



U.S. Fish & Wildlife Service

Data Collection Requirements and Procedures for Mapping Wetland,
Deepwater, and Related Habitats of the United States (version 3)

U.S. FISH & WILDLIFE SERVICE - ECOLOGICAL SERVICES
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This document can be found at <http://www.fws.gov/wetlands/Data/Contributed-Data>

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DATA COLLECTION REQUIREMENTS AND PROCEDURES FOR MAPPING WETLAND, DEEPWATER AND RELATED HABITATS OF THE UNITED STATES

Preface

These technical procedures serve as a reference for conducting the image analysis work associated with mapping wetlands and deepwater habitats. This document is intended to be comprehensive, however situations may develop that require modifications or additions.

It is impractical to include all of the technical aspects of data handling and analysis within this document or anticipate all resource inventory needs. Users are advised that other written conventions or formal training may be useful in recognizing and describing wetland habitats, image interpretation and/or mapping protocols. More detailed field guides, regional information, wetland plant lists and soils descriptions are available.

This information is intended to provide general guidelines for work performance, but should not be substituted for direct communication with the appropriate Program, Project, or Technical Specialist(s) regarding procedural questions. For additional information contact:

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General Disclaimer

The use of trade, product, industry or firm names, or products in this report is for informative purposes only and does not constitute an endorsement by the U.S. Government or the Fish and Wildlife Service.

1. INTRODUCTION

The mission of the U. S. Fish and Wildlife Service (Service) is to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people. The Service supports programs relating to migratory birds, endangered species, certain marine mammals, inland sport fisheries, and wildlife refuges. The Service communicates information essential for public awareness and understanding of the importance of fish and wildlife resources and changes reflecting environmental conditions that ultimately will affect the welfare of people. To this end, the Service maintains an active role in the inventory, monitoring, and assessment of wetland habitats of the Nation.

The Service established the National Wetlands Inventory (NWI) to provide resource managers with information on the location, extent, and types of wetlands and deepwater habitats. Congress recognized that wetlands are nationally significant resources and that they have been affected by human activities. Direction was given to NWI with enactment of the Emergency Wetlands Resources Act (Public Law 99-645). The Act and its subsequent amendments gave NWI specific goals and deadlines for producing wetland maps for the conterminous United States, Alaska, Hawaii, and the Trust Territories.

The objective of mapping wetlands and deepwater habitats remains to produce medium resolution information on the location, type, size of these habitats such that they are accurate at the product scale of 1:12,000 (1:63,360 in Alaska). The Service continues to recognize the limitations of using remotely sensed information as the primary data source for mapping, and additionally, by policy, excluded some wetland types from its inventory (see Section 6 - Limitations). The Service did not design or intend these procedures to yield legal or regulatory products.

The Service provides habitat information to a diverse user base including local planning commissions, regional governments, multinational corporations, and foreign governments. However, the Service must continue to develop contemporary applications of its data that will facilitate broader use and relevancy for integrated natural resource management and decision making in the future. Advances in information technology and geographic information systems have influenced public expectations for greater utility and functionality from Government data sources.

There is an ever-growing importance and sensitivity placed on data quality and integrity. The Service strives to present information on wetlands, deepwater and related habitats in an accurate, clear, complete, and unbiased manner. To ensure the effectiveness and reliability of wetland map data, the Service has established quality standards, instituted quality assurance, and quality control protocols. The goal of these protocols is to ensure that the data collection, analysis, verification, and reporting methods are used to produce uniform information. The information collected using these requirements and procedures are intended to support the decision-making process. Unintended use of the information or products is discouraged.

The technical procedures described here have been developed by the Service to provide the quality assurance measures and protocols needed to produce accurate wetland map products. Because of recent technological innovations and the changing realm of computerized mapping, this document has been expanded over previous quality control guidelines that were referred to as "Mapping Conventions" and "Photointerpretation Conventions". Although revisions to existing operating conventions have taken place

periodically since 1981, these documents provided “...specific instructions to the photo interpreter when applying the” Service’s classification system “...to aid photo interpreters to correctly identify, classify and delineate wetlands on high altitude aerial photography.” This document applies to modern processes that use digital imagery and take a more comprehensive approach in describing quality control procedures by directly linking to Service Standards (FGDC 2008, FGDC 2013 and National Standards and Quality Components (USFWS 2004), while providing flexibility to accommodate different technologies.

2. STANDARDIZED CLASSIFICATION AND TERMINOLOGY

In providing wetland habitat information, the Service uses the Federal Geographic Data Committee (FGDC) Standard, Classification of Wetlands and Deepwater Habitats (Cowardin et al. 1979) which is the approved Federal Standard for mapping, monitoring and reporting wetlands data. This provides a standardized system of nomenclature and terms for habitat mapping only. The Cowardin system defines wetlands in a biological framework. (See Appendix A)

Cowardin et al. (1979), was developed to meet four long-range objectives:

- Describe ecological units that have certain homogeneous natural attributes.
- Arrange these units in a system to aid resource management decisions
- Provide units for inventory and mapping
- Provide uniformity in concepts and terminology throughout the nation

2.1. Wetland Classification - Adaptations for Mapping Purposes

One of the uses of the Cowardin classification system is inventory and mapping of wetlands and deepwater habitats. A classification used in the mapping is scale-specific both for the minimum size of units mapped and for the degree of detail attained. It is necessary to develop a specific set of data collection procedures to accommodate map-making using remotely sensed imagery as the primary data source.

For example, some water chemistry, halinity, water depth, substrate size and types and even some differences in vegetative species cannot be reliably ascertained from air photos or digital imagery used by the Service. Image analysts must primarily rely on physical or spectral characteristics evident on high altitude imagery to make decisions regarding wetland classification and deepwater determinations.

Other considerations regarding wetland classification and mapping constraints involve the potentially huge number of classification combinations that are possible using the Cowardin system. Currently, the NWI wetlands dataset contains over 5,300 unique classification codes. Some diversity in classification coding and nomenclature is desirable as it provides descriptors of unique habitat types or wetland conditions. However, the proliferation of mapping codes is neither useful nor desirable and the need to provide uniformity in the terminology is essential to describe ecological characterization. For this reason, conventions have been developed to limit the number and types of classification code descriptors to those that will be most informative about wetland and deepwater habitats.

Adaptations to the Cowardin classification system have been made to conform to operational and practical constraints in the data collection and mapping processes. These are reflected in the code diagram information developed by the Service (Appendix B), the Water Regime Restriction Table (Table A-1),

mixed classes combinations (Table A-2), mixed sub-classes combinations (Table A-3) and a glossary of terminology (Appendix C).

3. DATA COLLECTION GUIDELINES

Mapping involves a number of functions including feature identification, classification, field verification, and methods for data capture and storage, generation of map products in digital formats, procedural documentation, and application of technology. Each function requires a level of standardization to produce consistent products (USFWS 2004). All existing maps have been through extensive quality control reviews at the image interpretation stage, draft and final map stages of production. When they were produced, the maps reflected the type and extent of wetland habitats that the Service was able to portray given technical and logistical constraints.

By 2014, the Service's National Wetlands Inventory had mapped 100% of wetlands of the conterminous United States. With the completion of this digital dataset, the Service is now moving from its vision of building the wetlands layer to maintaining and updating it as a National Geospatial Data Asset. The Service is asking our stakeholders such as Federal, state, tribal, and territorial agencies to assume more wetland mapping responsibilities, by producing new and updated data for their areas of interest.

The existing digital wetland library would be used as a basis for updating and the assumption that the base wetland map information was essentially correct at the time it was produced forms the underlying premise for this updating process.

The goals of updating the dataset are to produce digital wetland data that match existing wetland and deepwater conditions (on the ground) as closely as possible, and to do so while using resources efficiently and cost effectively. The decision to retain or change existing map features or attributes is based on several factors outlined by the data creation guidelines discussed in the next section. Updates shall conform to the principles listed below:

- The resulting wetlands map data must support clear, unambiguous interpretation of the wetland features represented.
- The position and classification accuracy of the mapped features must meet current standards, and the dataset as a whole must represent the scientific precision that underlies the Service's habitat mapping objectives.
- Wetland and deepwater feature delineation and attribution distinguish features by class, subclass, water regime, and/or special modifier.

3.1. Basic Data Creation Guidelines:

Data producers should make qualitative determination(s) about the usefulness of the original wetland data (i.e. Should it be updated or re-done?). In some cases, wetland map data may be so outdated or inaccurate that the map should be replaced entirely. Some basic revision guidelines include:

- Retain all lakes, ponds, rivers, bays, sounds, estuaries, perennial streams and other water bodies regardless of size, unless a feature has obviously changed or no longer exists.

- Revise coastal shorelines only if there are obvious manmade changes or substantial natural changes.
- Revise wetland or deepwater boundaries by using ancillary data sources and the geographical features that define location and configuration.
- Revise existing wetland and deepwater habitat delineations and attributes only where reliable ancillary data indicates a change or there is positive visual evidence of a change.
- On revised or updated maps, there will be a temporal difference between the update and older edition map. Seasonal or climatic variations in the source imagery should be considered when making update changes or revisions.
- Change obsolete attributes codes to meet current standards.
- Replace unknown water regime with the appropriate water regime modifier.
- Add any appropriate special modifiers.
- Revise bathymetric information (i.e. lacustrine sub-system delineations) only if pertinent new information is available or where shorelines have obviously not been modified.
- Revise classification of vegetative surface cover only in one of the following minimum change criteria is met:
 - The total area of the feature to be re-delineated or re-classified is greater than 0.25 acre.
 - The hierarchy of the re-classification is Cowardin class level or higher (subclass for forested or shrub areas).

Do not label upland(s) as part of a standard product. The Wetlands Geodatabase is a seamless wetlands dataset that does not contain upland features (<https://www.fws.gov/wetlands/>). All features mapped need to be represented as polygons.

3.2. Avoiding Extraneous Detail and Misrepresentation of Data

Technological advances in the acquisition of remotely sensed imagery and computerized mapping techniques often provide the ability to capture more detailed information about earth objects. The use of such technologies can be advantageous in terms of producing better quality natural resource information in a more timely fashion and often at a reduced cost. However, appropriate use of these capabilities requires specific knowledge of project objectives, limitations, and the proper application of the products.

In the context of conducting a medium resolution national mapping effort, updated wetlands maps should reflect ecological characterization or land use condition that influence the size, distribution or classification of wetland habitats. Enhancements to refine cartographic precision should be undertaken only to the extent they bring products into conformance with the Service's standards and quality requirements.

When mapping wetlands, deepwater and riparian habitats, image analysts will address the following criteria in priority order:

1. Delineation of wetland and deepwater habitats to resemble extent and shape;
2. Appropriate classification to the Cowardin sub-class level;
3. The horizontal accuracy minimum requirement for the mapping area is commensurate with the base imagery/map scale, according to the FGDC Wetlands Mapping Standard (2008);

4. Classification of Cowardin water regime;
5. More detailed classification of Cowardin modifiers that can be determined by the imagery.
6. More precise geographical location or boundary determination that can be determined by the imagery.

Unrealistic attempts to characterize habitats should be avoided unless specifically required by special project specifications or instructions from the Service Project Manager(s). Detail is often confused with quality. The goal of the Service is to produce high quality resource maps. Steps that are implemented to add additional detail (delineation or classification of extremely small features or components) lends a sense of false precision and can misrepresent the data in a way that it was not intended to be used.

Excessive detail of mapped features should be avoided. Within a wetland boundary, the delineation of ecologically unsubstantiated internal breaks should be avoided. Intricate sub-delineation of wetland types (less than 1.0 ac.) within a wetland is often not warranted. In areas of undulating terrain (i.e. ridge and swale) or complexes of wetland classes (i.e. small shrub islands within emergent meadow), it is best to identify and characterize the wetland by a single classification rather than attempt to delineate and classify internal features. Highly detailed resource information can be provided by the Service through various special projects.

4. TECHNICAL PROCEDURES FOR DATA COLLECTION AND IMAGE ANALYSIS

The delineation of wetlands, deepwater habitats, and riparian features through image analysis forms the foundation for deriving all subsequent products and data results. Consequently, the Service places a great deal of emphasis on the quality of the image interpretation. The Service does not attempt to adapt or apply the products of these techniques to regulatory or legal authorities regarding wetland boundary determinations, jurisdiction or land ownership, but rather uses the information to assist in resource mapping and habitat characterization. Coordination and consultation with the Service's National Wetlands Inventory staff is very important to understand classification application concepts, wetland delineations, and national project objectives.

4.1. Image Interpretation of Wetlands - General Concepts

This document is not a primer on wetland ecology, interpretation, or resource analysis using remotely sensed imagery. Wetland image analysts need to be fully trained before attempting to apply these data collection procedures (see section 4.2.3.a Personnel Qualifications).

There are "basic elements" that can aid in identification of wetland habitats from aerial photographs or digital imagery. The image analyst uses these to make decisions about ecological habitat boundaries to map wetlands. These same elements are used in the quality control review of delineated information to check for accuracy and completeness.

Tone (also called Hue or Color) -- Tone refers to the relative brightness or color of elements on a photograph. It is, perhaps, the most basic of the interpretive elements because without tonal differences one of the other elements could be discerned.

Size -- The size of objects must be considered in the context of the scale of a photograph. The scale will help you determine if an object is a stock pond or large lake or reservoir.

Shape -- Refers to the general outline of objects. Regular geometric shapes are usually indicators of human presence and use.

Texture -- The impression of "smoothness" or "roughness" of image features is caused by the frequency of change of tone in images. It is produced by a set of features too small to identify individually. Grass, cement, and water generally appear "smooth", while a forest canopy may appear "rough".

Pattern (spatial arrangement) -- The patterns formed by objects in an image can be diagnostic. Consider the difference between (1) the random pattern formed by a natural grove of trees and (2) the evenly spaced rows formed by an orchard or planted forest.

Shadow -- Shadows may aid interpreters in determining the height of objects on aerial imagery. However, they can also obscure objects within them.

Geographic Location -- This characteristic of imagery is especially important in identifying vegetation types and landforms. For example, large oval depressions in the ground are readily identified as Carolina Bays in the coastal regions of southeast.

Association -- Some objects are always found in association with other objects. The context of an object can provide insight into what it is. For instance, a nuclear power plant is not (generally) going to be found in the midst of single-family housing.

For general information on photo interpretation and photo interpretation techniques, users are referred to the following publications:

Avery, T.E. 1970. Interpretation of Aerial Photographs 4th edition. Burgess Publishing Co., Minneapolis, MN. 324 p.

Lillesand, T.M. and R.W. Kiefer. 1987. Remote Sensing and Image Interpretation 2nd edition. John Wiley and Sons, Inc., New York, NY. 721 p.

W. Philipson (editor) 1996. Manual of Photographic Interpretation (Second edition). American Society for Photogrammetry and Remote Sensing. Bethesda, MD

Ustin, S. 2004. Manual of Remote Sensing, Volume 4, Remote Sensing for Natural Resource Management and Environmental Monitoring, (3rd Edition). Wiley Publishing, Inc., Indianapolis, IN. 768 p.

Also, see: <http://www.asprs.org/> for additional information on remote sensing techniques.

4.2. Technical Methodologies:

Currently there are various accepted techniques used to interpret, and map wetlands. The technologies change with time and this section does not contain a comprehensive discussion of all possible data capture

methods. One of the predominant approaches currently being employed by the Service is presented below.

4.2.1. On-Screen Method

This process is the current method most feasible for identifying and delineating wetlands using digital imagery and supporting tools.

The on-screen method involves viewing digital map data that overlays digital imagery on a computer screen. Changes to the map data to make it current with the digital imagery can be made on-screen and the digital data file checked and saved or exported.

The on-screen method was primarily developed for updating existing wetland maps, although it can be used to do original habitat mapping. The Environmental Systems Research, Incorporated's (ESRI) ArcDesktop products (latest version) employ geodatabase formats for viewing, editing and storing map data. Compared with previous methodologies, this greatly improved the administration, access, management, and integration of spatial data. The ArcDesktop system also provides access to a suite of editing tools and creates files that are easily transferred facilitating efficient collaborative mapping.

The on-screen method has several distinct advantages:

- Uses digital imagery
- Provides seamless coverage of work areas
- Easily transportable to other platforms
- Digital topographic maps, or other ancillary digital data layers (e.g. hydric soils layer) can be added as a direct backdrop for image interpretation.
- Automated verification routines incorporate geographic information system (GIS) capability and logic checks.

There are also several limitations associated with this method:

- The process is machine/cursor driven. This requires an GIS-literate operator
- On-screen viewing generally does not include stereo capabilities. USGS digital topographic maps help compensate for this by providing hydrographic, topographic, cultural, and contour information to assist.
- Electronic media requires different preparation, storage, distribution and archiving skills

The on-screen process developed for updating wetland maps relies on the image interpreter's ability to recognize, accurately delineate and classify wetlands, perform data edits, and verify the digital file. A custom verification tool was developed to provide technical quality control or logic checks of the digital data. This tool can be accessed at <https://www.fws.gov/wetlands/Data/Verification-Tools.html> . Editing and updating wetland digital map data using an on-screen process implies the following:

- ArcDesktop software will be used in a Windows environment to edit existing digital data

- Digital imagery will be used as the base imagery to update the wetlands information
- The existing wetland map digital data will overlay and register to a USGS digital topographic base map or rectified imagery where available
- The Service's customized data verification tool will be used to assist the updating and editing and data verification processes

4.2.2. Minimum Hardware and Software Requirements

Desktop Work Stations: The customized Data Verification Tool is an ESRI model created in Model Builder. To run these tools, any workstation must be capable of running the ArcDesktop suite. ESRI has published system requirements for ArcGIS: www.esri.com.

Hardware specifications change with technological developments. It is recommended that a GIS workstation and computer hardware should be used.

Software – ArcGIS (latest version) was best suited to performing map edits on-screen. ArcDesktop provides a suite of efficient editing tools, interactive editing capability, and integrated version control of data.

Other software packages and data formats may be used to conduct wetland mapping, however, data must be converted to an ESRI file geodatabase to use the Data Verification tool and to be incorporated into the Wetlands Master Geodatabase.

4.2.3. a. Personnel Qualifications

Personnel using the on-screen method need to be experienced in the identification and classification of wetlands. Using the on-screen method, image analysts are responsible for insuring the ecological integrity of the mapping process as well as most of the cartographic accuracy. The identification, delineation and attribution of features is done within the digital data file requiring analysts to understand the ecological aspects of wetlands as well as be able to operate in a computerized mapping environment. For this reason, image analysts using this method should be experienced with ArcDesktop (latest version) software, and have familiarity with geodatabases and editing spatial data. Inefficient or inadequately trained interpreters will greatly increase work time and potentially create numerous technical difficulties.

It is suggested that individual data analysts seek certification or advanced training as provided in the example below:

Certified Mapping Scientist, Remote Sensing (ASPRS) - A professional that specializes in analysis of images acquired from aircraft, satellites or ground bases, or platforms using visual or computer-assisted technology. Analysis is used by various specialized disciplines in the study of natural resources, temporal changes, and for land use planning. They develop analytical techniques and sensor systems.

Three years of experience in photogrammetric or cartographic applications, all of which have been in a position of responsibility that demonstrated knowledge and competence in planning and application. Three years of specialized experience at a professional level in remote sensing and interpretation of data from various imaging systems.

4.2.3.b. Defining the project area

NWI is a digital dataset that no longer constrains analysts to quadrangle based work areas. Work areas may be river corridors, watersheds, counties, or any custom boundary. However, defining the project area in geographical terms is important for the purposes of selecting the appropriate digital data from the Service's wetlands geodatabase, acquiring, and registering digital ancillary data, metadata tracking, and edge matching. Project areas must be at least 10,000 acres in size and be contiguous in shape with no interior holes. Projects that are uniquely shaped or overly complex should be approved by National Wetlands Inventory staff. Cooperators producing wetlands data for a specific area may request a digital mapping project by defining a project area and providing a shape file or feature class of the project area boundary, and forwarding the request to the Service's Wetlands Database Administrator. Digital wetlands data will then be 'checked-out' from the master geodatabase to the data producer and provided in file geodatabase format. Data is provided in a uniform projection (Albers Equal-Area Conic Projection). The horizontal planar units are meters. The horizontal planar datum is the North American Datum of 1983 (NAD83). Analysts must map all wetland and deepwater features (or other target habitats) within the project boundary.

Data must be returned to the Service's National Wetlands Inventory in file geodatabase format. In order to 'check-in' revisions to the Master geodatabase, the file geodatabase returned must match the 'checked-out' geodatabase (with revisions) initially provided. Data must have passed verification toolset and quality control review(s).

4.2.3.c. Digital topographic maps

A digital topographic map is a scanned image of a USGS standard series topographic map. The image inside the map neat line is georeferenced to the surface of the earth and fit to the UTM projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map. These form the standard base for mapping using the heads-up method.

4.2.3.d. Digital imagery

Digital orthophotos are rectified digital imagery that combine the image characteristics of a photograph with the geometric qualities of a map. Digital orthophotos are also geo-referenced, which means that any point on the orthophoto is referenced to its actual latitude/longitude (its actual location on the earth). Ortho-rectification removes distortion in the photo and provides uniform scale throughout the image. It is vital that imagery used as base information conform to federal standards of horizontal accuracy (

Not all digital imagery meets federal imagery standards. For this reason, checking the accuracy and registration of the digital imagery is an important first step. This can be done by aligning the digital imagery with the matching portion of the DRG. Since USGS products will continue to be the base data for the wetlands mapping effort, all digital data are aligned or compared to the USGS standard or rectified orthophoto products or maps. If imagery is scanned and rectified, acquired from non-conventional sources or if digital imagery is used, it must match the standards established for the base. This can be accomplished by checking alignment of known features on the image and map for correlation, checking datum corner points, or by establishing ground sample points at known location and distance. Digital

imagery, when used as a base, will be considered acceptable if at a scale of 1:10,000 known features or points appear not more than 5 meters from their location on the base.

4.2.3. e. Incorporating and using National Wetlands Inventory (NWI) digital data.

The existing NWI dataset is an invaluable tool for updating or re-mapping wetland maps. In most cases, the existing NWI data have been collected using high altitude aerial photography and field verified for accuracy. The map information has been quality control reviewed by Service Regional personnel, qualitatively inspected by national team member(s), incorporated and distributed to review as draft products, finalized and digitized. NWI digital data are currently available for the majority of the nation and should be evaluated and used as a starting point for any heads-up project. (See:

<https://www.fws.gov/wetlands/Data/Data-Download.html>)

Existing digital data coming from the Service's wetlands geodatabase may retain some issues that have carried over from the older NWI dataset. Some of the most common issues include the following: .

- 1) The digital files contained artifacts or errors from older software or data capture processes.
- 2) There were alignment and systemic zoom transfer scope offsets to the digital data.
- 3) The NWI maps contained older map codes (attributes) that are no longer used. This is especially true for raster-scanned images of older NWI maps available online.
- 4) Ties or edge matching between quadrangles was often "forced" at the digital map stage with no resolution of feature delineations, often resulting in data gaps or conflicts

Of primary concern is the alignment of the wetlands digital data with the digital imagery and standardized base. During the manual transfer process of registering the interpreted photographic information to a stable base map, offsets of the data were created. These offsets are not uniform in direction, frequency of occurrence, or magnitude. In areas with these errors, adjustments or complete re-mapping is required so that data align with the base information as required by the data quality requirements.

4.2.3.f. Acquiring and Incorporating Ancillary Digital Data

Minimal data requirements for mapping wetlands using the heads-up method are digital imagery, digital topographic maps, and if conducting map updates, existing NWI map data. Optional ancillary data may include, digital soils data, digital elevation models, hydrology, coastal navigation chart data, etc. (see Section 7.2 below). These ancillary data should be acquired as available from other sources.

Alignment and registration of ancillary data should be checked against the DRG or orthorectified imagery. Analysts should be aware of the data limitations for any the digital datasets used. Some of these issues are discussed in Section 7.2 below.

4.2.3.g. Minimum Wetland Classification

The minimum standard for wetland classification is; ecological system, subsystem (with the exception of palustrine), class, subclass for emergent, forested and shrub, water regime and (where applicable) special modifiers. Reference to the Federal Geographic Data Committee Wetland Map Standards (2009) should be made to help ensure consistent, compliant data classification.

(https://www.fgdc.gov/standards/projects/FGDC-standards-projects/wetlands-mapping/FinalDraft_FGDC_WetlandsMappingStandard_2009-01.pdf)

4.2.3.h. ArcDesktop Editing - Image analysis

The Wetlands Geodatabase is the foundation for the Service’s digital wetlands data holdings that make up the wetland geospatial data for the nation. The geodatabase is composed of five geographical units (conterminous U.S., Alaska, Puerto Rico and the Virgin Islands, Hawaii, and the Pacific Trust). The geodatabase is designed to provide feature class information for wetlands polygons, riparian and other related data. Each feature class is structured to include definitions and purpose, product description and use, metadata and limitations.

The source imagery used to interpret wetlands should be a minimum of 1m resolution or as specified in Table 1. Spatial resolution refers to the detail with which a map depicts the location and shape of geographic features. The larger the map scale, the higher the possible resolution. Base imagery is the ortho-rectified imagery (aerial photography/satellite imagery) that is used as the base image to overlay wetlands data. The base imagery must be rectified to a national standard dataset. The purpose of specifying base imagery requirements is to produce a high detail and consistent wetland data layer. Table 1-Spatial Resolution Requirements of Source Imagery. (Source: FGDC 2008)

	Lower 48 States and Hawaii*	Alaska	In-Shore Deepwater
Resolution	1 meter	5 meters	3 meters

**Includes the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. In-shore deepwater habitats are excluded. Alaska is also excluded.*

4.3 Data Accuracy and Precision

4.3.1 Target Mapping Unit

The Target Mapping Unit (TMU) is an estimate of the size class of the smallest wetlands that can be consistently mapped and classified at a particular scale of imagery, and that the image-interpreter attempts to map consistently. The size of a TMU is based on a simple square or a circle shape (a polygon with significant interior area relative to its perimeter) and not a long, narrow rectangle (i.e., a linear feature with little or no discernable interior area at the scale of interest). Therefore, wetlands which appear long and narrow (less than 15 feet wide at a scale of 1:12,000), such as those following drainage-ways and

stream corridors, are excluded from consideration when establishing the TMU. TMU requirements are shown in Table 2.

Table 2 -Targeted Mapping Unit(s) and Requirements

	Lower 48 States, Hawaii, & Territories *	Estuarine & Lacustrine Deepwater **	Alaska (Including Deepwater)
TMU	0.5 acres (0.2 ha)	1.0 acres (0.4 ha)	5.0 acres (2.0 ha)
Feature Accuracy (Wetland Identification)	98%	98%	98%
Attribute Accuracy (FGDC Wetlands Classification)	85%	85%	85%

**Includes the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Estuarine and lacustrine deepwater habitats are excluded. Alaska is also excluded.*

***Includes the Estuarine and Lacustrine deepwater of the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Alaska is excluded.*

4.3.2 Feature Accuracy

Producer’s Accuracy – Ninety-eight percent of all wetlands visible on an image, at the size of the TMU or larger shall be mapped regardless of the origin (natural, farmed, or artificial.)

Universal scale - The universal working scale is the scale where review or edits are done in ArcDesktop and at which the delineations are quality controlled. The universal scale should range between 1:7,000 and 1:12,000 in an ArcDesktop session, which exceeds the requirements to ensure accuracy and sufficient detail.

Maximum zoom - This is the maximum magnification an analyst should use for wetland delineation and classification purposes. This scale is established at 1:5,000. Delineations performed below this maximum zoom threshold greatly exceed the requirements, and may misrepresent the data as more precise than supported by the techniques and objectives established by the Service. Delineations performed at scales larger than this threshold lead to project inefficiencies.

Linear and point data - No linear or point data are contained with the wetlands layer. Features too small to be mapped as small polygons far exceed the minimum mapping unit and will not be included. Linear geometries should not be included as part of the mapping process.

Existing linear and point features from older wetland maps have been converted to polygon features and included in the wetlands feature class. Narrow wetland and deepwater features must be mapped as polygons. Historically many linear features were not collected by NWI as they were represented on NWI overlay maps as the blue lines from the USGS Topographic maps. Now that NWI has evolved from a map overlay product to a geospatial dataset, all linear habitat features should be captured as polygons.

4.3.3. Quality Control and Quality Assurance

All data collectors are required to coordinate to the extent possible with National Wetlands Inventory staff for data reviews and quality assurance steps prior to submission to the Service's Wetlands Geodatabase.

Internal reviews and checking - Quality control of interpreted map products will be performed on 100% of the project area by a qualified image analyst other than the person performing the original work. To accomplish this, the review analyst will perform an incremental screen by screen (working west to east or north to south) qualitative review of the project area at no less than 1:12,000 scale. After completing a row or column of screen views, edits should be saved in the file geodatabase.

Internal quality control review of interpreted images should include a comparison of contours, hydrographic symbols, or cultural features from the DRG to wetland delineations and vegetation signatures. There is considerable latitude allowed in conducting qualitative reviews. However, a complete review of the project area with the backdrop of the standardized base visible at a scale larger than 1:12,000 must be completed. All work shall adhere to all National Standards and Quality Requirements and these Data Collection Requirements.

Attribute table review - During the quality control review the analyst will access the attribute table and review for errors. Sorting various data fields in ascending order can easily isolate null attributes, empty attributes, improper attributes and very small, or "sliver" polygons.

Draft product review - The production of draft map products is optional. Hardcopy maps of the wetland data may be made to review in the field or to provide visual inspection of mapped features at various smaller scales than is practical to view on-screen. There are no specifications for draft products since they are considered interim work products - not for distribution.

Data Verification - The Geodatabase is a mechanism for spatial and attribute data that contains specific storage structures for features, collections of features, attributes, relationships between attributes and relationships between features. Many of the geospatial data checks are inherent in the creation of a geodatabase in ArcDesktop.

Customized data verification tools have been constructed to automate (to the extent possible) the technical quality control functions necessary to ensure the geodatabase is accurate. This suite of functions has been designed to address geospatial errors, digital anomalies, and some logic checks that make use of the

power of a geographic information system. These tools are extensions to Environmental Systems Research, Incorporated's (ESRI) ArcDesktop GIS software products. The latest version of the verification tools and accompanying user documentation can be found at; <http://www.fws.gov/wetlands/Data/Tools-Forms.html> .

For digital data to be accepted into the Service's Wetland Geodatabase, they must first pass verification. A number of geospatial quality control checks are mandatory for the digital data to pass verification. Other functions the verification tools perform will flag potential problems but provide the image analyst the option of editing or ignoring the feature.

Edge matching - Edge matching of wetland interpretation is required for a seamless wetland database. There are two types of edge matching: 1) internal ties along the borders of source images and 2) external ties to pre-existing wetland data immediately adjacent to the project area.

The Service requires that in all cases, internal edge matching shall be performed. Wetland mapping units lying along the outer borders of source images within a project area, whenever practical shall be edge-matched with interpretations on all adjacent images within the project area. All polygon features shall be edited to ensure an identical or coincident transition across images in the entire project area. At a minimum, features located on the outer edge of the project area will be closed exactly at the border of the project area. Because some maps have been updated, there may be some temporal differences in the data.

Edge matching of data adjacent to the project area can be facilitated by referencing on-line data available at <https://www.fws.gov/wetlands/Data/Data-Download.html> or by establishing a web mapping service (WMS) connection to the existing wetland data at <http://www.fws.gov/wetlands/Data/Web-Map-Services.html>.

4.3.4. Metadata

Metadata are stored in the Wetlands Geodatabase in FGDC compliant format. Metadata at the National level is provided to comply with the Service's Metadata Documentation and Record form. These data address the informational content of each of the five map areas contained in the Wetlands Geodatabase. Additional supplemental information, which serves as project level metadata, is included as well.

Project Level Metadata - Project level metadata is tracked by the creation of a project boundary polygon for each project area checked-out from the Service's Wetlands Master Geodatabase and modified/updated. This will provide the needed tracking and reference information to the geodatabase users.

Mandatory Submissions - A completed Supplemental Map Information Report (supplemental metadata) must be included with submission of the digital data. This information becomes the "project level metadata" or intra-data specific to the updated version of the geodatabase.

Optional Submissions - Submission of completed field data forms and/or field photographs are optional. These are supplemental information to the data and should be clearly labeled if included. Each

photograph submitted must be linked to subject matter discussed on the field data form and be provided at 72 dpi in JPEG or TIFF format.

The Supplemental Map Report and Field Data Form are standardized report forms designed specifically for the Service's geodatabase and are included as Appendix E – Supplemental Map information Template.

4.3.5 Digital Data Requirements and Delivery

The digital data must conform to the following criteria:

- Digital data must be submitted and pass FWS quality control reviews prior to submission to the wetlands geodatabase
- Digital wetlands data must be provided in file geodatabase format
- Data will be in a uniform projection (Albers Equal-Area Conic Projection). The horizontal planar datum is the North American Datum of 1983, also called NAD83
- Data must have passed the verification toolset. All polygons must have a valid attribute code to depict wetland habitat type. Implementation recommendations for ensuring attribute validity are in Appendix D.
- Data must be internal to the project area; data should be seamless.

5. NON-COMPLIANT MAP DATA

For any wetland mapping activity that will not comply with the existing FGDC Wetlands Mapping Standards, a waiver is required from the Service's Data Steward for Water Resources and Wetlands. A waiver is an authorized exemption from a specific minimum requirement(s) in the FGDC standard and will only be considered for non-conformance to technical specifications of spatial resolution, source imagery, geospatial accuracy requirements, or level of classification. A waiver may only be granted for projects not directly or indirectly funded with the use of federal funds.

The intent of these products is to fill an immediate data gap, or where there is existing provisional data, known as scalable data (see Section 8 - Achieving Quality Requirements for Wetland and Deepwater Data). These areas should be replaced with standardized wetland map information as funding and priorities will allow. Areas of interior Alaska may fall into this category. Consulting National Wetlands Inventory staff prior to initiating this type of data collection is recommended.

6. LIMITATIONS

The Service's wetland and deepwater habitat maps were prepared from the analysis of high altitude imagery. Wetlands were identified based on vegetation, visible hydrology, and geography. There is a margin of error inherent in the use of imagery, thus detailed on-the-ground inspection of any particular site, may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the ancillary data, and the amount of ground truth verification work conducted. Wetlands or other mapped features may have changed since the date of the imagery and/or fieldwork. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site. Most data discrepancies will occur in the application of the different subclasses and water regime modifiers assigned to particular wetlands. Aerial imagery typically reflects conditions during the specific year or season in which it was captured. Precise description of hydrologic characteristics requires detailed knowledge of the duration and timing of surface inundation, both yearly and long-term as well as an understanding of groundwater fluctuations. Because such information is seldom available, the water regimes are described in general terms. The analysts' goal is to assign average condition. Assigning water regime based on a single point-in-time image can lead to misrepresentations, especially in times of drought or extreme high water conditions.

Certain wetland habitats may not be consistently mapped because of the limitations of aerial imagery as the primary data source used to detect wetlands (USFWS 2004). These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and near shore coastal waters.

Reefs include tropical reef communities (coral or tubercid worm reefs) and oyster (*Crassostrea virginica*) reefs. Reef communities form a vital component of coastal ecosystems. Tropical coral and worm reefs can be found in the Florida Keys extending south from Miami and Soldier Key to the Dry Tortugas, Puerto Rico, the U.S. Virgin Islands, Hawaii and the islands of the Pacific Trust Territories. Oyster reefs can be found in several states along the south Atlantic and Gulf coasts. Reefs are found offshore in water depths from less than 1 m to over 40 m. Because of their depth, most reefs go undetected by aerial imagery used to map wetlands (Dahl 2005).

Cowardin et al. (1979) does not recognize ephemeral water areas as a wetland type. Therefore, ephemeral waters are not included as part of this mapping effort. Different agencies describe "ephemeral wetlands" in different ways. Ephemeral waters are areas that are flooded or ponded with surface runoff for less than seven days. Wetlands such as seasonal ponds, temporary ponds or vernal pools (U.S. EPA – www.epa.gov) are included as wetland types in the Service's mapping efforts.

Historically, the Service excluded certain types of "farmed wetlands" by policy. Other farmed wetlands cannot be determined from aerial imagery and may not be included. Contact the Service's National Wetlands Inventory staff for additional information on what types of farmed wetlands are included on wetland maps.

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than is described here. There is no attempt, in either the design or products of the Service's inventory, to define the limits of proprietary jurisdiction of any Federal, state or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate Federal, state or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

7. UNIVERSAL TECHNICAL PROCESSES

7.1. Suitable Imagery

In general, the most recent era imagery available should be used to update resource maps. Only high quality imagery should be acquired and used. The preferred type is digital color infrared with a resolution of 1.0 meter. Experienced wetland interpreters have found color infrared to be superior to other imagery types for recognition and classification of wetland vegetation types. There are multiple sources of imagery available including products from the National Agricultural Imaging Program, USGS digital orthoimagery products, state acquired imagery, and others.

Wherever possible, leaf-off (early spring or late fall) imagery will be used. A number of studies have found that imagery obtained when vegetation is dormant allows for better identification of wetland boundaries, areas covered by water, drainage patterns, separation of coniferous from deciduous forest, and classification of some understory vegetation. (U.S. Environmental Protection Agency 1991) There are distinct advantages to using leaf-off imagery to detect the extent of forested wetland. Visual evidence of hydrologic conditions such as saturation, flooding, or ponding combined with ancillary data sources including soil surveys, topographic maps, and wetland maps are used to identify and delineate the aerial extent of forested wetlands. Leaf-off imagery is an important tool in this process.

7.2. Ancillary Data as an Aid to Image Analysis

All data sources can vary in quality, resolution, availability, and age. Data sources should be scrutinized for applicability to meet project objectives. The analyst is required to use all available and approved photographic imagery, topographic maps, soils information, or any other sources of ancillary data that can be reasonably obtained during image interpretation. Review of these materials is helpful in interpreting digital imagery. It is suggested to use technically sound, reliable data sources to aid in the determination of wetland habitats. Some recognized sources of ancillary data might include the following:

U.S. Geological Survey (USGS) Topographic Maps. Areas indicated on USGS 1:24,000 scale (1:63,250 scale in AK) topographic maps by swamp symbology should be closely inspected on the source imagery. These features are often excellent indicators of wetland and unless strong evidence indicates otherwise, should be included on the map. Due to the nature of USGS topographic mapping, wetlands marked on USGS quadrangles tend to be at least seasonally flooded (U.S. Geological Survey 2001). All permanent water bodies are also mapped by USGS. USGS DRG's can be acquired at <http://nationalmap.gov/ustopo/index.html>.

USGS maps also provide hydrographic, topographic, and cultural information. Many interpretation errors can be avoided if the degree of slope is taken into consideration. The location, shape, drainage pattern, and surrounding physical and cultural features are all important clues when mapping wetlands. Analysts should also take into consideration the potential for the existence of slope wetlands, particularly in high relief or geologically complex landscapes, and that the existence of seepage driven, perched, and other saturated wetlands can occur on topographic slopes. Geologic maps and data may be helpful in identifying areas where slope wetlands may be encountered. The date of the topographic map should always be considered when using this information.

The USGS quadrangles or USGS Water Resources Data (stream gauge data) should be used as the primary data source in determining if the river channel is perennial or intermittent. A continuous line on topographic maps indicates perennial streams whereas; intermittent streams are shown as a broken line. The exceptions to this are provisional maps produced by the USGS.

U.S. Geological Survey – National Hydrographic Data (NHD) and other Hydrologic Data Sets: NHD data include lakes, rivers, ponds, and streams. The high-resolution dataset is most desirable for use in conjunction with wetlands mapping projects. USGS NHD data can be acquired at <http://nhd.usgs.gov>

Natural Resource Conservation Service County Soil Surveys. Soil survey maps are useful ancillary data providing the description, classification, and mapping of soils within a county. These maps are a representation of various soil patterns and types on the landscape. The complexity of the soil patterns, scale of the base imagery, field techniques employed, date compiled, and the minimum mapping unit for soil classification all play a role in how the soils information was produced and the utility as ancillary data for mapping wetlands. When used by an experienced image analyst as ancillary data, soils maps are useful in assisting in separating upland from wetland (hydric) soils. Hydric soils information can be found at: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/use/hydric/> .

The soil survey geographic (SSURGO) database duplicates the original soil survey maps and presents it in digital form. The SSURGO data represents the most detailed level of digital soil information. <http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>

National Oceanic and Atmospheric Administration Navigational Charts: A NOAA navigational, or nautical chart, is a graphic representation of the estuarine, marine and near shore environment. They are primarily used to plot routes for sea-going vessels. All nautical charts depict coastline features, configuration of the sea bottom, tidal ranges, location of man-made and natural hazards to navigation, and the properties of the earth's magnetism. Nautical charts are especially useful in determining the subtidal and intertidal subsystem breaks in the Marine and Estuarine wetland classification systems. They are also useful in determining the location and extent of mangrove vegetation, coastal shoals, flats, or bars. NOAA Navigation Charts can be found at <http://www.nauticalcharts.noaa.gov/>

Previous Edition NWI Maps and Ancillary Project Information: Whenever a previous edition of an NWI map exists, the analyst will use the map as ancillary information to determine the location and extent of wetlands based on an earlier period. Using previous edition Service wetland maps will provide important information on the presence or absence of wetlands. This information is useful to the analyst using imagery that is more current or imagery at a different scale. Different techniques to update maps will require different formats for the best use of the NWI data. For example, the heads-up technique is designed to use digital data overlain on imagery that is more recent, whereas, traditional stereoscopic techniques have used hard copy maps as ancillary work materials. Existing digital wetland map information can be found at: <http://www.fws.gov/wetlands/Data/Web-Map-Services.html>

Local or Regional Studies or Maps and Other Data Sources: The analyst is also encouraged to consult appropriate internal and external resources (regional experts, on-site resource managers, etc.) to assist in the interpretation process. Examples of this type of information include water management or district maps, vegetation maps or surveys, digital elevation data and local habitat studies or characterizations. The Service's Wetlands Coordinators, state agencies, or regional authorities are often good sources for such information. The interpretation and delineation of wetlands and deepwater habitats is expected to meet the Service's standards for accuracy and consistency. Communication and problem resolution procedures to ensure product acceptance should be maintained throughout the project.

7.3. Field Reconnaissance

Field reconnaissance can address questions regarding image interpretation, land use practices, and classification of wetlands. Fieldwork is also done as a quality control measure to verify that map information is correct. Viewing digital data on laptop or other portable devices can facilitate the review of wetlands map data in the field.

Initial field reconnaissance provides an opportunity for image analysts to become familiar with wetland communities and land use patterns. Information gained from field studies in combination with the analyst's skills and experience in image interpretation and use of ancillary data should result in successful wetland delineation and classification. In these instances, fieldwork should involve visits to a cross section of wetland types and geographical settings, as well as to sites that may be mapped using different image types, scales, and dates.

Timing of fieldwork inevitably influences results, particularly regarding vegetation data and water regime classification. Work conducted in early spring will highlight different components of an ecosystem than work conducted late in fall when different water conditions and plant species may predominate on the same site.

7.3.1. Preparation for Field Reconnaissance

To ensure accurate and consistent interpretation of imagery and to resolve various problems, analysts need to conduct field reconnaissance to correlate image signatures with observed wetland and upland types. The actual number of person-days required in the field is often determined by access to field sites, weather, travel logistics, etc. Preplanning of the field trip should include identification of hydric soils or hydric soil characteristics likely to be encountered, information about common wetland plants and their distribution, dominant land use, drainage practices, agricultural crops and some preliminary image analysis of sites to be field inspected.

Field sites should be chosen based on such things as commonly occurring image signatures or habitats characterizing an area; unusual but important imagery signatures (some which may be difficult to identify); borderline signatures (those features that might be wetland or upland) and; specific signature problems based on the date of imagery (recent burning, extreme high or low water conditions). All sites should be accessible. Analysts will want to select field sites near roads or public lands if access is limited.

7.3.2. Field Sites and Data Collection

While in the field, representative photographs of land use and wetland types should be obtained. Field data sheets for selected sites should be completed. The exact location of the field photographs, site location referred to in notes and other information must be provided. Wherever possible, digital cameras, data recorders, and ground positioning satellite (GPS) should be used to provide information that is more accurate.

Any handwritten field notes regarding changes observed should be clear and understandable. Notations might include ‘extend or add this wetland’; ‘delete wetland’; or ‘refine delineation’.

Time spent in the field is invaluable. To realize maximum results, it is often necessary to reassess some potential field sites based on work already completed versus time, access to sites and priorities.

7.3.3. Field Work as Verification

Image interpreters may conduct field verification exercises to ensure accurate and consistent interpretation of imagery. Field trip reports and field data provide documentation of the field verification efforts including, general descriptions of wetlands and uplands in an area, descriptions of surface water conditions both on the imagery and at the time of fieldwork, and details about the quality of the source materials used. Field data should be collected in a geospatial feature class; and can be submitted to the National Wetlands Inventory accompanying the final wetland information. For more information about submitting field data, contact National Wetlands Inventory staff.

7.4. Aids to Field Determinations

7.4.1 Plant Species That Occur in Wetlands

The presence of wetland plant species often provides important ancillary information to help biologists determine if a site is a wetland, or to gain insight to length and periodicity of flooding. Many plant species, however, seemingly grow equally well in wetlands and upland conditions. To clarify what plants may be found in wetlands a list of wetland plant species, “National List of Plant Species That Occur in Wetlands” (Reed 1988). In the listing, wetland plants are divided into four indicator categories based on a frequency of occurrence in wetland. These categories include:

Obligate wetland - Usually occur in wetlands

Facultative wet - Usually occur in wetlands, but may occur in non-wetlands

Facultative - Occur in wetlands and non-wetlands

Facultative upland - Usually occur in non-wetlands, but may occur in wetlands

A list of plant species with the wetland indicator status found at a particular site can provide useful information about the site. This information, taken from the field data form, will be entered into a database for future reference and use. Wetland plant information can be accessed at http://wetland-plants.usace.army.mil/nwpl_static/v34/home/home.html

7.4.2 Hydric Soil Lists and Indicators

Hydric soils are defined as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, July 13, 1994).

A list of the Nation's soils with actual or high potential for hydric conditions has been prepared by Natural Resources Conservation Service. "Hydric Soils of the United States" includes at least one phase in the listing that meets the hydric soil criteria. The list does not include soils that are classified at categories higher than the series level in Soil Taxonomy (USDA - NRCS 1999) nor does it include map units that may contain these series. The list is useful in identifying map units that may contain hydric soils. There is a national list of hydric soils as well as state and county lists. While the state and county lists may provide more regionally specific information, analysts should be aware that they may not be comprehensive in their presentation of all soil series with hydric characteristics.

Hydric soils lists and maps reflect only the soil series or map unit considered hydric. Soil map units may contain inclusions of smaller features with hydric characteristics (wetland). Soils that are artificially drained or protected (for instance, by levees) may be listed as hydric even though it will no longer meet the Cowardin definition of wetland.

Experienced analysts should rely on field indicators as a more reliable way to help identify existing wetlands. Nearly all hydric soils exhibit characteristic morphologies that result from repeated periods of saturation and/or inundation for more than a few days. Saturation or inundation when combined with anaerobic microbiological activity in the soil causes a depletion of oxygen. This anaerobiosis promotes biogeochemical processes such as the accumulation of organic matter and the reduction, translocation, and/or accumulation of iron and other reducible elements. These processes result in characteristic morphologies, which persist in the soil during both wet and dry periods, making them particularly useful for identifying hydric soils (USDA - NRCS, Wetland Science Institute and Soils Division 1996). Field Indicators of Hydric Soils in the United States (2006) is a guide to help identify and delineate hydric soils in the field. The most recent version of the field indicators document can be found at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053171.pdf

7.5. Field Forms and Reporting Requirements

A field trip report may be completed for data collection projects. Mapping projects require a field trip report subject to the requirements established by NWI staff.

Field trip reports shall discuss the details of the field reconnaissance efforts (including participants, dates, and location), ancillary data sources, and uses, general descriptions of wetlands and uplands in the area, description of water conditions, details about the quality and interpretation of the imagery and any special problems, findings or conventions.

During each field trip, participants are encouraged to complete Field Data Forms at a variety of different check sites, which are well distributed throughout the trip area. The exact number of check sites may be determined by specific project specifications, weather conditions, access to sites, trip objectives, etc. Good quality digital photographs should be provided for field sites for which a Field Data Form is completed (Field Data Form is included in Appendix E).

7.6. Private Land Access Protocol

The Service respects private property and landowner rights. Personnel should contact landowners in advance to obtain permission to access private lands to conduct field verification or evaluations. Site visits will not be made where this is not possible, or landowners cannot be contacted. At no time should Service personnel cross fences, gates, and barriers or traverse posted property without permission of the landowner. Analysts should select alternative field sites near roads or public lands if access is limited.

8. ACHIEVING QUALITY REQUIREMENTS FOR WETLAND AND DEEPWATER DATA

Quality requirements for wetland data are defined as “level of accuracy” benchmarks in the National Standards and Quality Requirements. This information can be found at; http://www.fws.gov/stand/standards/dl_wetlands_WWW.html. They include minimum requirements for wetland identification, delineation, and classification accuracy. Additional requirements for digital data accuracy and metadata ensure data are complete and accurate.

The Service has produced more specific Information Quality Guidelines for information disseminated by the agency. These guidelines are applicable to all Service offices that disseminate information to the public to ensure the information complies with the basic standards of quality to ensure and maximize its objectivity, utility, and integrity.

The quality and integrity of the Service’s wetland map products is based on a process involving multiple levels of quality oversight.

As part of this process, wetland map data must pass these quality control procedures to ensure the information is accurate. The steps include: 1) review by technical specialist(s) 2) pass automated verification routines, and 3) pass final verification and data integrity inspection as provided by National Wetlands Inventory staff. Each step and components are described below:

8.1 Review by Technical Specialist(s)

This quality assurance step defines the responsibilities of the image analyst(s) for data quality and completeness. There are two mandatory sub-steps:

8.1.1 Internal Inspections of Data Quality - Quality control of interpreted map products will be performed by a qualified image analyst other than the person performing the original work. The reviewing analyst will adhere to all National Standards, Quality Requirements, and Technical Specifications and will perform a 100% review of the work. This internal inspection may be completed by non-Service personnel under the specific technical direction and performance monitoring by a Government official through an extramural agreement.

Internal quality control review of interpreted images (regardless of methodology used) should include a comparison of contours, hydrographic symbols or cultural features from the USGS base map to wetland delineations and vegetation signatures. All available ancillary data should be used during this quality control review. The responsible reviewer must record the pertinent information regarding the review process to accompany the appropriate metadata for the project area.

*If internal review is conducted by the Service, it does not substitute for a Regional quality control review as described below.

8.1.2 Regional Quality Control - This is considered exclusively a Service function that must be performed by responsible Service personnel. Regional quality control of map products entails spot-checking of not less than 20% of the project area by qualified personnel. The Service has the discretion of how these quality controls are completed (i.e. using different technical means, field verification, etc.) Upon completion of the Regional quality control review, the Service should be prepared to certify that work products meet all applicable standards, quality requirements, and technical specifications. If the products do not meet these standards, the Service has two options: Correct the work to bring it into compliance with quality standards, or return the work to the originating entity citing deficiencies and requesting additional work be completed to meet the standard(s).

The Service may choose to use other qualified Service personnel to perform quality control reviews. Work backlogs, level of expertise and experience in mapping particular wetland types may be factors in soliciting quality control review from other qualified Service personnel to ensure the work is accurate and completed in a timely fashion. Not less than 20% of the project area must be reviewed to ensure the work is complete and meets the quality requirements and specifications.

8.1.3 Final Quality Control Review (National Quality Assurance) - This is considered exclusively a Service function that must be performed by responsible Service personnel. Final quality control of map products entails spot-checking of not less than 10% of the project area by qualified personnel. Any qualified Service personnel may conduct final quality control reviews. These reviews may entail using various technical means or field verification to check the work. Final quality control reviewers must coordinate closely with Regional quality control personnel regarding revisions or modification to the work products. Ultimately, the certification of data integrity and quality by the Service's National Wetlands Inventory Quality Assurance Coordinator and Data Steward will conclude the data collection phase of the project.

8.2 Scalable Products

Scalable map products may be generated within interior Alaska as initial or interim information. These interim products may include map information at different scales, classification level(s), or resolution. The goal is to develop maps that can be expanded or upgraded on demand. The production of interim products is at the discretion of the Service with an approved waiver provided by the Service's Data Steward for Water Resources and Wetlands. They do need to conform to the specifications established for standard map products or data. Geographical context will dictate the procedures used to produce and distribute any interim map information.

8.3 Data Verification

All digital data files will be subjected to rigorous quality control inspections. Data verification includes quality control checks that address the geospatial correctness, digital integrity and some cartographic aspects of the digital data. This step takes place after the ecological data collection phase of the project has been completed, reviewed, and approved as qualitatively acceptable. Implementation of quality checks ensures that the data conform to the specified criteria, thus achieving the project objectives.

The Service has developed customized Verification Tools for performing data checks on wetland map data. These tools can be found at: <https://www.fws.gov/wetlands/Data/Verification-Tools.html>. This suite of tools are modules run in Environmental Systems Research, Incorporated's (ESRI) suite of geographic information system products. The latest version of the verification tools has been constructed to automate (to the extent possible) the quality control functions necessary to ensure the geodatabase is accurate. Various functions have been designed to address geospatial errors, digital anomalies, and some logic checks that make use of the power of the geographic information system. Additional quality assurance issues not readily apparent on the verification tools may be handled by the geodatabase architecture itself.

Some quality control functions of the verification tools will flag potential problems but provide the image analyst the option of editing or ignoring the feature. This is to accommodate the image analyst's ability to determine the best ecological portrayal of the data. For example, a small lake that is only 18 acres has been identified during the data verification process as a potential problem based on its size (18 acres) and classification (lacustrine) because the minimum size for a lacustrine lake is 20 acres. The analyst has information that the lake depth exceeds 90 feet (greater than the 6.6 foot required depth for lacustrine) and thus determines that lacustrine is the proper classification.

There are seven functions executed by the automated verification checking process (see Description of the Verification Tests within Appendix E). At a minimum, digital data must pass the critical tests for topology and attribution of the quality control procedure to be considered qualitatively acceptable. Critical verification tests include "Unattributed or Null Attributed Wetlands," "Adjacent Wetlands with the Same Attribute," "Wetlands less than 0.01 Acres," and "Overlapping Polygons."

8.4 Attribute Validity

This standard requires that all polygons have a valid attribute code to depict wetland habitat type. To avoid attribute errors, all data submissions must be run through the attribute verification check prior to submission for inclusion in the wetlands geospatial data layer.

8.5 Oversight, Data Integrity, and Database Management

The National Wetlands Inventory Data Center has primary responsibility for the Service's wetlands geodatabase configuration and systems. This includes responsibility for the integrity and distribution of the digital geo-spatial data developed by the Service as part of the wetland and deepwater habitat mapping effort. Geodatabase Management is an important part to successful application of the processes used to verify, assimilate, distribute, and archive geo-spatial wetland data. The Geodatabase Manager plays a substantial role in the quality assurance of the digital data files. This includes the following responsibilities:

8.5.1 Final Data Verification - The Geodatabase Manager performs the final verification checks of the digital data before it is approved and entered into the wetlands geodatabase.

This final check involves some geospatial analysis, logic checking, and ensuring the necessary supporting documentation has been provided in proper format.

8.5.2 Records and Documentation - Additional reporting requirements applicable to all mapping projects include submission of a Supplemental Map Report (User Report) included as Appendix F. This will be used as project specific metadata information.

Submission of completed field data forms and/or field photographs are optional. These are supplemental information to the data and should be clearly labeled if included. Information on where to store these images will be provided by the Service's Geodatabase Manager (Wetlands_Team@fws.gov). New or updated digital wetlands data must be returned to the Service's National Wetlands Inventory. Data must have passed verification and Regional review(s).

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APPENDIX A: WETLAND AND DEEPWATER CLASSIFICATION FOR MAPPING PURPOSES

Wetlands

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of substrate development and the types of plant and animal communities living in the substrate and on its surface. The single feature that most wetlands share is a substrate that is at least periodically saturated with or covered by water. The water creates severe physiological problems for all plants and animals except those that are specially adapted for such conditions.

Wetland “substrates” consist of unconsolidated mineral material, organic material, or rock that is flooded or saturated long enough each year to support wetland organisms. Most wetland substrates also qualify as “soil.” According to the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), “soil” is a natural body that occurs at the land surface and has recognizable horizons, or layers, or has the ability to support rooted plants. As noted, the great majority of wetlands have soil; obvious exceptions include bedrock and boulder or cobble shores that lack horizons and have too little fine material to support rooted plants. In this classification, the term “soil” is only used for wetland substrates that meet the USDA definition. The more generic term “substrate” may be applied to *any* wetland, but is most often used in this classification when referring to nonvegetated habitats and when defining terms (e.g., individual Water Regimes, Marine, and Estuarine Subsystems) that apply to, or include, both habitats that have soil and habitats that do not.

The following definition of wetlands neither is designed, nor intended, to support legal, regulatory, or jurisdictional analyses, nor does it attempt to differentiate between regulatory and non-regulatory wetlands.

WETLANDS are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes¹; (2) the substrate is predominantly undrained hydric soil²; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

As noted in this definition, plant community composition, soil morphology, and site wetness (hydrology) are the principal indicators of whether a site is a wetland for ecological purposes. Site wetness, i.e., the presence of water, while central to the concept of wetland, is often the most

¹ Lichvar, R. W., and J. T. Kartesz. 2009. North American Digital Flora: National Wetland Plant List, version 2.4.0 U.S. Army Corps of Engineers, Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, and BONAP, Chapel Hill, North Carolina

² U.S. Department of Agriculture, Natural Resources Conservation Service. 2010. Field indicators of hydric soils in the United States. Version 7. L.M. Vasilas, G.W. Hunt, and C.V. Noble, eds. USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

difficult indicator to assess accurately because it is more dynamic (temporally variable) than plant community composition or soil properties. Plants and soil tend to reflect the prevailing degree of wetness at a site over time. For this reason, they frequently are excellent indicators of relative wetness, and this is why they are listed first as indicators of wetlands.

The intended that *all available information* should be used in making a wetland identification, as follows:

- If plants and soil are present at a site, then both a predominance of hydrophytes and a predominance of undrained hydric soil, as well as wetland hydrology, should be required for positive wetland identification.
- If plants are present but soil is absent (e.g., Algal Aquatic Beds on rock substrates), then a predominance of hydrophytic vegetation, as well as wetland hydrology, should be required for a positive wetland identification.
- If plants are absent but soil is present, then a predominance of undrained hydric soil, as well as wetland hydrology, should be required for positive wetland identification.
- If neither plants nor soil is present, then the wetland identification must be made strictly based on hydrology. In this case, the substrate should be “saturated with water or covered by shallow water at some time during the growing season of each year.” Cowardin et al. (1979) fully realized how vague this hydrologic definition was but, given the lack of detailed hydrologic data from the diversity of wetland types, geologic regions, and climatic regions of the U.S., there was no way they could have been more specific. Even today, these data are not readily available across the nation.

In these examples, three (3) indicators – hydrophytic vegetation, undrained hydric soil, and wetland hydrology; two (2) indicators—hydrophytic vegetation and wetland hydrology or undrained hydric soil and wetland hydrology; and one (1) indicator—wetland hydrology, respectively, would be used to make the identification, based on the features available at the particular site.

Deepwater Habitats

DEEPWATER HABITATS *are permanently flooded lands lying below the deepwater boundary of wetlands.* Deepwater habitats include environments where surface water is permanent and often deep, so that water, rather than air, is the principal medium within which the dominant organisms live, whether or not they are rooted in, or attached to, the substrate. As in wetlands, the dominant plants are hydrophytes.

Wetlands and deepwater habitats are defined separately because traditionally the term wetlands has not included deep, permanent water; however, both must be considered in an ecological approach to classification. **The Wetland Classification Standard includes five major Systems: Marine, Estuarine, Riverine, Lacustrine, and Palustrine.** The first four of these include both wetlands and deepwater habitats but the Palustrine includes only wetland habitats.

Limits

The upland limit of wetlands is characterized by (1) the boundary between land with predominantly hydrophytic cover and land with predominantly mesophytic or xerophytic cover;

(2) the boundary between soil that is predominantly hydric and soil that is predominantly nonhydric; and (3) the boundary between land that is flooded or saturated at some time during the growing season each year and land that is not.

The boundary between wetlands and deepwater habitats in the Marine and Estuarine Systems coincides with the elevation of the extreme low water of spring tide; all permanently flooded areas are considered deepwater habitats in these Systems. The boundary between wetlands and deepwater habitat in the Riverine and Lacustrine Systems lies at a depth of 2.5 m (8.2 ft) below low water; however, if emergents, shrubs, or trees grow beyond this depth at any time, their deepwater edge is the boundary.

The 2.5-m lower limit for inland wetlands was selected because it approximates the maximum depth to which emergent plants normally grow.

The Classification System

The structure of this classification is hierarchical, progressing from Systems and Subsystems at the most general levels to Classes, Subclasses. Modifiers for Water Regime, Water Chemistry, and Soil are applied to Classes and Subclasses. Special Modifiers describe wetlands and deepwater habitats that have been either created or highly modified by humans or beaver. (Table A - 1 – NWI Water Regime Restriction Table showing acceptable combinations of water regimes and classes/subclasses.)

Systems and Subsystems

The term SYSTEM refers here to a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors. We further subdivide Systems into more specific categories called SUBSYSTEMS.

The characteristics of the five major Systems—Marine, Estuarine, Riverine, Lacustrine, and Palustrine—have been discussed at length in the scientific literature and the concepts are well recognized; however, there is frequent disagreement as to which attributes should be used to bound the Systems in space. For example, both the limit of tidal influence and the limit of ocean-derived salinity have been proposed for bounding the upstream end of the Estuarine System.

Marine System (M)

Definition. The Marine System consists of the open ocean overlying the continental shelf and its associated high-energy coastline. Marine habitats are exposed to the waves and currents of the open ocean and the Water Regimes are determined primarily by the ebb and flow of oceanic tides. Salinities exceed 30 parts per thousand (ppt), with little or no dilution except outside the mouths of estuaries. Shallow coastal indentations or bays without appreciable freshwater inflow, and coasts with exposed rocky islands that provide the mainland with little or no shelter from wind and waves are also considered part of the Marine System because they generally support typical marine biota.

Limits. The Marine System extends from the outer edge of the continental shelf shoreward to one of three lines: (1) the landward limit of tidal inundation (extreme high water of

spring tides), including the splash zone from breaking waves; (2) the seaward limit of wetland emergents, trees, or shrubs; or (3) the seaward limit of the Estuarine System, where this limit is determined by factors other than vegetation. Deepwater habitats lying beyond the seaward limit of the Marine System are outside the scope of the WCS.

Description. The distribution of plants and animals in the Marine System primarily reflects differences in four factors: (1) degree of exposure of the site to waves; (2) texture and physicochemical nature of the substrate; (3) amplitude of the tides; and (4) latitude, which governs water temperature, the intensity and duration of solar radiation, and the presence or absence of ice.

Subsystems

Subtidal (M1) The substrate in these habitats is continuously covered with tidal water (i.e., located below extreme low water).

Intertidal (M2) The substrate in these habitats is flooded and exposed by tides; includes the associated splash zone.

Estuarine System (E)

Definition. The Estuarine System consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The salinity may be periodically increased above that of the open ocean by evaporation. Along some low-energy coastlines there is appreciable dilution of seawater. Offshore areas with typical estuarine plants and animals, such as red mangroves (*Rhizophora mangle*) and eastern oysters (*Crassostrea virginica*), are also included in the Estuarine System.³

Limits. The Estuarine System extends (1) upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow; (2) seaward to an imaginary line closing the mouth of a river, bay, or sound; and (3) to the seaward limit of wetland emergents, shrubs, or trees where they are not included in (2). The Estuarine System also includes offshore areas of continuously diluted seawater.

Description. The Estuarine System includes both estuaries and lagoons. It is more strongly influenced by its association with land than is the Marine System. In terms of wave action, estuaries are generally considered low-energy systems.

Estuarine water regimes and water chemistry are affected by one or more of the following forces: oceanic tides, precipitation, and freshwater runoff from land areas, evaporation, and wind. Estuarine salinities range from hyperhaline to oligohaline (see salinity modifiers). The salinity may be variable, as in hyperhaline lagoons (e.g., Laguna Madre, Texas) and most estuaries (e.g., Chesapeake Bay, Virginia-Maryland); or it may be relatively stable, as in sheltered euhaline

³ The Coastal Zone Management Act of 1972 defines an estuary as “that part of a river or stream or other body of water having unimpaired connection with the open sea, where the sea-water is measurably diluted with freshwater derived from land drainage.” The Act further states, “The term includes estuary-type areas of the Great Lakes.” However, in the WCS we do not consider areas of the Great Lakes as Estuarine.

embayments (e.g., Chincoteague Bay, Maryland) or embayments with partly obstructed access or small tidal range (e.g., Pamlico Sound, North Carolina).

Subsystems.

Subtidal (E1) The substrate in these habitats is continuously covered with tidal water (i.e., located below extreme low water).

Intertidal (E2) The substrate in these habitats is flooded and exposed by tides; includes the associated splash zone.

Riverine System (R)

Definition. The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 ppt or greater. A channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.

Limits. The Riverine System is bounded on the landward side by upland, by the channel bank (including natural and man-made levees), or by wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. In braided streams, the System is bounded by the banks forming the outer limits of the depression within which the braiding occurs.

The Riverine System terminates at the downstream end where the concentration of ocean-derived salts in the water equals or exceeds 0.5 ppt during the period of annual average low flow, or where the channel enters a lake. It terminates at the upstream end where tributary streams originate, or where the channel leaves a lake. Springs discharging into a channel are considered part of the Riverine System.

Description. Water is usually, but not always, flowing in the Riverine System. Upland islands or Palustrine wetlands may occur in the channel, but they are not included in the Riverine System. Palustrine Moss-Lichen Wetlands, Emergent Wetlands, Scrub-Shrub Wetlands, and Forested Wetlands may occur adjacent to the Riverine System, often on a floodplain.

Subsystems.

The Riverine System is divided into four Subsystems: the Tidal, the Lower Perennial, the Upper Perennial, and the Intermittent. Each is defined in terms of water permanence, gradient, substrate, and the extent of floodplain development. All four Subsystems are not necessarily present in all rivers, and the order of occurrence may be other than that given below.

Tidal (R1) This Subsystem extends from the upstream limit of tidal fluctuations down to the upper boundary of the Estuarine System, where the concentration of ocean-derived salts reaches 0.5 ppt during the period of average annual low flow. The gradient is low and water velocity fluctuates under tidal influence. The stream bottom is mainly mud with occasional patches of sand. Oxygen deficits may sometimes occur and the fauna is similar to that in the Lower Perennial Subsystem. The floodplain is typically well developed.

Lower Perennial (R2) This Subsystem is characterized by a low gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed.

Upper Perennial (R3) This Subsystem is characterized by a high gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists of rock, cobbles, or gravel with occasional patches of sand. The natural dissolved oxygen concentration is normally near saturation. The fauna is characteristic of running water, and there are few or no planktonic forms. The gradient is high compared with that of the Lower Perennial Subsystem, and there is very little floodplain development.

Intermittent (R4) This Subsystem includes channels that contain flowing water only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be absent.

Lacustrine System (L)

Definition. The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with 30 percent or greater areal coverage; and (3) total area of at least 8 hectares (ha) (20 acres). Similar wetlands and deepwater habitats totaling less than 8 ha are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin equals or exceeds 2.5 m (8.2 ft) at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5 ppt.

Limits. The Lacustrine System is bounded by upland or by wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. Lacustrine Systems formed by damming a river channel are bounded by a contour approximating the normal spillway elevation or normal pool elevation, except where Palustrine wetlands extend lakeward of that boundary. Where a river enters a lake, the extension of the Lacustrine shoreline forms the Riverine-Lacustrine boundary.

Description. The Lacustrine System includes permanently flooded lakes and reservoirs (e.g., Lake Superior), intermittent lakes (e.g., playa lakes), and tidal lakes with ocean-derived salinities below 0.5 ppt (e.g., Grand Lake, Louisiana). Typically, there are extensive areas of deep water and there is considerable wave action. Islands of Palustrine wetlands may lie within the boundaries of the Lacustrine System.

Subsystems.

Limnetic (L1) This subsystem includes all deepwater habitats (i.e., areas ≥ 2.5 m [8.2 ft] deep below low water) in the Lacustrine System. Many small Lacustrine Systems have no Limnetic Subsystem.

Littoral (L2) This subsystem includes all wetland habitats in the Lacustrine System. It extends from the shoreward boundary of the System to a depth of 2.5 m (8.2 ft) below low water, or to the maximum extent of nonpersistent emergents if these grow at depths greater than 2.5 m.

Palustrine System (P)

Definition. The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2.5 m (8.2 ft) at low water; and (4) salinity due to ocean-derived salts less than 0.5 ppt.

Limits. The Palustrine System is bounded by upland or by any of the other four Systems.

Description. The Palustrine System was developed to group the vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie, which are found throughout the U.S. It also includes the small, shallow, permanent, or intermittent water bodies often called ponds. Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries; on river floodplains; in isolated catchments; or on slopes. They may also occur as islands in lakes or rivers. The erosive forces of wind and water are of minor importance except during severe floods. There are often great similarities between wetlands lying adjacent to lakes or rivers and isolated wetlands of the same Class in basins without open water.

Subsystems. None.

Classes, Subclasses

The CLASS is the highest taxonomic unit below the Subsystem level. It describes the general appearance of the habitat in terms of either the dominant life form of the vegetation or the physiography and composition of the substrate—features that can be recognized without the aid of detailed environmental measurements. Vegetation is used at two different levels in the classification. The basic life form layers, from highest to lowest—trees, shrubs, emergents, emergent mosses or lichens, and surface plants or submergents—are used to define Classes because they are relatively easy to distinguish, do not change distribution rapidly, and have traditionally been used for classification of wetlands and habitat assessment.⁴ Pioneer plants that

⁴ The initial attempts to use familiar terms such as marsh, swamp, bog, and meadow at the Class level were unsuccessful primarily because of wide discrepancies in the use of these terms in various regions of the United States. In an effort to resolve that difficulty, we based the Classes on the fundamental components (life form, water regime, substrate type, water chemistry) that give rise to such terms. This approach has greatly reduced the misunderstandings and confusion that result from the use of the familiar terms.

colonize wetlands during dry periods, but disappear when surface water returns, are treated at the Subclass level because they are transient and may be mesophytes or xerophytes. Use of life forms at the Class level has two major advantages: (1) extensive biological knowledge is not required to distinguish between various life forms, and (2) many life forms can be readily identified on a variety of remote sensing products.

If living vegetation (except pioneer species) covers 30 percent or more of the substrate, we distinguish Classes on the basis of the life form of the plants that constitute the uppermost layer of vegetation and that possess an aerial coverage 30 percent or greater. For example, an area with 50 percent areal coverage of trees over a shrub layer with a 60 percent areal coverage would be classified as Forested Wetland; an area with 20 percent areal coverage of trees over the same (60 percent) shrub layer would be classified as Scrub-Shrub Wetland. When trees or shrubs alone cover less than 30 percent of an area but in combination cover 30 percent or more, the wetland is assigned to the Class Scrub-Shrub. When trees and shrubs cover less than 30 percent of the area but the total cover of vegetation (except pioneer species) is 30 percent or greater, the wetland is assigned to the appropriate Class for the predominant life form below the shrub layer.

When the height of two or more plant life forms in an area is equal, and each covers 30 percent or more of the area, the Class is based on the life form that has the greater cover. If the cover of the life forms is equal, then the Class is based on the life form that is more persistent. If the life forms are equally persistent, then the Class is based on the life form that would normally be considered to be more advanced from a successional standpoint (e.g., shrub > emergent plant > emergent moss or lichen).

Finer distinctions in life forms are recognized at the SUBCLASS level. Subclasses are named based on the specific life form with the greatest areal coverage. In Scrub-Shrub and Forested Wetlands, for example, most Subclasses are distinguished by leaf type (broad-leaved deciduous, needle-leaved deciduous, broad-leaved evergreen, and needle-leaved evergreen).

When an area is covered more or less uniformly by dead trees or dead shrubs—regardless of their abundance—and living vegetation covers less than 30 percent of that area, the site would be placed in either the Dead Forested Wetland Subclass or the Dead Scrub-Shrub Wetland Subclass, depending on whether dead trees or dead shrubs predominate. However, if living vegetation covers 30 percent or more of a stand of dead trees or shrubs, then the dominant life form, Class, and Subclass would be based on the living vegetation, using the rules outlined above.

If living vegetation covers less than 30 percent of the substrate, the physiography and composition of the substrate are the principal characteristics used to distinguish Classes. Substrate particle sizes include boulders, stones, cobbles, gravel, sand, silt, and alone or in combination, along with the term ‘bedrock,’ as Subclasses for nonvegetated wetlands and deepwater habitats.

The nature of the substrate reflects regional and local variations in geology and the influence of wind, waves, and currents on erosion and deposition of substrate materials. Bottoms, Shores, and Streambeds are separated based on duration of inundation. In the Riverine, Lacustrine, and Palustrine Systems, Bottoms are submerged all or most of the time, whereas Streambeds and

Shores are exposed much of the time. In the Marine and Estuarine Systems, Bottoms are Subtidal, whereas Streambeds and Shores are Intertidal. Bottoms, Shores, and Streambeds are further divided at the Class level based on the important characteristic of rock versus unconsolidated substrate. Subclasses are based on finer distinctions in substrate material unless, as with Streambeds and Shores, pioneer plants (often mesophytes or xerophytes) cover 30 percent or more of the substrate; the Subclass then is simply “vegetated.” Reefs are a unique Class in which the substrate itself is composed primarily of living and dead animals. Subclasses of Reefs are designated based on the type of organism that formed the reef.

Rock Bottom (RB)

Definition. The Class Rock Bottom includes all wetlands and deepwater habitats with substrates having an aerial cover of stones, boulders, or bedrock 75 percent or greater and vegetative cover of less than 30 percent.

Description. The rock substrate of the rocky benthic or bottom zone is one of the most important factors in determining the abundance, variety, and distribution of organisms. The stability of the bottom allows a rich assemblage of plants and animals to develop. Rock Bottoms are usually high-energy habitats with well-aerated waters. Temperature, salinity, current, and light penetration are also important factors in determining the composition of the benthic community. Animals that live on the rocky surface are generally firmly attached by hooking or sucking devices, although they may occasionally move about over the substrate. Some may be permanently attached by cement. A few animals hide in rocky crevices and under rocks, some move rapidly enough to avoid being swept away, and others burrow into the finer substrates between boulders. Plants are also firmly attached (e.g., by holdfasts), and in the Riverine System both plants and animals are commonly streamlined or flattened in response to high water velocities.

Subclasses

Bedrock (RB1) Bottoms in which bedrock covers 75 percent or more of the surface.

Rubble (RB2) Bottoms with less than 75 percent areal cover of bedrock, but stones and boulders alone, or in combination with bedrock, cover 75 percent or more of the surface.

Dominant species in the Marine and Estuarine Systems are the encrusting sponges *Hippospongia*, the tunicate *Cnemidocarpa*, the sea urchin *Strongylocentrotus*, the sea star *Pisaster*, and the sea whip *Muricea*. Examples of dominant Species in the Lacustrine, Palustrine, and Riverine are the freshwater sponges *Spongilla* and *Heteromeyenia*.

Unconsolidated Bottom (UB)

Definition. The Class Unconsolidated Bottom includes all wetlands and deepwater habitats with at least 25 percent cover of particles smaller than stones and a vegetative cover less than 30 percent.

Description. Unconsolidated Bottoms are characterized by the lack of large stable surfaces for plant and animal attachment. They are usually found in areas with lower energy than

Rock Bottoms, and may be very unstable. Exposure to wave and current action, temperature, salinity, and light penetration determines the composition and distribution of organisms.

Most macro algae attach to the substrate by means of basal holdfast cells or discs; in sand and mud, however, algae penetrate the substrate and higher plants can successfully root if wave action and currents are not too strong.

In the Marine and Estuarine Systems, Unconsolidated Bottom communities are relatively stable. They vary from the Arctic to the tropics, depending largely on temperature, and from the open ocean to the upper end of the estuary, depending on salinity.

In the Riverine System, the substrate type is largely determined by current velocity, and plants and animals exhibit a high degree of morphologic and behavioral adaptation to flowing water. Certain species are confined to specific substrates and some are at least more abundant in one type of substrate than in others. In the Lacustrine and Palustrine Systems, there is usually a high correlation, within a given water body, between the nature of the substrate and the number of species and individuals.

Subclasses

Cobble-Gravel (UB1) The unconsolidated particles smaller than stones are predominantly cobbles and gravel, although finer sediments may be intermixed.

Sand (UB2) The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed.

Mud (UB3) The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed. Organisms living in mud must be able to adapt to low oxygen concentrations.

Organic (UB4) The unconsolidated material smaller than stones is predominantly organic; there is no minimum depth requirement. The organic material is dead plant tissue in varying stages of decomposition. The number of species is limited and faunal productivity is very low.

Aquatic Bed (AB)

Definition. The Class “Aquatic Bed” includes wetlands and deepwater habitats where plants that grow principally on or below the surface of the water (i.e., surface plants or submergents) are the uppermost life form layer with at least 30 percent areal coverage.

Description. Aquatic Beds represent a diverse group of plant communities that require surface water for optimum growth and reproduction. They include submerged or floating-leaved rooted vascular plants, free-floating vascular plants, submergent mosses, and algae. They are best developed in relatively permanent water or under conditions of repeated flooding. The plants are attached to the substrate, and float freely on, or beneath, the water surface.

Subclasses

Algal (AB1) In these Aquatic Beds, algae have the greatest areal coverage. Algal Beds are widespread and diverse in the Marine and Estuarine Systems, where they occupy substrates characterized by a wide range of sediment depths and textures. They occur in both the Subtidal and Intertidal Subsystems and may grow to depths of 30 m (98 ft.). Coastal Algal Beds are most luxuriant along the rocky shores of the Northeast and West. Kelp (*Macrocystis*) beds are especially well developed on the rocky substrates of the Pacific Coast.

Inland, the stoneworts *Chara*, *Nitella*, and *Tolypella* are examples of algae that look much like vascular plants and may grow in similar situations. However, meadows of *Chara* may be found in Lacustrine water as deep as 40 m (131 ft), where hydrostatic pressure limits the survival of vascular submergents (phanerogams). Other algae bearing less resemblance to vascular plants are also common. Mats of filamentous algae may cover the bottom in dense blankets, and may rise to the surface under certain conditions, or may become stranded on Unconsolidated or Rocky Shores.

Aquatic Moss (AB2) In this Subclass, aquatic mosses have the greatest areal coverage. Aquatic mosses are far less common than algae or vascular plants. Aquatic Moss Beds occur primarily in the Riverine System and in Permanently Flooded and Intermittently Exposed parts of some Lacustrine systems. The most important genera such as *Fissidens*, *Drepanocladus*, and *Fontinalis*. *Fontinalis* may grow to depths as great as 120 m (394 ft). For simplicity, aquatic liverworts of the genus *Marsupella* are included in this Subclass.

Rooted Vascular (AB3) In this Subclass, rooted vascular plants have the greatest areal coverage. In the Marine and Estuarine Systems, Rooted Vascular Beds include a large array of species that grow primarily below water. They have been referred to by others as temperate grass flats); tropical marine meadows; and eelgrass beds, turtlegrass beds, and seagrass beds. The greatest number of species occurs in shallow, clear tropical or subtropical waters of moderate current strength in the Caribbean and along the Florida and Gulf Coasts. Dominant species include turtlegrass (*Thalassia testudinum*), shoalgrass (*Halodule wrightii*), manatee grass (*Cymodocea filiformis*), widgeon grass (*Ruppia maritima*), sea grasses (*Halophila* spp.), and wild celery (*Vallisneria americana*).

Five major vascular species dominate along the temperate coasts of North America: shoalgrass, surf grasses (*Phyllospadix scouleri*, *P. torreyi*), widgeon grass, and eelgrass (*Zostera marina*). Eelgrass beds have the most extensive distribution, but they are limited primarily to the more sheltered estuarine environment. In the lower salinity zones of estuaries, stands of widgeon grass, grassy pondweed (*Potamogeton*), and wild celery often occur, along with naiads (*Najas*) and water milfoil (*Myriophyllum*).

In the Riverine, Lacustrine, and Palustrine Systems, rooted vascular submergent plants occur at all depths within the photic zone. They often occur in sheltered areas where there is little water movement. However, they also occur in the flowing water of the Riverine System, where they may be streamlined or flattened in response to high water velocities. Typical inland genera include pondweeds, horned pondweed (*Zannichellia palustris*), ditch grasses (*Ruppia*), wild celery, and waterweed (*Elodea*). The riverweed (*Podostemum ceratophyllum*) is included in this Class despite its lack of truly recognizable roots.

Some rooted vascular aquatic plants have floating leaves. Typical dominants include water lilies (*Nymphaea*, *Nuphar*), floating-leaf pondweed (*Potamogeton natans*), and water shield (*Brasenia schreberi*). Plants such as yellow water lily (*Nuphar luteum*) and water smartweed (*Polygonum amphibium*), which may stand erect above the water surface or substrate, may be considered either emergents or rooted vascular aquatic plants, depending on the life form adopted at a particular site.

Floating Vascular (AB4) In this Subclass, vascular plants that float freely on or below the water surface have the greatest areal coverage. Floating Vascular Beds occur mainly in the Lacustrine, Palustrine, and Riverine Systems and in the less saline waters of the Estuarine System. Dominant plants that float on the surface include the duckweeds (*Lemna*, *Spirodela*), water lettuce (*Pistia stratiotes*), common water hyacinth (*Eichhornia crassipes*), water chestnut (*Trapa natans*), water mosses (*Salvinia* spp.), and mosquito ferns (*Azolla* spp.). These plants are found primarily in protected portions of slow-flowing rivers and in the Lacustrine and Palustrine Systems. They are easily moved about by wind or water currents and cover a large area of water in some parts of the country, particularly the Southeast. Dominant types for beds floating below the surface include bladderworts (*Utricularia*), coontails (*Ceratophyllum*), and watermeals.

Reef (RF)

Definition. The Class Reef includes ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates.

Description. Reefs are characterized by their elevation above the surrounding substrate and their interference with normal wave flow; they are primarily subtidal, but parts of some reefs may be intertidal as well. Although corals, oysters, and tubeworms are the most visible organisms and are mainly responsible for reef formation, other mollusks, foraminifera, coralline algae, and other forms of life also contribute substantially to reef growth. Frequently, reefs contain far more dead skeletal material and shell fragments than living matter.

Subclasses

Coral (RF1) Coral Reefs are widely distributed in shallow waters of warm seas, in Hawaii, Puerto Rico, the Virgin Islands, and southern Florida. They are stable, well-adapted, highly diverse, and highly productive ecosystems with a great degree of internal symbiosis. Coral Reefs lie almost entirely within the Subtidal Subsystem of the Marine System, although the upper part of certain Reefs may be Intertidal. Examples of dominant corals are Porites, *Acropora*, and *Montipora*. The distribution of these types reflects primarily their elevation, wave exposure, the age of the Reef, and its exposure to waves.

Mollusk (RF2) This Subclass occurs in both the Intertidal and Subtidal Subsystems of the Estuarine System. These Reefs are found on the Pacific, Atlantic, and Gulf Coasts and in Hawaii and the Caribbean. Mollusk Reefs may become extensive, affording a substrate for sedentary and boring organisms and a shelter for many others. Reef mollusks are adapted to great variations in water level, salinity, and temperature and these same factors control their distribution. Examples of this Subclass are the oysters *Ostrea* and *Crassostrea*.

Worm (RF3) Worm Reefs are constructed by large colonies of Sabellariid worms living in individual tubes constructed from cemented sand grains. Although they do not support as diverse a biota as do Coral and Mollusk Reefs, they provide a distinct habitat that may cover large areas. Worm Reefs are generally confined to tropical waters, and are most common along the coasts of Florida, Puerto Rico, and the Virgin Islands. They occur in both the Intertidal and Subtidal Systems of the Marine and Estuarine Systems where the salinity approximates that of seawater. The reef worm *Sabellaria* is an example of a dominate type for this Subclass.

Streambed (SB)

Definition. The Class Streambed includes all wetlands contained within the Intermittent Subsystem of the Riverine System and all channels of the Estuarine System or of the Tidal Subsystem of the Riverine System that are completely dewatered at low tide.

Description. Streambeds vary greatly in substrate and form depending on the gradient of the channel, the velocity of the water, and the sediment load. The substrate material frequently changes abruptly between riffles and pools, and complex patterns of bars may form on the convex side of single channels or be included as islands within the bed of braided streams. In mountainous areas the entire channel may be cut through bedrock. In most cases streambeds are not vegetated because of the scouring effect of moving water, but, like Unconsolidated Shores, they may be colonized by “pioneer” annuals or perennials during periods of low flow or they may have perennial emergents and shrubs that are too scattered to qualify the area for classification as Emergent Wetland or Scrub-Shrub Wetland.

Subclasses

Bedrock (SB1) This Subclass is characterized by a bedrock substrate covering 75 percent or more of the stream channel. It occurs most commonly in the Riverine System in high mountain areas or in glaciated areas where bedrock is exposed. Examples of types are the mollusk *Ancylus*, the oligochaete worm *Limnodrilus*, the snail *Physa*, the fingernail clam *Pisidium*, and the mayflies *Caenis* and *Ephemerella*.

Rubble (SB2) This Subclass is characterized by stones, boulders, and bedrock that, combined, cover 75 percent or more of the channel; however, bedrock alone covers less than 75 percent. Like Bedrock Streambeds, Rubble Streambeds are most common in mountainous areas and the dominant organisms are similar to those of Bedrock and are often forms capable of attachment to rocks in flowing water.

Cobble-Gravel (SB3) In this Subclass at least 25 percent of the substrate is covered by unconsolidated particles smaller than stones; cobbles or gravel predominate. The Subclass occurs in riffle areas or in the channels of braided streams.

Sand (SB4) In this Subclass, sand-sized particles predominate among the particles smaller than stones. Sand Streambed often contains bars and beaches interspersed with Mud Streambed or it may be interspersed with Cobble-Gravel Streambed in areas of fast flow or heavy sediment load.

Mud (SB5) In this Subclass, the particles smaller than stones are chiefly silt or clay. Mud Streambeds are common in arid areas where intermittent flow is characteristic of streams of low gradient. Such species as tamarisk (*Tamarix gallica*) may occur, but are not dense enough to

qualify the area for classification as Scrub-Shrub Wetland. Mud Streambeds are also common in the

Organic (SB6) This Subclass is characterized by channels formed in peat or muck. Organic Streambeds are common in the small creeks draining Estuarine Emergent Wetlands with organic soils.

Vegetated (SB7) These Streambeds are exposed long enough to be colonized by pioneer plants that, unlike Emergent Wetland plants or Scrub-Shrub Wetland plants, are usually killed by rising water levels. Many of the pioneer species are weedy mesophytes or xerophytes. At least 30 percent cover of pioneer plants is required. Common panic grass (*Panicum capillare*) is a typical species in the Riverine System.

Rocky Shore (RS)

Definition. The Class Rocky Shore includes wetland habitats characterized by bedrock, stones, or boulders, which singly or in combination have an areal cover of 75 percent or more, and an areal coverage by vegetation of less than 30 percent.

Description. In Marine and Estuarine Systems, Rocky Shores are generally high-energy habitats that lie exposed because of continuous erosion by wind-driven waves or strong currents. The substrate is stable enough to permit the attachment and growth of sessile or sedentary invertebrates and attached algae or lichens. Rocky Shores usually display a vertical zonation that is a function of tidal range, wave action, and degree of exposure to the sun. In the Lacustrine and Riverine Systems, Rocky Shores support sparse plant and animal communities.

Subclasses

Bedrock (RS1) These wetlands have bedrock covering 75 percent or more of the surface and less than 30 percent areal coverage of macrophytes.

Rubble (RS2) These wetlands have less than 75 percent areal cover of bedrock, but stones and boulders alone or in combination with bedrock cover 75 percent or more of the area. The areal coverage of macrophytes is less than 30 percent.

Unconsolidated Shore (US)

Definition. The Class Unconsolidated Shore includes all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders, or bedrock; (2) less than 30 percent areal cover of vegetation other than pioneer plants. Intermittent or intertidal channels of the Riverine System and intertidal channels of the Estuarine System are classified as Streambed.

Description. Unconsolidated Shores are characterized by substrates lacking vegetation except for pioneer plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms such as beaches, bars, and flats, all of which are included in this Class. Unconsolidated Shores are commonly found adjacent to Unconsolidated Bottoms in all Systems; in the Palustrine and Lacustrine Systems, the Class may occupy the entire basin. As in Unconsolidated Bottoms, the

particle size of the substrate and the water regime are the important factors determining the types of plant and animal communities present. Different substrates usually support characteristic invertebrate fauna. Faunal distribution is controlled by waves, currents, interstitial moisture, salinity, and grain size.

Subclasses

Cobble-Gravel (US1) The unconsolidated particles smaller than stones are predominantly cobbles and gravel. Shell fragments, sand, and silt often fill the spaces between the larger particles. Stones and boulders may be found scattered on some Cobble-Gravel Shores. In areas of strong wave and current action these shores take the form of beaches or bars, but occasionally they form extensive flats.

Sand (US2) The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed. Sand may be either calcareous or terrigenous in origin. Sand shores are a prominent feature of the Marine, Estuarine, Riverine, and Lacustrine Systems where the substrate material is exposed to the sorting and washing action of waves. Examples of

Mud (US3) The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed. Anaerobic conditions often exist below the surface. Mud Shores have a higher organic content than Cobble-Gravel or Sand Shores. They are typically found in areas of minor wave action. They tend to have little slope and are frequently called flats. Mud Shores support diverse populations of tube-dwelling and burrowing invertebrates that include worms, clams, and crustaceans. They are commonly colonized by algae and diatoms that may form a crust or mat.

Irregularly flooded Mud Shores in the Estuarine System have been called salt flats, pans, or pannes. They are typically high in salinity and are usually surrounded by, or lie on the landward side of, Emergent Wetland. In many arid areas, Palustrine and Lacustrine Mud Shores are encrusted or saturated with salt. They are also called alkali flats, salt flats, and saltpans. Mud Shores may also result from removal of vegetation by man, animals, or fire, or from the discharge of thermal waters or pollutants.

Organic (US4) The unconsolidated material smaller than stones is predominantly organic; there is no minimum depth requirement. The organic material is dead plant tissue in varying stages of decomposition. In the Marine and Estuarine Systems,

Vegetated (US5) Some nontidal Shores are exposed for a sufficient period to be colonized by **pioneer plants** that, unlike Emergent Wetland plants or Scrub-Shrub Wetland plants, are usually killed by rising water levels. Many of the pioneer species are weedy mesophytes or xerophytes. At least 30 percent cover of pioneer plants is required. Examples of dominate types are rough cocklebur (*Xanthium strumarium*) and large barnyard grass (*Echinochloa crusgalli*).

Moss-Lichen Wetland (ML)

Definition. The Moss-Lichen Wetland Class includes areas where mosses or lichens cover at least 30 percent of substrates other than rock and where emergents, shrubs, or trees alone or in combination cover less than 30 percent.

Description. Mosses and lichens are important components of the flora in many wetlands, especially in the North, but these plants usually form a ground cover under a dominant layer of trees, shrubs, or emergents. In some instances, higher plants are uncommon and mosses or lichens dominate the flora. Such Moss-Lichen Wetlands are not common, even in the northern U.S. where they occur most frequently.

Subclasses

Moss (ML1) The areal coverage of mosses exceeds that of lichens. Moss dominated wetlands are most abundant in the far northern boreal forests and Arctic tundra, where they are dominated by peat mosses such as *Sphagnum fuscum* and *S. warnstorffii*. These wetlands are typically called bogs whether *Sphagnum* or higher plants dominate. In Alaska, *Drepanocladus revolvans*, *D. lycodioides*, and the liverwort *Chiloscyphus fragilis* may dominate shallow pools with semipermanent water. Other mosses, including *Campylium stellatum*, *Aulacomnium palustre*, *A. turgidum* and *Oncophorus wahlenbergii*, are typical of wet, saturated soils in these regions.

Lichen (ML2) The areal coverage of lichens exceeds that of mosses. Lichen Wetlands also are a Northern Subclass. Reindeer moss (*Cladina* and *Cladonia*) principal occur in boreal and Arctic regions. Lichen cover is generally elevated above moss, sedge-moss, or dwarf shrub-sedge-moss layers. Areas with mosses and lichens are called bogs or fens, the distinction being based on the availability of nutrients and the particular plant species present. The presence of Lichen Wetlands has been noted in the Hudson Bay Lowlands.

Emergent Wetland (EM)

Definition. In this wetland Class, emergent plants—i.e., erect, rooted, herbaceous hydrophytes, excluding mosses and lichens—are the tallest life form with at least 30% areal coverage. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.

Description. In areas with relatively stable climatic conditions, Emergent Wetlands maintain the same appearance year after year. In other areas, such as the prairies of the central U.S., violent climatic fluctuations cause them to revert to an open water phase in some years. Emergent Wetlands are found throughout the U.S. and occur in all Systems except the Marine. Emergent Wetlands are known by many names, including marsh, wet meadow, fen, prairie pothole, and slough. Areas that are dominated by pioneer plants, which become established during periods of low water, are not Emergent Wetlands and should be classified as Vegetated Unconsolidated Shores or Vegetated Streambeds.

Subclasses

Persistent (EM1) The areal coverage of persistent emergents exceeds that of nonpersistent emergents. Persistent emergents are emergent hydrophytes whose stems and leaves are evident all year above the surface of the water or above the soil surface if water is absent. Persistent Emergent Wetlands occur only in the Estuarine and Palustrine Systems.

Persistent Emergent Wetlands dominated by saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*S. patens*), big cordgrass (*S. cynosuroides*), Roemer's rush (*Juncus roemerianus*), narrow-leaved cattail (*Typha angustifolia*), and marsh-millet (*Zizaniopsis miliacea*) are major components of the Estuarine Systems of the Atlantic and Gulf Coasts of the U.S. On

the Pacific Coast, woody saltwort (*Salicornia virginica*), broom seepweed (*Suaeda californica*), seaside arrow-grass (*Triglochin maritimum*), and California cordgrass (*Spartina foliosa*) are common dominants.

Palustrine Persistent Emergent Wetlands contain a vast array of grasslike plants such as cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), saw grass (*Cladium jamaicense*), sedges (*Carex* spp.); and true grasses such as manna grasses (*Glyceria* spp.), slough grass (*Beckmannia syzigachne*), and common river grass (*Scolochloa festucacea*). There is also a variety of broad-leaved persistent emergents such as purple loosestrife (*Lythrum salicaria*), Mexican dock (*Rumex mexicanus*), swamp loosestrife (*Decodon verticillatus*), and some species of smartweeds (*Polygonum*).

Nonpersistent (EM2) The areal coverage of nonpersistent emergents exceeds that of persistent emergents. Nonpersistent emergents are emergent hydrophytes whose stems and leaves are evident above the water surface or above the soil surface if surface water is absent, only during the growing season or shortly thereafter. During the dormant season, there is no obvious sign of emergent vegetation. Nonpersistent Emergent Wetlands occur in all Systems except the Marine. Nonpersistent emergents also include species such as green arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), and arrowheads (*Sagittaria* spp.). Movement of ice in Estuarine, Riverine, or Lacustrine Systems often removes all traces of emergent vegetation during the winter. Where this occurs, the area should be classified as Nonpersistent Emergent Wetland.

Phragmites (EM5) Wetlands in this subclass are dominated by common reed (*Phragmites australis*).

Scrub-Shrub Wetland (SS)

Definition. In Scrub-Shrub Wetlands, woody plants less than 6 m (20 ft) tall are the dominant life form—i.e., the tallest life form with at least 30 percent areal coverage. The “shrub” life form actually includes true shrubs, young specimens of tree species that have not yet reached 6 m in height, and woody plants (including tree species) that are stunted because of adverse environmental conditions.

Description. Scrub-Shrub Wetlands may represent a successional stage leading to Forested Wetland, or they may be relatively stable communities. They occur only in the Estuarine and Palustrine Systems, but are one of the most widespread Classes in the U.S. Scrub-Shrub Wetlands are known by many names, such as shrub swamp, shrub carr, bog, fen, and pocosin. For practical reasons we have also included stands of young trees less than 6 m tall.

Subclasses

Broad-leaved Deciduous (SS1) In this Subclass, broad-leaved deciduous species have the greatest areal coverage within the shrub layer. In the Estuarine System, Dominant species include species sea-myrtle (*Baccharis halimifolia*) and high-tide bush (*Iva frutescens*). In the Palustrine System, typical species are alders (*Alnus* spp.), willows (*Salix* spp.), buttonbush (*Cephalanthus*

occidentalis), red osier dogwood (*Cornus stolonifera*), honeycup (*Zenobia pulverulenta*), Douglas' meadowsweet (*Spiraea douglasii*), bog birch (*Betula pumila*), and young red maple (*Acer rubrum*).

Needle-leaved Deciduous (SS2) In this Subclass, needle-leaved deciduous species have the greatest areal coverage within the shrub layer. A dominant type include young or stunted tamarack and southern bald cypress (*Taxodium distichum*).

Broad-leaved Evergreen (SS3) In this Subclass, broad-leaved evergreen species have the greatest areal coverage within the shrub layer. In the Estuarine System, vast wetland acreages are dominated by mangroves (*Rhizophora mangle*, *Languncularia racemosa*, *Conocarpus erectus*, and *Avicennia germinans*). In the Palustrine System, the broad-leaved evergreen species are typically found on organic soils. Northern representatives are labrador tea (*Ledum groenlandicum*), bog rosemary (*Andromeda polifolia* L.), bog laurel (*Kalmia polifolia*), and the semi-evergreen, leatherleaf (*Chamaedaphne calyculata*). In the South, shinyleaf (*Lyonia lucida*), coastal dogbobbie (*Leucothoe axillaris*), inkberry (*Ilex glabra*), and the semi-evergreen, swamp titi (*Cyrilla racemiflora*), are characteristic broad-leaved evergreen species.

Needle-leaved Evergreen (SS4) In this Subclass, needle-leaved evergreen species have the greatest areal coverage within the shrub layer. Examples of dominant types include young or stunted black spruce (*Picea mariana*) and pond pine (*Pinus serotina*).

Dead (SS5) This Subclass includes stands of dead woody plants less than 6 m tall, regardless of their density, with less than 30 percent cover of living vegetation. If living vegetation equals or exceeds 30 percent in such stands, the Class and Subclass are based on the dominant life form of the living plants. Dead Scrub-Shrub Wetlands are usually produced by a prolonged rise in the water level resulting from impoundment by landslides, humans, or beavers. Such wetlands may also result from fire, salt spray, sea level rise, insect infestation, air pollution, or herbicides.

Deciduous (SS6) A wetland plant community where deciduous shrubs or woody vegetation less than 6 meters (20 feet) tall represents the dominant spatial coverage.

Evergreen (SS7) A wetland plant community where evergreen shrubs or woody vegetation less than 6 meters (20 feet) tall represents the dominant spatial coverage.

Forested Wetland (FO)

Definition. In Forested Wetlands, trees are the dominant life form—i.e., the tallest life form with at least 30 percent areal coverage. Trees are defined as woody plants at least 6 m (20 ft) in height.

Description. Forested Wetlands are most common in the eastern U.S. and in those sections of the West where moisture is relatively abundant, particularly along rivers and in the mountains. They occur only in the Palustrine and Estuarine Systems and normally possess an overstory of trees, an understory of young trees or shrubs, and an herbaceous layer. Forested Wetlands in the Estuarine System, which include the mangrove forests of Florida, Puerto Rico,

and the Virgin Islands, are known by such names as swamps, hammocks, heads, and bottoms. Such common names are often applied, in combination with species names or plant association names, in Palustrine forests as well (e.g., cedar swamp, bottomland hardwoods).

Subclasses

Broad-leaved Deciduous (FO1) In this Subclass, broad-leaved deciduous species have the greatest areal coverage in the tree layer. Broad-leaved Deciduous Forested Wetlands, which are represented throughout the United States, are most common in the South and East. Common dominate species include red maple, American elm (*Ulmus americana*), ashes (*Fraxinus pennsylvanica* and *F. nigra*), black gum (*Nyssa sylvatica*), tupelo gum (*N. aquatica*), swamp white oak (*Quercus bicolor*), overcup oak (*Q. lyrata*), and swamp chestnut oak (*Q. michauxii*). Wetlands in this Subclass generally occur on mineral soils or highly decomposed organic soils.

Needle-leaved Deciduous (FO2) In this Subclass, needle-leaved deciduous species have the greatest areal coverage in the tree layer. The southern representative of the Needle-leaved Deciduous Subclass is bald cypress, which is noted for its ability to tolerate long periods of surface inundation. Tamarack is characteristic of the Boreal Forest Region, where it occurs as a dominant on organic soils. Relatively few other species are included in this Subclass.

Broad-Leaved Evergreen (FO3) In this Subclass, broad-leaved evergreen species have the greatest areal coverage in the tree layer. In the Southeast, Broad-leaved Evergreen Forested Wetlands reach their greatest development. Red bay (*Persea borbonia*), loblolly bay (*Gordonia lasianthus*), and sweet bay (*Magnolia virginiana*) are prevalent, especially on organic soils. Other dominate species include red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Languncularia racemosa*), which are adapted to varying levels of salinity.

Needle-leaved Evergreen (FO4). In this Subclass, needle-leaved evergreen species have the greatest areal coverage in the tree layer. Black spruce, growing on nutrient-poor organic soils, represents a major dominant of the Needle-leaved Evergreen Subclass in the North. Eastern arborvitae (*Thuja occidentalis*) dominates northern wetlands on more nutrient-rich sites. Along the Atlantic Coast, Atlantic white cedar (*Chamaecyparis thyoides*) is one of the most common dominants on organic soils. Pond pine is a common needle-leaved evergreen found in the Southeast in association with dense stands of broad-leaved evergreen and deciduous shrubs.

Dead (FO5) This Subclass includes stands of dead woody plants 6 m in height or taller, regardless of their density, with less than 30 percent cover of living vegetation. If living vegetation equals or exceeds 30 percent in such stands, the Class and Subclass are based on the dominant life form of the living plants. Dead Forested Wetlands, like Dead Scrub-Shrub Wetlands, are most common in, or around the edges of, man-made impoundments and beaver ponds. The same factors that produce Dead Scrub-Shrub Wetlands produce Dead Forested Wetlands.

Deciduous (FO6) A wetland plant community where deciduous tree species 6 meters (20 feet) tall or taller represent the dominant spatial coverage.

Evergreen (FO7) A wetland plant community where evergreen tree species 6 meters (20 feet) tall or taller represent the dominant spatial coverage.

Water Regime Modifiers

Description of hydrologic characteristics requires detailed knowledge of the duration and timing of surface inundation, both yearly and long-term, as well as an understanding of groundwater fluctuations. Because such information is seldom available, the Water Regimes that, in part, determine characteristic wetland and deepwater plant and animal communities are described here in only general terms. Water Regimes are grouped under three major headings, Tidal Salt, Nontidal, and Tidal Fresh.

Tidal Salt

Tidal Salt Water Regime Modifiers are used for wetlands and deepwater habitats in the Marine and Estuarine Systems, where ocean-derived salinity equals or exceeds 0.5 ppt. These Water Regimes are primarily a function of oceanic tides.

Subtidal (L) Tidal salt water continuously covers the substrate.

Irregularly Exposed (M) Tides expose the substrate less often than daily.

Regularly Flooded (N) Tides alternately flood and expose the substrate at least once daily.

Irregularly Flooded (P) Tides flood the substrate less often than daily.

The periodicity and amplitude of tides vary in different parts of the U.S., mainly because of differences in latitude and geomorphology. On the Atlantic Coast, two nearly equal high tides are the rule (semidiurnal); on the Gulf Coast, there is frequently only one high tide and one low tide each day (diurnal); and on the Pacific Coast there are usually two unequal high tides and two unequal low tides (mixed semidiurnal).

Tides range in height from about 9.5 m (31 ft.) at St. John, New Brunswick to less than 1 m (3.3 ft.) along the Louisiana coast. Tides of only 10 cm (4.0 inches) are common in Louisiana. Therefore, although no hard and fast rules apply, the division between Regularly Flooded and Irregularly Flooded Water Regimes would probably occur approximately at mean high water on the Atlantic Coast, at the lowest level of the higher high tide on the Pacific Coast, and just above mean tide level of the Gulf Coast. The width of the intertidal zone is determined by the tidal range, the slope of the shoreline, and the degree of exposure of the site to wind and waves.

Tidal Fresh

The Tidal Subsystem of the Riverine System and tidally influenced parts of the Palustrine and Lacustrine Systems are unique because the hydrology of their habitats is driven primarily by nontidal inputs and outputs, but influenced by tides as well. In these habitats, ocean-derived salts measure less than 0.5 ppt. The hydrologic regimes of Tidal Fresh habitats are described through the use of four Nontidal Water Regime Modifiers, coupled with the suffix ‘-Tidal Fresh’, as in

Seasonally Flooded-Tidal Fresh, and an additional Modifier based on tidal action. Each of the first four Modifiers reflects the relative duration of substrate inundation during the growing season. It also indicates that, in response to oceanic tides, the water level at each site rises and falls daily. The fifth Modifier focuses specifically on the daily flooding and exposure of the substrate by tides at the water's edge. Use of certain Modifiers is limited to certain Systems.

Permanently Flooded-Tidal Fresh (V) Tidal fresh water covers the substrate throughout the year in all years. This Modifier is used for Riverine, Lacustrine, and Palustrine habitats.

Semipermanently Flooded-Tidal Fresh (T) Tidal fresh surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface. This Modifier is used for Riverine, Lacustrine, and Palustrine habitats.

Seasonally Flooded-Tidal Fresh (R) Tidal fresh surface water is present for extended periods (generally for more than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the depth to substrate saturation may vary considerably among sites and among years. This Modifier is used for Palustrine habitats only.

Temporarily Flooded-Tidal Fresh (S) Tidal fresh surface water is present for brief periods (from a few days to a few weeks) during the growing season, but the water table usually lies well below the ground surface for the most of the season. This Modifier is used for Palustrine habitats only.

Regularly Flooded-Tidal Fresh (Q) Tides alternately flood and expose the substrate daily for variable periods (from a few weeks to several months) during the growing season. This Modifier is used for Riverine and Lacustrine habitats.

Nontidal

Nontidal Water Regime Modifiers are used for all nontidal parts of the Palustrine, Lacustrine, and Riverine Systems. Although not influenced by oceanic tides, Nontidal Water Regimes may be affected by wind or seiches in lakes. Nontidal Water Regimes are defined in terms of the growing season that, for the purposes of this classification, begins with green-up and bud-break of native plants in the spring and ends with plant dieback and leaf-drop in the fall due to the onset of cold weather. During the rest of the year, which is defined as the dormant season, even extended periods of flooding may have little influence on the development or survival of plant communities.

Permanently Flooded (H) Water covers the substrate throughout the year in all years.

Intermittently Exposed (G) Water covers the substrate throughout the year except in years of extreme drought.

Semipermanently Flooded (F). Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface.

Seasonally Flooded (C) Surface water is present for extended periods (generally for more than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the depth to substrate saturation may vary considerably among sites and among years.

Seasonally Flooded-Saturated (E) Surface water is present for extended periods (generally for more than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the substrate typically remains saturated at or near the surface.

Seasonally Saturated (B). The substrate is saturated at or near the surface for extended periods during the growing season, but unsaturated conditions prevail by the end of the season in most years. Surface water is typically absent, but may occur for a few days after heavy rain and upland runoff.

Continuously Saturated (D) The substrate is saturated at or near the surface throughout the year in all, or most, years. Widespread surface inundation is rare, but water may be present in shallow depressions that intersect the groundwater table, particularly on a floating peat mat.

Temporarily Flooded (A) Surface water is present for brief periods (from a few days to a few weeks) during the growing season, but the water table usually lies well below the ground surface for the most of the season.

Intermittently Flooded (J) The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this Water Regime may change as soil moisture conditions change. Some areas exhibiting this Water Regime do not fall within our definition of wetland because they do not have hydric soils or support hydrophytes. This Water Regime is generally limited to the arid West.

Artificially Flooded (K) The amount and duration of flooding are controlled by means of pumps or siphons in combination with dikes, berms, or dams. The vegetation growing on these areas cannot be considered a reliable indicator of Water Regime. Examples of Artificially Flooded wetlands are some agricultural lands managed under a rice-soybean rotation, and wildlife management areas where forests, crops, or pioneer plants may be flooded or dewatered to attract wetland wildlife. Neither wetlands within nor resulting from leakage from man-made impoundments, nor irrigated pasturelands supplied by diversion ditches or artesian wells, are included under this Modifier. The Artificially Flooded Water Regime Modifier should not be used in the Riverine system or for impoundments or excavated wetlands unless both water inputs and outputs are controlled to achieve a specific depth and duration of flooding.

Table A - 1 – NWI Water Regime Restriction Table showing acceptable combinations of water regimes and classes/subclasses.

NWI Water Regime Restriction Table

Class/Subclass	Code	Marine		Estuarine		Riverine			Lacustrine		Palustrine				
		Subtidal M1	Intertidal M2	Subtidal E1	Intertidal E2	Tidal R1	Lower Perennial R2	Upper Perennial R3	Intermittent R4	Limnetic L1	Littoral L2	P			
ROCK BOTTOM	RB	L		L		TV		FGH		V	GHK	TV	FGHK	FGHK	
Bedrock	RB1	L		L		TV		FGH		V	GHK	TV	FGHK	FGHK	
Rubble	RB2	L		L		TV		FGH		V	GHK	TV	FGHK	FGHK	
UNCONSOLIDATED BOTTOM	UB	L		L		TV	FGH	FGH		V	GHK	TV	FGHK	TV	FGHK
Cobble-Gravel	UB1	L		L		TV	FGH	FGH		V	GHK	TV	FGHK	TV	FGHK
Sand	UB2	L		L		TV	FGH	FGH		V	GHK	TV	FGHK	TV	FGHK
Mud	UB3	L		L		TV	FGH	FGH		V	GHK	TV	FGHK	TV	FGHK
Organic	UB4			L		TV	FGH			V	GHK	TV	FGHK	TV	FGHK
AQUATIC BED	AB	L	MN	L	MN	QTV	CFGH	CFGH		V	GHK	QTV	CFGHK	RTV	CFGHK
Algal	AB1	L	MN	L	MN	TV	FGH	FGH		V	GHK	TV	FGHK	TV	FGHK
Aquatic Moss	AB2					TV	FGH	FGH		V	GHK	TV	FGHK	TV	FGHK
Rooted Vascular	AB3	L	M	L	M	QTV	CFGH	CFGH		V	GHK	QTV	CFGHK	RTV	CFGHK
Floating Vascular	AB4			L	MN	QTV	CFGH	CFGH		V	GHK	QTV	CFGHK	RTV	CFGHK
REEF	RF	L	MN	L	MN										
Coral	RF1	L	MN												
Mollusk	RF2			L	MN										
Worm	RF3	L	MN	L	MN										
STREAMBED	SB				MNP	Q			ACJ						
Bedrock	SB1				MNP	Q			ACJ						
Rubble	SB2				MNP	Q			ACJ						
Cobble-Gravel	SB3				MNP	Q			ACJ						
Sand	SB4				MNP	Q			ACJ						
Mud	SB5				MNP	Q			ACJ						
Organic	SB6				MNP	Q			C						
Vegetated	SB7								ACJ						
ROCKY SHORE	R5		MNP		MNP	Q	AC	AC			Q	ACJK			
Bedrock	R51		MNP		MNP	Q	AC	AC			Q	ACJK			
Rubble	R52		MNP		MNP	Q	AC	AC			Q	ACJK			
UNCONSOLIDATED SHORE	US		MNP		MNP	Q	ACEJ	ACEJ			Q	ACEJK	R5	ACEJK	
Cobble-Gravel	US1		MNP		MNP	Q	ACJ	ACJ			Q	ACJK	R5	ACJK	
Sand	US2		MNP		MNP	Q	ACJ	ACJ			Q	ACJK	R5	ACJK	
Mud	US3		MNP		MNP	Q	ACJ	ACJ			Q	ACJK	R5	ACJK	
Organic	US4		MNP		MNP	Q	E	E			Q	E		E	
Vegetated	US5						ACJ	ACJ			Q	ACJK		ACJK	

Saltwater Tidal = BROWN Water Regimes; Freshwater Tidal = BLUE Water Regimes; Nontidal = RED Water Regimes.

Table Revised January 1, 2016

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Table A - 2 – NWI Water Regime Restriction Table showing acceptable combinations of water regimes and classes/subclasses. (continued)

Class/Subclass	Code	Marine		Estuarine		Riverine				Lacustrine		Palustrine
		Subtidal M1	Intertidal M2	Subtidal E1	Intertidal E2	Tidal R1	Lower Perennial R2	Upper Perennial R3	Intermittent R4	Limnetic L1	Littoral L2	P
MOSS-LICHEN	ML											BCDE
Moss	ML1											BCDE
Lichen	ML2											BCDE
EMERGENT												
Persistent	EM1				NP							RST ABCDEFJK
Non persistent	EM2				NP	QTV	FGH			QTV FGHK	TV	FGHK
Phragmites australis	EM5				P							RST ABCDEFK
SCRUB-SHRUB												
Broad-Leaved Deciduous	SS1				P							RST ABCDEFJK
Needle-Leaved Deciduous	SS2				P							RST ABCDEFJK
Broad-Leaved Evergreen	SS3				NP						RS	ABCDEK
Needle-Leaved Evergreen	SS4				P						RS	ABCDEK
Dead	SS5				MNP						TV	FGHK
Deciduous	SS6				P							RST ABCDEFJK
Evergreen	SS7				NP						RS	ABCDEK
FORESTED												
Broad-Leaved Deciduous	FO1				P							RST ABCDEFK
Needle-Leaved Deciduous	FO2				P							RST ABCDEFK
Broad-Leaved Evergreen	FO3				NP						RS	ABCDEK
Needle-Leaved Evergreen	FO4				P						RS	ABCDEK
Dead	FO5				MNP						TV	FGHK
Deciduous	FO6				P							RST ABCDEFK
Evergreen	FO7				NP						RS	ABCDEK

Saltwater Tidal = BROWN Water Regimes; Freshwater Tidal = BLUE Water Regimes; Nontidal = RED Water Regimes.

Mixed Classes

In some cases, a mixed class description provides the best characterization of a wetland. Mixed classes are constrained by certain combinations and their reciprocals (Table A - 3).

Table A - 3 - List of accepted mixed classes and their reciprocals.

Cowardin Mixed Classes (or reciprocal)	Mapping Attributes (and reciprocals)	Attribute Example
Forested/Aquatic bed	FO/AB	PFO1/ABF
Scrub shrub/Aquatic bed	SS/AB	PSS1/ABF
Emergent/Aquatic bed	EM/AB	PEM1/ABF
Aquatic bed/ Reef	AB/RF	M1AB3/RF1L
Aquatic bed/Rocky shore	AB/RS	E2AB/RSN
Aquatic bed/Unconsolidated bottom	AB/UB	E1AB/UB4L
Aquatic bed/Unconsolidated shore	AB/US	E2AB/US2M
Forested/Emergent	FO/EM	PFO1/EM1A
Scrub shrub/Emergent	SS/EM	PSS1/EM1C
Emergent/Moss lichen	EM/ML	PEM1/ML1B
Emergent/Rocky shore	EM/RS	E2EM1/RSN
Emergent/Unconsolidated shore	EM/US	E2EM1/USM
Forested/Scrub shrub	FO/SS	PFO4/SS4B
Scrub shrub/Moss lichen	SS/ML	PSS3/MLB
Scrub shrub/Unconsolidated shore	SS/US	PSS1/USC
Forested/Moss lichen	FO/ML	PFO2/MLB
Forested/Unconsolidated shore	FO/US	PFO1/USA
Unconsolidated shore/Reef	US/RF	E2US/RF2N

In Alaska, wetlands may be represented by numerous mixed class designations due to mapping scale as well as unique ecological features. These account for the extreme variability of wetland habitats found within the Arctic tundra, boreal forest, Aleutian Islands, and Pacific Gulf Coastal ecoregions of the State. In particular, permafrost underlying treeless and tree lined Arctic and boreal environments, may be described by unique wetland classifications not found elsewhere in the U.S. Some of these designations may have specific research and management applications.

Mixed Subclasses

The mixed subclasses are limited to certain combinations and their reciprocals (Table A - 4).

Table A - 4 - List of accepted mixed subclasses and their reciprocals.

Cowardin Mixed Subclasses (or reciprocal)	Mapping Attributes (and reciprocals)	Attribute Example
Broad leaved deciduous/Needle leaved deciduous	1/2 - 2/1	PFO1/2B PSS2/1B
Broad leaved deciduous/Broad leaved evergreen	1/3 - 3/1	PFO1/3A PSS1/3A
Broad leaved deciduous/Needle leaved evergreen	1/4 -4/1	PFO1/4A PSS4/1B
Needle leaved deciduous/Needle leaved evergreen	2/4 - 4/2	PFO2/4B PSS4/2B
Needle leaved deciduous/Broad leaved evergreen	2/3 - 3/2	PFO2/3A PSS2/3C
Broad leaved evergreen/Needle leaved evergreen	3/4 - 4/3	PFO3/4C PSS3/4C
Dead/Any forested or scrub shrub subclass	5/* - */5	
Deciduous/Any forested or scrub shrub subclass	6/* - */6	
Evergreen/Any forested or scrub shrub subclass	7/* - */7	

Other Modifiers

To describe wetlands and deepwater habitats, one must apply certain Modifiers to the classification hierarchy. The Modifiers described were adapted from existing classifications or were developed specifically for this classification system.

Special Modifiers

Many wetland and deepwater habitats are man-made, and natural ones have been modified to some degree by the activities of humans or beaver. With the exception of Beaver, all of the Special Modifiers describe human alterations to wetlands. Since the nature of these modifications often greatly influences the character of such habitats, special modifying terms have been included here to emphasize their importance. The following Modifiers should be used singly. It may be difficult, in some instances, to choose the single Special Modifier that best describes the landscape modification. Because the Diked/Impounded Modifier is crucial for use in coastal watersheds as denoting wetland modifications for sea level rise models, it will be given priority over any other Modifiers (e.g., diked/impounded spoil areas will be classified using the Diked/Impounded Modifier.)

Beaver (b) — These wetlands have been created or modified by beaver (*Castor canadensis*). Dam building by beaver may increase the size of existing wetlands or create small impoundments that are easily identified on aerial imagery. Such flooding frequently creates Dead Forested or Dead Scrub-Shrub Wetland initially, followed in a few years by Aquatic Bed and Emergent Wetland.

Partly Drained/Ditched (d) — A partly drained wetland has been altered hydrologically, but soil moisture is still sufficient to support hydrophytes. Drained areas that can no longer support hydrophytes are not considered wetland. This Modifier is also used to identify wetlands containing, or connected to, ditches. The Partly Drained/Ditched Modifier can be applied even if the ditches are too small to delineate. The Excavated Modifier should be used to identify ditches that are large enough to delineate as separate features; however, the Partly Drained/Ditched Modifier also should be applied to the wetland area affected by the ditching.

Farmed (f) — Farmed wetlands occur where the soil surface has been mechanically or physically altered for production of crops, but where hydrophytes would become reestablished if the farming were discontinued. Farmed wetlands should be classified as Palustrine-Farmed. Cultivated cranberry bogs may be classified Palustrine-Farmed or Palustrine Scrub-Shrub Wetland-Farmed.

Managed (m) — This modifier is used to identify wetlands where water inputs are controlled to achieve a specific water regime or habitat type. Water control structures in combination with dikes and impoundments are common; however, this modifier should not be used in conjunction with the Artificially Flooded regime nor used to describe reservoirs nor for use in the Riverine system.

Excavated (x) — This Modifier is used to identify wetland basins or channels that were excavated by humans.

Diked/Impounded (h) — These wetlands have been created or modified by a man-made barrier or dam that obstructs the inflow or outflow of water.

Artificial Substrate (r) — This Modifier describes concrete-lined drainage ways, as well as Rock Bottom, Unconsolidated Bottom, Rocky Shore and Unconsolidated Shore where the substrate material has been emplaced by humans. Jetties and breakwaters are examples of Artificial Rocky Shores.

Spoil (s) — The Spoil Modifier is used to describe wetlands where deposition of spoil material forms the primary substrate type. By definition, spoil is material that has been excavated and emplaced by humans. Ancillary data may be needed to identify spoil in areas such as reclaimed strip mines that have become vegetated.

Water Chemistry Modifiers

The accurate characterization of water chemistry in wetlands and deepwater habitats is difficult, both because of problems in measurement and because values tend to vary with changes in the season, weather, time of day, and other factors. Yet, very subtle changes in water chemistry, which occur over short distances, may have a marked influence on the types of plants or animals that inhabit an area. A description of water chemistry, therefore, must be an essential part of this classification system.

Two kinds of Water Chemistry Modifiers are employed in this classification: Salinity Modifiers and pH (hydrogen ion) Modifiers. All habitats are classified according to salinity, and freshwater habitats are further classified by pH levels.

Salinity Modifiers

Differences in salinity are reflected in the species composition of plants and animals. Many authors have suggested using biological changes as the basis for subdividing the salinity range between seawater and fresh water. Since the gradation between fresh and hypersaline or hyperhaline waters is continuous, any boundary is artificial, and few classification systems agree completely. The salinity classification adopted here for both coastal and inland waters is a modified version of the Venice System, which was originally proposed at an international “Symposium on the Classification of Brackish Waters.”

Estuarine and Marine waters are a complex solution of salts, dominated by sodium chloride (NaCl). The term *haline* is used to indicate the dominance of ocean salt. The relative proportions of the various major ions are usually similar to those found in seawater, even if the water is diluted below seawater strength. Dilution of seawater with fresh water and concentration of seawater by evaporation result in a wide range of recorded salinities in both surface water and interstitial water within the substrate.

The salinity of inland water is dominated by four major cations, calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K); and three major anions, carbonate (CO₃), sulfate (SO₄), and chloride (Cl). Salinity is governed by the interactions between precipitation, surface runoff, groundwater flow, evaporation, and sometimes evapotranspiration by plants. The ionic ratios of inland waters usually differ appreciably from those in the sea, although there are exceptions, The

great chemical diversity of these waters, the wide variation in physical conditions such as temperature, and often the relative impermanence of surface water, make it extremely difficult to subdivide the inland salinity range in a meaningful way.

The term *saline* is used to indicate that any of a number of ions may be dominant or codominant. These salinities are expressed in units of specific conductance as well as percent salt and they are covered by the salinity ranges (Table A - 5.)

Table A - 5 - Water chemistry modifiers and their corresponding mapping code.

Coastal Modifiers^a	Inland Modifiers^b	Salinity (ppt)	Approximate Specific Conductance (µMhos at 25°C)	Mapping Code
Hyperhaline	Hypersaline	>40	>60,000	1
Euhaline	Eusaline	30.0-40	45,000-60,000	2
Mixohaline	Mixosaline ^c	0.5-30	800-45,000	3
Polyhaline	Polysaline	18.0-30	30,000-45,000	4
Mesohaline	Mesosaline	5.0-18	8,000-30,000	5
Oligohaline	Oligosaline	0.5-5	800-8,000	6
Fresh	Fresh	<0.5	<800	0
^a Coastal Modifiers are used in the Marine and Estuarine Systems. ^b Inland Modifiers are used in the Riverine, Lacustrine, and Palustrine Systems.				

pH Modifiers

Acid waters are, almost by definition, poor in calcium and often generally low in other ions, but some very soft waters may have a neutral pH. It is difficult to separate the effects of high concentrations of hydrogen ions from low base content, and many studies suggest that acidity may never be the major factor controlling the presence or absence of particular plants and animals. Nevertheless, some researchers have demonstrated a good correlation between pH levels and plant distribution showed that plants can be used to predict the pH of moist peat.

There seems to be little doubt that, where a peat layer isolates plant roots from the underlying mineral substrate, the scarcity of minerals in the root zone strongly influences the types of plants

that occupy the site. For this reason, many authors subdivide freshwater, organic wetlands into mineral-rich and mineral-poor categories. We have instituted pH Modifiers for freshwater wetlands (Table A - 6) because pH has been widely used to indicate the difference between mineral-rich and mineral-poor sites, and because it is relatively easy to determine.

Table A - 6 - pH modifiers and their corresponding mapping code.

Modifier	pH of Water	Mapping Code
Acid	<5.5	a
Circumneutral	5.5-7.4	t
Alkaline	>7.4	i

Soil Modifiers

Soil is one of the most important physical components of wetlands. Through its depth, mineral composition, organic matter content, moisture regime, temperature regime, and chemistry, it exercises a strong influence over the types of plants that live on its surface and the kinds of organisms that dwell within it. In addition, the nature of soil in a wetland, particularly the thickness of organic soil, is of critical importance to engineers planning construction of highways or buildings. For these and other reasons, it is essential that soil be considered in the classification of wetlands.

As noted in Section 2.2, we have placed the boundary between wetlands and deepwater habitats in the Riverine and Lacustrine Systems at a depth of 2.5 m (8.2 ft) below low water because this represents the approximate limit of soil as defined in Soil Taxonomy (Soil Survey Staff 1999) and the approximate maximum depth to which emergent plants normally grow. Thus, according to our definitions, inland wetlands may have soil, but inland deepwater habitats do not. All Palustrine waters are less than 2.5 m deep; therefore, potentially all Palustrine habitats have soil. In the Marine and Estuarine Systems, the deep limit of soil lies at a depth of 2.5 m below extreme low water; however, we separate wetlands from deepwater habitats precisely at the extreme low water mark in those Systems. So, according to our definitions, Marine and Estuarine wetlands may have soil, and deepwater habitats may have soil out to the 2.5-m depth limit.

The most basic distinction in soil classification in the U.S. is between mineral soil and organic soil (Soil Survey Staff 1999). In general *“a soil is classified as an organic soil (Histosols) if more than half of the upper 80 cm (32 inches) of the soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic matter.”* Soil that does not meet this criterion is considered mineral soil. Organic soil material is soil material that contains at least 12-18 percent organic carbon by weight, the required amount depending on the clay content in the mineral fraction (Soil Survey Staff 1999). See Appendix E for additional details on the differences between mineral and organic soils.

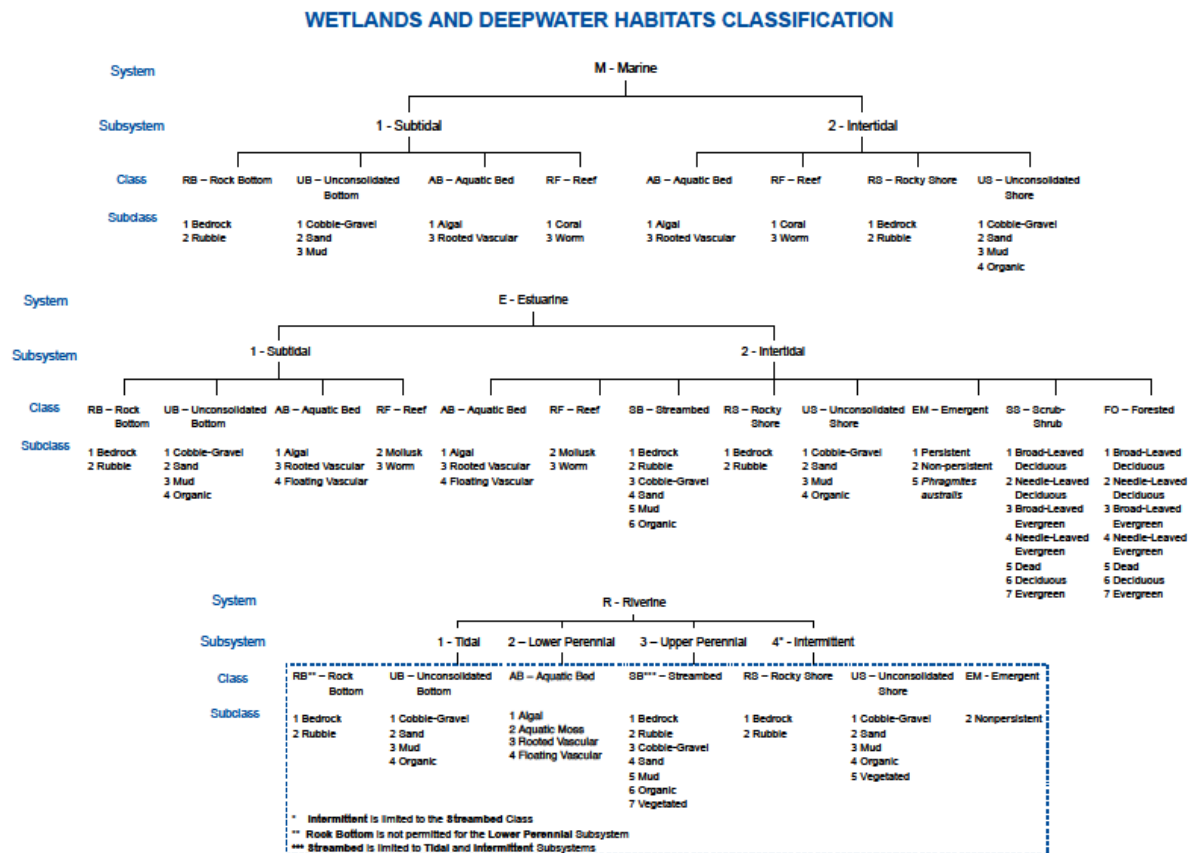
The U.S. soil classification is hierarchical and permits the description of soils at several levels of detail. For example, suborders of the order Histosols are recognized according to the degree of decomposition of the organic matter. In the WCS, we use the Soil Modifiers Organic and Mineral, based on the criteria presented above. If a more detailed soil classification is desired, the latest edition of *Keys to Soil Taxonomy* (Soil Survey Staff 2010) should be used.

Table A - 7 - Soil modifiers and mapping codes.

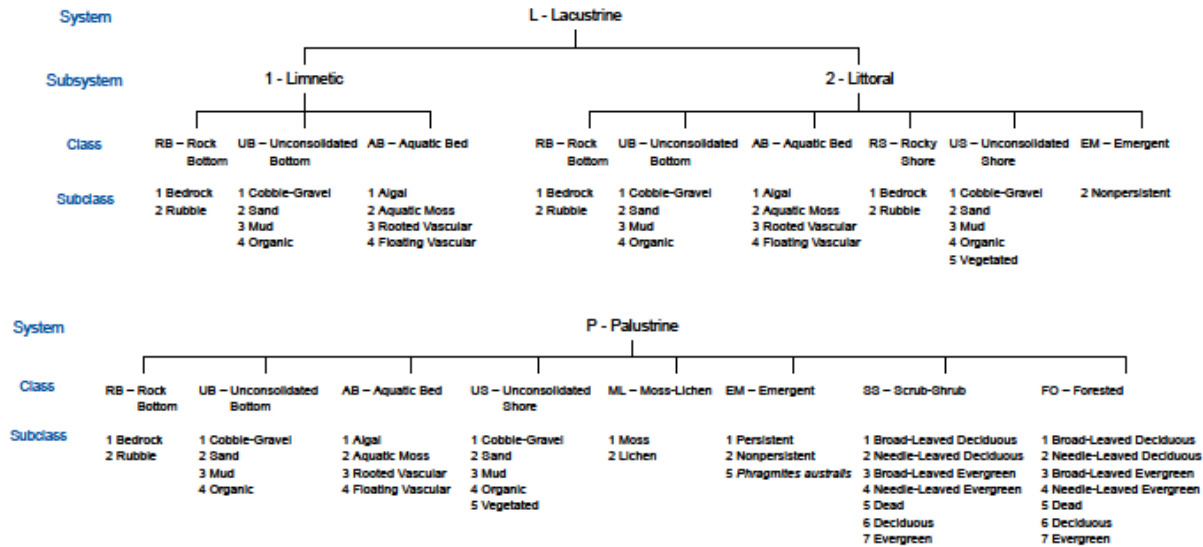
Modifier	Mapping Code
Organic Soil	g
Mineral Soil	n

APPENDIX B. MAP CODE DIAGRAM

For the purposes of applying the wetland classification system for mapping, a series of letter and number codes has been developed by the Service. The following map code diagram shows codes and relationships of wetland systems (e.g. estuarine), subsystems (e.g. intertidal), and classes (e.g. emergent).



WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



MODIFIERS			
In order to more adequately describe the wetland and deepwater habitats, one each of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy.			
Water Regime			Soil
Nontidal	Saltwater Tidal	Freshwater Tidal	g Organic n Mineral
A Temporarily Flooded B Seasonally Saturated C Seasonally Flooded D Continuously Saturated E Seasonally Flooded / Saturated F Semipermanently Flooded G Intermittently Exposed H Permanently Flooded J Intermittently Flooded K Artificially Flooded	L Subtidal M Irregularly Exposed N Regularly Flooded P Irregularly Flooded	Q Regularly Flooded-Fresh Tidal R Seasonally Flooded-Fresh Tidal S Temporarily Flooded- Fresh Tidal T Semipermanently Flooded-Fresh Tidal V Permanently Flooded-Fresh Tidal	
Water Chemistry			pH Modifiers for Fresh Water a Acid t Circumneutral i Alkaline
Halinity/Salinity			
1 Hyperhaline / Hypersaline 2 Euhaline / Euhaline 3 Microhaline / M ixosaline (Brackish) 4 Polyhaline 5 Mesohaline 6 Oligohaline 0 Fresh			

APPENDIX C: GLOSSARY OF TERMS FOR APPENDIX A AND B.

Acid: Term applied to water or soil with a pH less than 5.5.

Aeration: The exchange of air in soils with air from the atmosphere

Alkaline: Term applied to water or soil with a pH greater than 7.4.

Bar: An elongated landform formed by waves, currents, or deposition of unconsolidated sediments such as sand, gravel, stones, cobbles, or rubble and with water on two sides.

Beach: A sloping landform on the shore of larger water bodies, generated by waves, currents, or deposition of sediments and extending from the water to a distinct break in landform or substrate type.

Brackish: Marine and Estuarine waters with Mixohaline salinity. The term should not be applied to inland waters.

Boulder: Rock fragments larger than 60.4 cm (24 inches) in diameter.

Broad-leaved deciduous: Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season.

Broad-leaved evergreen: Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that generally remain green and are usually persistent for a year or more.

Calcareous: Formed of calcium carbonate or magnesium carbonate by biological deposition or inorganic precipitation. Calcareous sands are usually formed of a mixture of fragments of mollusk shell, echinoderm spines and skeletal material, coral, foraminifera, and algal platelets.

Channel: An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.

Circumneutral: Term applied to water with a pH of 5.5 to 7.4.

Cobbles: Rock fragments 7.6 cm (3 inches) to 25.4 cm (10 inches) in diameter.

Deciduous stand: A plant community where deciduous trees or shrubs represent the dominant spatial coverage of woody vegetation.

Dominant: The species making up the majority of spatial cover.

Dormant season: The non-growing portion of the year for vegetation.

Effectively drained: A condition where ground or surface water has been removed by artificial means to the point that an area no longer meets the definition of wetland.

Emergent hydrophytes: Erect, rooted, herbaceous angiosperms that may be temporarily to permanently flooded at the base but do not tolerate prolonged inundation of the entire plant.

Emergent mosses: Mosses occurring in wetlands, but generally not covered by water.

Estuary: Estuaries are found at the mouth of a river(s) entering the sea where the current of the river meets the tide and salt water and freshwater mix.

Evergreen stand: A plant community where evergreen trees or shrubs represent the dominant spatial coverage of woody vegetation.

Extreme high water of spring tides: The highest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme higher high water of mixed semidiurnal tides.

Extreme low water of spring tides: The lowest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme lower low water of mixed semidiurnal tides.

Euhaline: Marine water with excessive or supersaturated with sea salt at a level of 30 to 35 ppt.

Euslaine: Inland water with excessive or supersaturated with inland salts.

Flat: Flats are unconsolidated sediments found along lakes, rivers, estuarine or marine near shore areas that may be irregularly shaped or elongate and continuous with the shore.

Floating plant: A non-anchored plant that floats freely in the water or on the surface.

Floating-leaved plant: A rooted, herbaceous hydrophyte with some leaves floating on the water surface; e.g., white water lily, floating-leaved pondweed. Plants such as yellow water lily sometimes have leaves raised above the surface are considered floating-leaved plants or emergents, depending on their growth habit at a particular site.

Freshwater: Term applied to water with salinity less than 0.5 ppt dissolved salts.

Gravel: A mixture composed primarily of rock fragments 2 mm (0.08 inch) to 7.6 cm (3 inches) in diameter.

Ground Water: Water filling all the unblocked pores of an underlying material below the water table.

Growing season: The frost-free period or growing portion of the year.

Haline: Term used to indicate presence of ocean salt.

Herbaceous: Vegetation with the characteristics of an herb; a plant with no persistent woody stem above ground.

Hydric soil: Soil that is wet long enough to produce anaerobic conditions, thereby influencing the growth of plants.

Hydrophyte, hydrophytic: Any plant growing in water or on a substrate that is at least periodically deficient in oxygen because of excessive water content.

Hyperhaline: Term to characterize waters with salinity greater than 40 ppt due to ocean-derived salts.

Mesohaline: Term to characterize waters with salinity of 5 to 18 ppt due to ocean-derived salts.

Mesophyte, mesophytic: Any plant growing where moisture and aeration conditions lie between extremes. (Plants typically found in habitats with average moisture conditions, not usually dry or wet.)

Mesosaline: Term to characterize waters with salinity of 5 to 18 ppt land-derived salts.

Mineral soil: Soil composed of predominantly mineral rather than organic materials.

Mixohaline: Term to characterize water with salinity of 0.5 to 30 ppt ocean salts.

Mixosaline: Term to characterize waters with salinity of 0.5 to 30 ppt land-derived salts.

Mud: Wet soft earth composed predominantly of clay and silt--fine mineral sediments less than 0.074 mm in diameter.

Muck: A dark colored, well decomposed organic soil.

Needle-leaved deciduous: Woody gymnosperms (trees or shrubs) with needle-shaped or scale-like leaves that are shed during the cold or dry season.

Needle-leaved evergreen: Woody gymnosperms with green, needle-shaped, or scale-like leaves that are retained by plants throughout the year.

Nonpersistent emergents: Emergent hydrophytes whose leaves and stems break down at the end of the growing season so that most aboveground portions of the plants are easily transported by currents, waves, or ice. The breakdown may result from normal decay or the physical force of strong waves or ice. At certain seasons of the year there are no visible traces of the plants above the surface of the water.

Oligohaline: Term to characterize water with salinity of 0.5 to 5.0 ppt ocean-derived salts.

Oligosaline: Term to characterize water with salinity of 0.5 to 5.0 ppt land-derived salts.

Organic soil: Soil composed of predominantly organic rather than mineral material. The organic material is made up of plant and animal residue in the soil in various stages of decomposition.

Peat: Soil that is largely undecomposed organic matter that has accumulated under excess moisture.

Persistent emergent: Emergent hydrophytes that normally remain standing at least until the beginning of the next growing season.

pH value: PH is a numerical designation of acidity or alkalinity in water or soil.

Pioneer plants: Herbaceous annual and seedling perennial plants that colonize areas as a first stage in secondary succession.

Photic zone: The extent (depth) that sunlight penetrates a water column.

Polyhaline: Term to characterize water with salinity of 18 to 30 ppt due to ocean salts.

Polysaline: Term to characterize water with salinity of 18 to 30 ppt due to land-derived salts.

Saline: General term for waters containing various dissolved salts. Restricted to description of inland waters where the ratios of the salts often vary; the term haline is applied to estuarine and marine waters where the salts are roughly in the same proportion as found in undiluted seawater.

Salinity: Salinity is the total amount of dissolved material in grams in one kilogram of seawater.

Sand: Composed predominantly of coarse-grained mineral sediments with diameters larger than 0.074 mm and smaller than 2 mm.

Shrub: A woody plant that, at maturity, is usually less than 6 meters (20 feet) tall and generally exhibits several erect, spreading, or prostrate stems.

Sound: A body of water that is usually broad, elongate, and parallel to the shore between the mainland and one or more islands.

Spring tide: The highest high and lowest low tides during the lunar month.

Rubble Stone: Rock fragments larger than 25 cm (10 inches) but less than 60 cm (24 inches).

Submergent plant: A vascular or nonvascular hydrophyte, either rooted or non-rooted, which lies entirely beneath the water surface, except for flowering parts in some species; e.g., wild celery or the stoneworts.

Terrigenous: Derived from or originating on the land (usually referring to sediments) as opposed to material or sediments produced in the ocean (marine) or because of biologic activity (biogenous).

Tree: A woody plant which at maturity is usually 6 meters (20 feet) or more in height and generally has a single trunk, unbranched for 1 m or more above the ground, and a more or less definite crown.

Water table: The upper surface of a zone of saturation.

Woody plant: A seed plant (gymnosperm or angiosperm) that develops persistent, hard, fibrous tissues and includes species of trees and shrubs.

APPENDIX D: USING THE VERIFICATION TOOLS

Introduction

The Wetlands Data Verification Toolset is designed to automate the quality control functions necessary to ensure the accuracy of the data in the wetlands geodatabase. It has been designed to address geospatial errors, digital anomalies, and logic checks. In addition, it has the option to build a cumulative history table of identified errors to track the progress of corrections.

This toolset was created using Environmental Systems Research Institute's (ESRI) ModelBuilder and is compatible with ESRI ArcDesktop 10.6.1 software suite as well as ArcGIS Pro 2.3. It will only work on file geodatabases and replaces previous versions of custom wetlands verification tools.

Folder Contents

The verification toolset and associated files are contained in a folder called 'NWI_QAQC_Tool' (Figure 1). This folder can be stored in any location on your machine and contains:

Readme.txt

Wetlands Data Verification Toolset Installation and User Information.pdf

Workspace folder

NWI_Wetland_Codes.gdb

Wetlands_Database_Schema.gdb

Scripts.tbx

NWI_QAQC_Tool.tbx

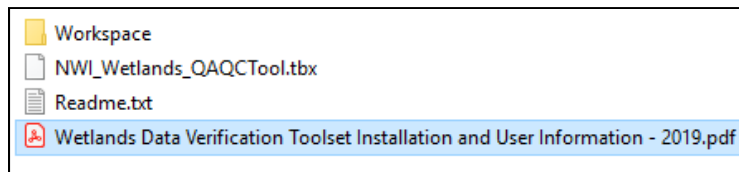
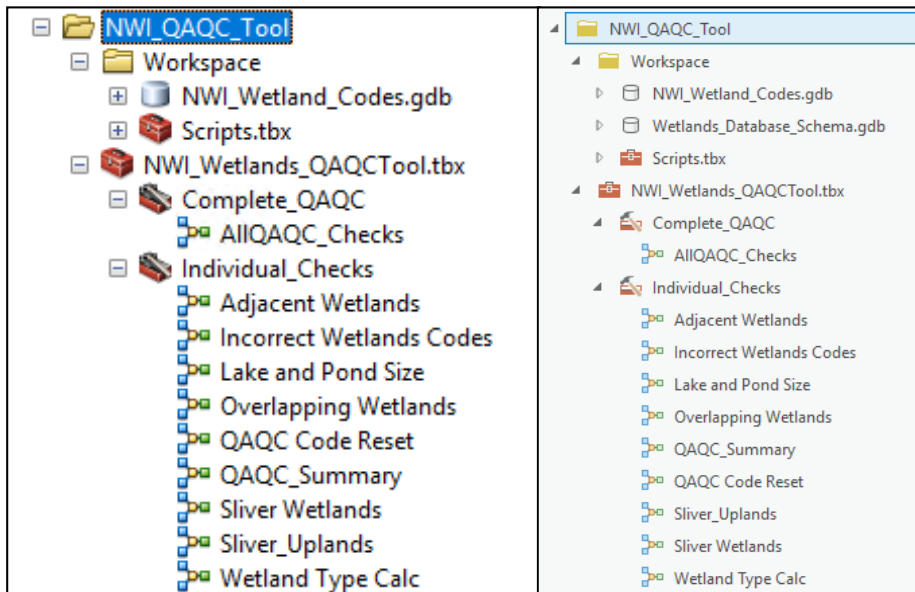


Figure 1. NWI_QAQC_Tool view in ArcCatalog (left), ArcGIS Pro (right), and Windows Explorer (bottom).

Readme.txt provides a general description of the contents and purpose of the folder.

The **Wetlands Data Verification Toolset Installation and User Information** document provides descriptions and procedures on the use of the verification models.

The **NWI wetland codes geodatabase** within the workspace folder serves as a reference for the code portion of the tool and must remain in the same directory as the toolbox.

The **wetlands database schema** organizes feature classes in the format used by the verification tool. Users can import data into respective feature classes and use it as the tool input.

The **Scripts toolbox** contains tools referenced by the complete QAQC tool. These are not standalone tools and should not be run individually.






The **NWI_QAQC_Tool.tbx** is the ArcToolbox that contains the Wetlands QAQC models, compatible with ArcDesktop 10.6.1 and ArcGIS Pro 2.3.

Dataset Compatibility

This toolset was designed to work on **file geodatabases** extracted from the FWS wetlands database and will only work on data following that schema. Specifically, it requires the feature class CONUS_wet_poly in a CONUS_wetlands feature dataset, and CONUS_wet_projects in a CONUS_projects feature dataset (substitute AK, HI, PRVI or PacTrust for CONUS in other mapping areas). The CONUS_wet_projects feature class must contain a polygon that completely covers the area where wetland mapping was conducted. Sample file geodatabases matching these schemas are provided with this tool in the workspace folder. A sample file geodatabase can be copied and loaded with wetlands data or used as a reference to build file geodatabases with the correct schema. Use of this toolbox on other data formats or schemas will likely fail and is not recommended.

Running the models

To run any of the QAQC models:

- Navigate in Catalog to the  **NWI_QAQC_Tool** toolbox located in the NWI_QAQC_Tool folder.
- Open the toolbox, open either the  **Complete_QAQC** toolset or the  **Individual_Checks** toolset, and double-click on 'AllQAQC_Checks' or any of the individual models. A window will appear similar to the one in Figure 2, which will allow the user to select input data and provides a description of the tool on the right pane, if the  button is selected.
- Identify the mapping area (CONUS, AK, HI, PRVI, or PacTrust)
- Click the browse button  next to the Geodatabase text box and browse to the wetlands file geodatabase on which to conduct verification and then press 'OK' (Figure 2).

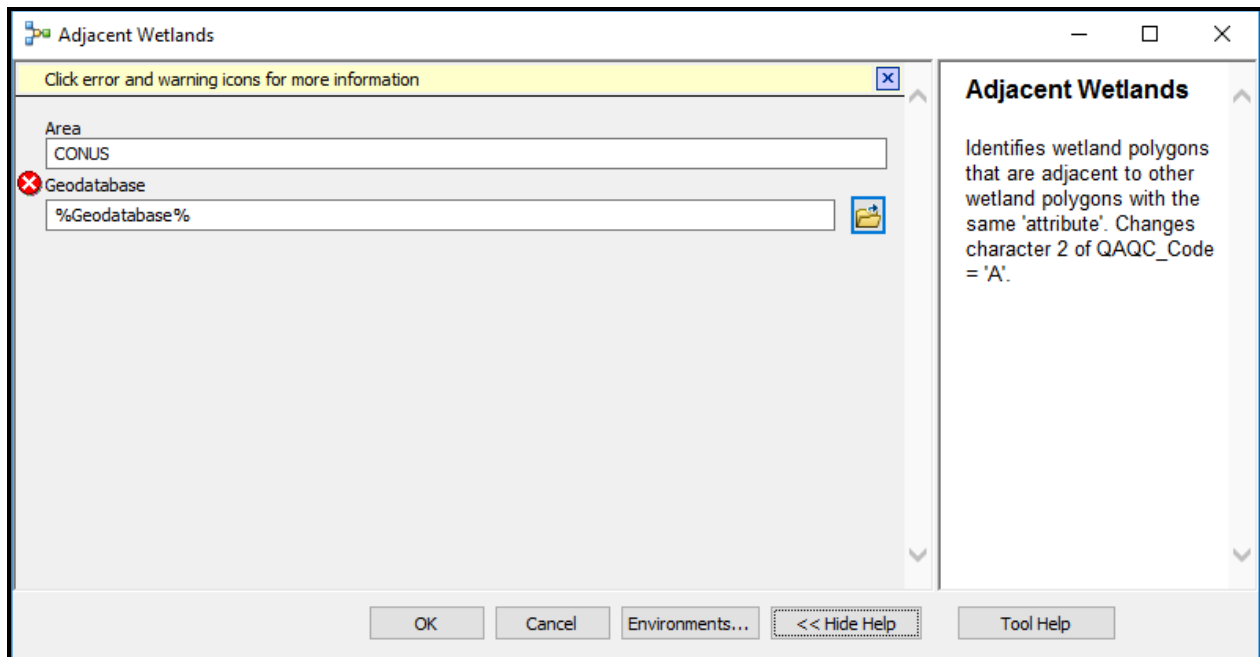


Figure 2. Example of a model user interface. Verify the mapping area and browse to the file geodatabase on which to conduct verification. Clicking ‘Tool Help’ shows a description of the selected tool.

Explanations of Verification Models

Complete QAQC

All QAQC Checks

This model performs complete data verification by running each individual model and then summarizing the results in a summary table. It includes the QAQC Code Reset, Incorrect Wetland Codes, Adjacent Wetlands, Sliver Wetlands, Sliver Uplands, Lake and Pond Size, Overlapping Wetlands, Wetland Type Calculation, and QAQC Summary models.

NOTE: Running the All QAQC Checks on projects that contain a high number of polygons or complex polygons may fail due to limitations in computer resources. It may be more efficient to run all the individual checks separately for these types of projects.

Optional Inputs

Verified By – Enter the individual or organization conducting the verification. This information will be output to the QAQC Summary table and QC History table (if option is selected).

Save History Table – This option will create a QAQC_History table and append subsequent iteration results of the QAQC_Summary table. Each group of errors appended from the QAQC_Summary table will be identified by a count iterator shown in the ‘Run’ field. The QAQC_History table will continue to grow with each iteration until it is manually deleted. This allows the user to track the progress of dataset edits between verification runs.

Individual Checks

QAQC Code Reset

This model calculates the QAQC_CODE = 'NNNNNN'. This erases all recorded errors in the dataset and properly attributes the field for use by all other models. Users should run this tool to reset error codes after each round of edits.

Incorrect Wetland Codes

This model cross-references the list of valid wetland codes and identifies wetland polygons with invalid codes, or null or blank values in the 'attribute' field. For identified code errors, this model changes the first character of the QAQC_CODE to 'C'.

To correct this error, users should change the attribute of the identified record to a valid wetland code.

Adjacent Wetlands

This model identifies wetland polygons that are adjacent to other wetland polygons with the same 'attribute', or multipart features. For identified errors, this model changes the second character of the QAQC_CODE to 'A'.

To correct this error, users should join adjacent polygons sharing the same attribute, change one of the attributes, or explode the multipart feature.

Sliver Wetlands

This model identifies wetland polygons less than 0.01 acres, which is smaller than the minimum mapping standard. For identified records, this model changes the third character of the QAQC_CODE to 'S'.

Genuine wetland features flagged as sliver wetlands can be justified as correct in the comments field of the QAQC_Summary table. Other features should be deleted or joined to adjacent polygons.

Sliver Uplands

Identifies upland islands or gaps in wetlands that are less than 0.01 acres. Because this model identifies gaps and missing areas, it changes the fourth character of the QAQC_CODE to 'U', in wetland polygons **adjacent** to the upland sliver. In addition, this tool creates a new sliver upland feature class in 'CONUS_wetlands' to assist in locating these small geographic features. This tool requires that 'CONUS_wet_projects' has a feature(s) that defines the wetland mapping project and completely covers all features in the 'CONUS_wet_poly' feature class.

Like sliver wetlands, these upland polygons may be genuine upland features and can be justified as such in the comments field of the 'QAQC_Summary' table. Otherwise, these areas can be copied from the generated feature class and merged with the appropriate adjacent polygon.

NOTE: This tool is among the most computationally intensive and may fail on geographically large project areas with many polygons. One possible remedy of this failure is to split a portion of 'CONUS_wet_poly' polygons into a new geodatabase, run the tool on each geodatabase, and then merge the resulting outputs to a single feature class.

Lake and Pond Size

This model identifies lake polygons that are less than 20 acres in size and ponds that are greater or equal to 20 acres in size. For identified records, it changes the fifth character of the QAQC_CODE to 'L' for small lakes or 'P' for large ponds. Generally, 20 acres is the threshold between classification of a pond and lake, but certain small lakes may be justified based on water depth as outlined in the [wetlands mapping standards](#). In those cases, comments should be added to the QAQC_Summary table for flagged wetland features. Otherwise, codes should be changed as appropriate.

Overlapping Wetlands

This model identifies overlapping wetland polygons and changes the sixth character of the QAQC_CODE to 'O'. The overlapping portions of these polygons are stored in the CONUS_wetlands feature dataset as a new feature class to assist in locating these features. Overlapping polygons should be edited so that polygons are not concurrent.

Wetland Type Calculation

This model populates the 'WETLAND_TYPE' field based on the wetland code in the 'attribute' field. The 'wetland_type' field provides a general description of the wetland and is used in the cartographic representation of the different wetland types on the Wetlands Mapper.

QAQC Summary

This model summarizes the QAQC_CODE field into a 'QAQC_Summary' table in the wetlands file geodatabase. It also defines each error type and records the user conducting the data verification along with a date/time stamp. Records shown in the 'QAQC_Summary' represent polygon counts for each unique code combination. Comments can be added to the 'comments' field of the QAQC_Summary table to justify specific types of errors.

OBJECTID	FREQUENCY	QAQC_CODE	Error_Type	Verified_By	Verification_Date	Verification_Comments	RUN
1	2	CNNNNN	Bad Code	Name	12/10/2018 4:48:18 PM	<Null>	1
2	3	NANNNN	Adjacent Polys	Name	12/10/2018 4:48:18 PM	<Null>	1
3	1	NANPNP	Adjacent Polys, Large Pond	Name	12/10/2018 4:48:18 PM	<Null>	1
4	3	NANUNN	Adjacent Polys, Sliver Upland	Name	12/10/2018 4:48:18 PM	<Null>	1
5	2	NANUNO	Adjacent Polys, Sliver Upland, Overlapping Wetland	Name	12/10/2018 4:48:18 PM	<Null>	1
6	3	NASNNN	Adjacent Polys, Sliver Wetland	Name	12/10/2018 4:48:18 PM	<Null>	1
7	1	NASPNP	Adjacent Polys, Sliver Wetland, Large Pond	Name	12/10/2018 4:48:18 PM	<Null>	1
8	1	NNNNLN	Small Lake	Name	12/10/2018 4:48:18 PM	Valid based on depth info.	1
9	27	NNNNNN	Passed Verification	Name	12/10/2018 4:48:18 PM	<Null>	1
10	2	NNNNNO	Overlapping Wetland	Name	12/10/2018 4:48:18 PM	<Null>	1
11	4	NNNUNN	Sliver Upland	Name	12/10/2018 4:48:18 PM	<Null>	1
12	4	NNNUNO	Sliver Upland, Overlapping Wetland	Name	12/10/2018 4:48:18 PM	<Null>	1
13	4	NNSNNN	Sliver Wetland	Name	12/10/2018 4:48:18 PM	<Null>	1
14	3	NNSNNO	Sliver Wetland, Overlapping Wetland	Name	12/10/2018 4:48:18 PM	<Null>	1
15	1	NNSUNO	Sliver Wetland, Sliver Upland, Overlapping Wetland	Name	12/10/2018 4:48:18 PM	<Null>	1

Figure 3. Because many polygons within a wetlands dataset will be flagged with multiple errors, the QAQC_Summary table shows the frequency of each unique combination of errors, and provides a comments field for justification.

Reviewing Verification Errors

To find specific instances of an error, in ArcMap or ArcGIS Pro, sort the 'CONUS_wet_poly' attribute table by QAQC_CODE and double-click the gray box associated with a given record on the far left side of the table (Figure 4). This will zoom the map display to that polygon.

OBJECTID*	ATTRIBUTE*	HGM_CODE	QAQC_CODE	WETLAND_TYPE	ACRES
4435	PEM1C	<Null>	NNSUNO	Freshwater Emergent Wetland	0.000733
4431	PSS1C	<Null>	NNSNNO	Freshwater Forested/Shrub Wetland	0.006964
4432	R2UBH	<Null>	NNSNNO	Riverine	0.00626
4427	PEM1A	<Null>	NNSNNN	Freshwater Emergent Wetland	0.000001

Figure 4. The 'QAQC_CODE' field in the 'CONUS_wet_poly' attribute table can be used to sort and review error codes.

The 'Select by Attribute' function, shown in Figure 5, can also be used to select all records of a defined QAQC_CODE value. Example below:

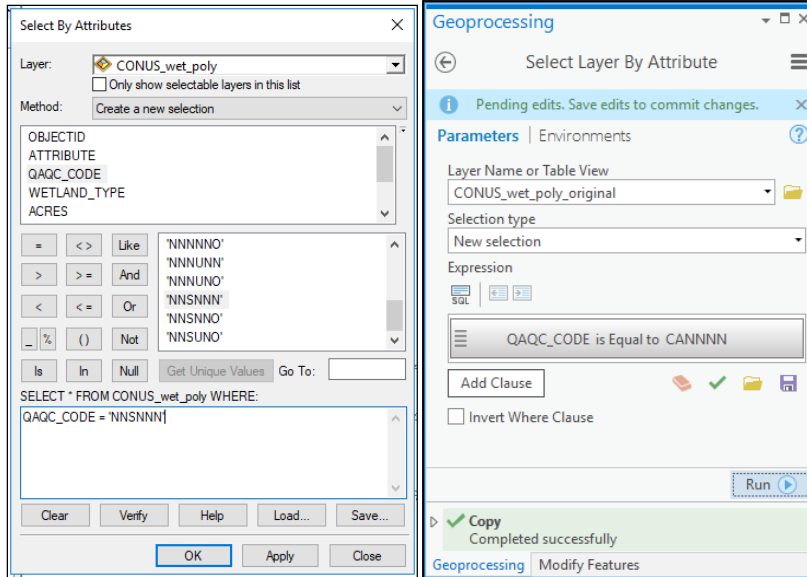


Figure 5. 'Select by Attributes', shown in ArcGIS 10.6 (left) and ArcGIS Pro (right) can help select and navigate to specific polygon errors.

To view the errors cartographically, create symbology rules on the CONUS_wet_poly feature class using the QAQC_CODE field. (e.g. QAQC_CODE = 'NNNNNN' symbolize green, all other values symbolize red).

For further information, assistance or questions contact: wetlands_team@fws.gov

Document Title

[Type the document subtitle]

Author

Date

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Study Area:

Classification Results:

Map of Project Study Area/Inset Map

Project Title

Project ID:

Source Imagery (month/year, emulsion, scale):

Collateral Data Used (ie. soils, imagery, Lidar):

Inventory Method (software versions, field work, photo interpretation methods etc):

Classification:

Data Limitations:

General Description of Project Area:

- *Geography:*
- *Vegetation, Soils, land Use:*
- *Natural History, Important Features:*

Description of wetland habitats:

- *Cowardin Classification:*
- *Wetland Classification Codes:*

Special Mapping Conventions and/or Unique Wetland Codes (if any):

Wetland Plant List: (optional)

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