Flooded and Semipermanently Flooded-Tidal (excluding Phragmites stands, but including mixtures containing this species - EM5), Palustrine Aquatic Bed, Palustrine Vegetated wetlands with a H water regime, Palustrine Unconsolidated Shores (F, E, or C water

[2]Ponds on wildlife management areas (e.g., refuges) should be considered to be of high significance due to their management. Since we do not presently have the location of refuges recorded in our digital database, these ponds may not be separated from the rest of the ponds. Hence, all ponds except industrial, commercial, stormwater detention, wastewater treatment, and similar ponds, are designated as having moderate potential for this function.

	regimes; mudflats), Seasonally Flooded/Saturated Palustrine wetlands impounded or beaver-influenced (all vegetation types [except PEM5Eh and PEM5Eb] and associated PUB waters), Lotic River or Stream wetlands that are PEM1E (including mixtures with Scrub-Shrub or Forested wetlands), Ponds associated with Semipermanently Flooded Vegetated wetlands, Palustrine Tidal Emergent wetlands (PEM1R and PEM1T and mixes with other EM and with SS and FO; excluding wetlands where EM5 is the only EM), Riverine Tidal Emergent wetlands, Riverine Tidal Unconsolidated Shores (except with S water regime), Ponds associated with all of the above wetland types
Moderate	Phragmites wetlands that are Seasonally Flooded/Saturated and wetter (PEM5E; PEM5F; PEM5H, and PEM5R) and contiguous with a waterbody, Phragmites-dominated Estuarine Emergent wetlands and contiguous to a waterbody, Seasonally Flooded-Tidal Palustrine Wetland where EM is the subordinate mixed class (e.g., PFO1/EM1R), Other Lacustrine Littoral Unconsolidated Bottom, Other Palustrine Unconsolidated Bottom (excluding industrial, commercial, stormwater detention, wastewater treatment, and similar ponds), Palustrine Emergent wetlands (including mixtures with Scrub-shrub) that are Seasonally Flooded and associated with permanently flooded waterbodies
Significant for Wood Duck	Lotic wetlands (excluding those along intermittent streams) that are Forested or Scrub-shrub or mixtures of these types with C, E, F, R, or H water regime; Lotic wetlands that are mixed Forested/Emergent or Unconsolidated Bottom/Forested with a E, F, R, or H water regime; Palustrine Tidal Forested or Scrub-shrub wetlands (and mixes with other types like the Lotic types) in estuarine reach with R or L water regime

Provision of Other Wildlife Habitat

The provision of other wildlife habitat by wetlands was evaluated in general terms. Species-specific habitat requirements were not considered. The criteria listed below are designed for the Northeast and many should be useful nationwide, but habitat requirements for regional and local wildlife need to be considered on a watershed-by-watershed basis for best results.

In developing an evaluation method for wildlife habitat in the glaciated Northeast, Golet (1972) designated several types as outstanding wildlife wetlands including: 1) wetlands with rare, restricted, endemic, or relict flora and/or fauna, 2) wetlands with unusually high visual quality and infrequent occurrence, 3) wetlands with flora and fauna at the limits of their range, 4) wetlands with several seral stages of hydrarch succession, and 5) wetlands used by great numbers of migratory waterfowl, shorebirds, marsh birds, and wading birds. Golet subscribed to the principle that in general, as wetland size increases so does wildlife value, so wetland size was important factor for determining wildlife habitat potential in his approach. Other important variables included dominant wetland class, site type (bottomland vs. upland; associated with waterbody vs. isolated), surrounding habitat type (e.g., natural vegetation vs. developed land), degree of interspersion (water vs. vegetation), wetland juxtaposition (proximity to other wetlands), and water chemistry.

For this analysis, wetlands important to waterfowl and waterbirds are identified in a separate assessment (see above) and rare wetlands are addressed in the function called "conservation of biodiversity" (see following subsection). Emphasis for assessing "other wildlife" was placed on conditions that would likely provide significant habitat for other vertebrate wildlife (mainly herps, interior forest birds, and mammals). Opportunistic species that are highly adaptable to fragmented landscapes are not among the target organisms, since there seems to be more than ample habitat for these species now and in the future. Rather, animals whose populations may decline as wetland habitats become fragmented by development are of key concern. For example, breeding success of neotropical migrant birds in fragmented forests of Illinois was extremely low due to high predation rates and brood parasitism by brown-headed cowbirds (Robinson 1990). Newmark (1991) reported local extinctions of forest interior birds in Tanzania due to fragmentation of tropical forests. Fragmentation of wetlands is an important issue for wildlife managers to address. Some useful references on fragmentation relative to forest birds are Askins et al. (1987), Robbins et al. (1989), Freemark and Merriam (1986), and Freemark and Collins (1992). The latter study includes a list of area-sensitive or forest interior birds for the eastern United States. The work of Robbins et al. (1989) is particularly relevant to the Northeast as they addressed area requirements of forest birds in the Mid-Atlantic states. They found that species such as the black-throated blue warbler, cerulean warbler, Canada warbler, and black-and-white warbler required very large tracts of forest for breeding. Table 1 lists some area-sensitive birds for the region. Ground-nesters, such as veery, black-and-white warbler, worm-eating warbler, ovenbird, waterthrushes, and Kentucky warbler, are particularly sensitive to predation which may be increased in fragmented landscapes. Robbins et al. (1989) suggest a minimum forest size of 7,410 acres to retain all species of the forest-breeding avifauna in the Mid-Atlantic region.

The analysis identifies two basic wetland types with potential for providing highly significant habitat for other wildlife: 1) large wetlands ($\geq$ 20 acres) regardless of vegetative cover but excluding pine plantations, and 2) smaller diverse wetlands (10-20 acres with multiple cover types). These two categories cover most wetlands along stream corridors that connect large wetland complexes. In addition to these wetlands, large clusters of small wetlands located within a forest matrix are also recognized as having high potential for wildlife habitat as well as vegetated wetlands connected to other vegetated wetlands by forests. The remaining vegetated wetlands are designated as having moderate potential significance for providing wildlife habitat.

Please note that in general, ponds are not listed as important as significant for "other wildlife." Wildlife species living in ponds, such as several species of frogs and turtles, are mentioned in the discussion of fish and shellfish habitat, since wetlands designated as important for fish and shellfish are provide required habitat for these species.

High — Large vegetated wetlands ($\geq$20 acres, excluding open

water,

nonvegetated areas, and pine plantations), small diverse wetlands (10-20 acres with 2 or more covertypes;

excluding

EM5 or open water as one of the covertypes), areas with large numbers of small isolated wetlands (within an upland forest matrix and including small ponds that may be vernal pools)

Moderate — Other vegetated wetlands

Given the general nature of this assessment of "other wildlife habitat," other individuals may want to refine this assessment in the future by having biologists designate "target species" that may be used to identify important wildlife habitats in a particular watershed. After doing this, they could identify criteria that may be used to identify potentially significant habitat for these species in the watershed. Dr. Hank Short (U.S. Fish and Wildlife Service, retired) compiled a matrix listing 332 species of wildlife and their likely occurrence in wetlands of various types in New England from ECOSEARCH models (Short et al. 1996) that he developed with Dr. Dick DeGraaf (U.S. Forest Service) and Dr. Jay Hestbeck (U.S. Fish and Wildlife Service).[3] DeGraaf and Rudis (1986) summarized habitat, natural history, and distribution of New England wildlife. Much of what is in the ECOSEARCH models comes from this source. These sources may be useful starting points for determining relationships between wildlife and wetlands.

[3] Copies of the matrix can be obtained by contacting R. Tiner (address on title page).

Table 1. List of some area-sensitive birds for forests of the Mid-Atlantic region. (Source: Robbins et al. 1989).

Species	Area (acres) at which probability of occurrence is reduced by 50%
Neotropical Migrants	
Acadian flycatcher	37
Blue-gray gnatcatcher	37
Veery	49
Northern parula	1,280
Black-throated blue warbler	2,500
Cerulean warbler	1,700
Black-and-white warbler	543
Worm-eating warbler	370
Ovenbird	15
Northern waterthrush	494
Louisiana waterthrush	865
Canada warbler	988
Summer tanager	99
Scarlet tanager	30
Short-distance Migrants	
Red-shouldered hawk	556
Permanent Residents	
Hairy woodpecker	17
Pileated woodpecker	408

Conservation of Biodiversity

In the context of this assessment, the term "biodiversity" is used to identify wetlands that may contribute to the preservation of an assemblage of wetlands that encompass the natural diversity of wetlands in a given watershed. Four types of wetlands may be identified: 1) certain wetland types that appear to be scarce or relatively uncommon in the watershed, 2) individual wetlands that possess several different covertypes (i.e., naturally diverse wetland complexes), 3) complexes of large wetlands, and 4) regionally unique or uncommon wetland types. The first two categories may include some wetlands that are human-impacted (e.g., impounded, excavated, timber harvested) or created; they support an uncommon wetland type and have been included as significant from our broad perspective. Some investigators may not consider such wetlands to be worth highlighting for "biodiversity" because they are the result of human actions and may not be viewed as reflecting "natural" conditions. Users can make their own decisions on how to regard these findings.

Schroeder (1996) noted that to conserve regional biodiversity, maintenance of large-area habitats for forest interior birds is essential. As mentioned previously, Robbins et al. (1989) suggest a minimum forest size of 7,410 acres to retain all species of the forest-breeding avifauna in the Mid-Atlantic region. Consequently, forested areas 7,410 acres and larger that contained contiguous palustrine forested wetlands and upland forests were designated as important for maintaining regional biodiversity of avifauna in the Mid-Atlantic Region based on recommendations by Robbins et al. (1989).   This criterion will be applied throughout the Northeast as no comparable data are available for other areas of the region. A few large wetlands in a watershed (e.g., possibly important for interior nesting birds and wide-ranging wildlife in general) and wetlands that are uncommon types (based on NWI mapping classification and not on Natural Heritage Program data) may also be identified as significant for biodiversity. The size of the "large" wetlands is variable depending on the distribution of size classes in a watershed, but they should typically be larger than 100 acres. All riverine and palustrine tidal wetlands and estuarine oligohaline vegetated wetlands are identified as significant for this function because they are often possess some of the most diverse wetland plant communities in the Northeast. We also identified other specific wetland types of particular interest to biodiversity. Phragmites-dominated wetlands are generally excluded from the listing except in urban areas where large stands (e.g., New Jersey Meadowlands) are recognized as significant natural habitats.

Use of Natural Heritage Program data and GAP data have been suggested, but use of these data are beyond the scope of our remotely sensed approach to wetland functional analysis. Consequently, wetlands designated as potentially significant for biodiversity by the W-PAWF assessment are simply a starting point or a foundation to build upon. Local knowledge of significant wetlands and Natural Heritage Program data can be applied by others to further refine the list of wetlands important for this function for specific geographic areas.

The following are examples of wetlands viewed as potentially significant for the conservation of biodiversity in the Northeast:

Regionally

Significant	Estuarine oligohaline vegetated wetlands (excluding Phragmites-dominated) Riverine tidal emergent wetlands (including tidal flats that are often colonized by nonpersistent plants during the growing season) Palustrine tidal emergent wetlands (excluding Phragmites-dominated) Palustrine tidal scrub-shrub wetlands Atlantic white cedar swamps Calcareous fens Bald cypress swamps Eelgrass beds Lotic fringe wetlands Areas with clusters of vernal pools Headwater seep wetlands? Rare plant habitats Forested wetland-forested upland complexes >7410 acres in size
Locally Significant (possibly)	Urban wetlands Shrub bogs Mussel reefs Oyster reefs Larch swamps Northern white cedar swamps Hemlock swamps Estuarine emergent wetlands (some areas) Lentic fringe wetlands (EM/AB and AB/EM wetlands) Uncommon types based on Inventory results

Summary

The U.S. Fish and Wildlife Service is attempting to add descriptors for landscape position, landform, and water flow path to its wetland digital database in the Northeast when updating NWI maps and digital data. When combined with typical NWI attributes from Cowardin et al. 1979 (system, subsystem, class, subclass, water regime, and special modifiers), the database contains many properties for each wetland that can be used to produce a preliminary assessment of wetland functions for large geographic areas. The focus of these analyses is on watersheds which are important land planning units for a number of agencies and organizations, but the same procedures can be applied to other land units such as counties or physiographic regions. The subject report provides the rationale for the criteria used to identify wetlands of potential significance for ten functions. These functions include: 1) surface water detention, 2) coastal storm surge detention, 3) streamflow maintenance, 4) nutrient transformation, 5) sediment and other particulate retention, 6) shoreline stabilization, 7) provision of fish and shellfish habitat, 8) provision of waterfowl and waterbird habitat, 9) provision of other wildlife habitat, and 10) conservation of biodiversity.

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