

Mapping Narrow Linear Habitats as Line Features

U.S. Fish and Wildlife Service National Wetlands Inventory (NWI)

Preface

This document is intended to serve as a resource to assist in mapping wetland habitats beyond the Federal Geographic Data Committee (FGDC) Wetland Mapping Standard (FGDC 2009). The general guidelines included in this document should not be substituted for direct communication with the NWI Program. Partners funding projects for inclusion into the national wetlands data layer must contact NWI staff early in the development of a project to ensure its success.

Introduction

The purpose of this document is to outline requirements for submitting features that lie beyond the FGDC Wetland Mapping Standard that will no longer be accepted as polygons within projects initiated (i.e., contracts signed) after September 30, 2022. These features, also known as Narrow linear habitats (NLH) are non-vegetated Cowardin-defined features (Federal Geographic Data Committee, 2013) that are less than 15 ft. (4.5m) wide in the U.S. and territories outside of Alaska. If project goals require the inclusion of NLH features beyond the Wetland Mapping Standard, these features can be submitted to NWI in a separate linear data layer. The submission of a linear data layer is NOT required by NWI to meet the Wetland Mapping Standard.

NWI Line Feature Class Requirements

Classification

The classification system used to map NLH is described in the FGDC endorsed standard, Wetlands and Deepwater Habitats of the United States (FGDC 2013). Only non-vegetated habitat areas beyond the standard can be represented as a line. These non-vegetated areas include: Riverine (R) or Estuarine (E) Systems, with Subsystem 1, 2, 3 or 4, and Class RB, UB, or SB (Figure 1).

Target Mapping Unit (TMU)

The Target Mapping Unit is an estimate of the size class of the smallest wetland that can be consistently mapped and classified at a particular scale of imagery. The TMU allows for mapping below a specified threshold but does not require it.

TMU for NWI Lines: The minimum TMU for mapping NWI linear features is 7 (2.1 m) feet wide or visible at 1:6,000 or approximately half of the existing wetland mapping standard. NWI requires that lines be mapped at that minimum TMU across the entire project area to be accepted into the national dataset. The TMU for each project area must be declared in the metadata, along with an associated justification and description of the quality assurance process used.

Wetland data that meet or exceed the TMU along with the producer's accuracy (PA) requirements will be accepted by NWI. For the lower 48 states, Hawaii and the Trust Territories, features that are at least 7 (2.1 m) feet wide shall be mapped with a PA of 98% for feature accuracy and 85% for attribute accuracy, or higher. Habitat changes that have occurred between the date of the base imagery and the date of field observation are not considered errors because the wetland was correctly classified on the base imagery.

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION FOR NWI LINES



MODIFIERS						
In order to more adequately describe the wetland and deepwater habitats, one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The formed modifier may also be applied to the ecological system.						
Water Regime			Special Modifiers	Water Chemistry		Soil
Nontidal	Saltwater Tidal	Freshwater Tidal		Halinity/Salinity	pH Modifiers for all Fresh Water	
A Temporarily Flooded	N Regularly Flooded	Q Regularly Flooded-Fresh Tidal	b Beaver	1 Hyperhaline / Hypersaline	a Acid	g Organic
C Seasonally Flooded	P Irregularly Flooded	T Semipermanently Flooded-Fresh Tidal	d Partly Drained/Ditched	2 Euhaline / Eusaline	t Circumneutral	n Mineral
F Semipermanently Flooded		V Permanently Flooded-Fresh Tidal	f Farmed	3 Mixohaline / Mixosaline (Brackish)	i Alkaline	
G Intermittently Exposed			m Managed	4 Polyhaline		
H Permanently Flooded			h Diked/Impounded	5 Mesohaline		
J Intermittently Flooded			r Artificial Substrate	6 Oligohaline		
			s Spoil	0 Fresh		
			x Excavated			

Classification of Wetlands and Deepwater Habitats of the United States, Cowardin *et al.* 1979

Figure 1 - All lines submitted to NWI must be non-vegetated Cowardin defined habitat types. This chart represents the population of acceptable codes that can be used to classify these features.

Accuracy

The position and classification accuracy of the mapped features must represent the scientific precision that underlies the Service's habitat mapping objectives. When mapping non-vegetated wetlands as lines, accuracy may be dependent upon several factors including:

- Mapping scale
- Resolution of imagery
- Season of imagery (leaf-off or leaf-on)
- Type of imagery or emulsion of imagery
- Environmental conditions when imagery was captured
- Availability and quality of ancillary or collateral data
- Training and experience of the image interpreter
- Mapping software/hardware and other related technologies

Classification accuracy of the final map product should be measured by the Producer's Accuracy metrics relative to the TMU. There is no requirement for User's Accuracy.

Producer's accuracy Ninety-eight percent of all wetlands **visible on an image** at the size of the TMU or larger are required to be mapped regardless of classification.

Attribute or categorical accuracy refers to the uncertainty level of feature classifications – e.g., correct/incorrect application of the FGDC Wetlands Classification Standard. Attribute accuracy for linear data submitted to NWI is 85%.

Horizontal or spatial accuracy requirements for lines submitted and distributed by NWI is 2.5m measured from the source imagery. The requirements for NWI lines necessitate that the spatial accuracies are reported at the 90% confidence interval. Accuracy reported at the 90% confidence level means that 90% of the positions in the data set will have an error with respect to position on the image that is equal to or smaller than the reported accuracy value. It is essential that a certain level of horizontal accuracy is maintained in the linear data layer to ensure that it is interoperable with mapped wetland polygons. Special care should be taken to ensure that lines meet accuracy requirements when they interact with wetland polygons.

Imagery Standards

Resolution

Base imagery is the ortho-rectified imagery (aerial photography/satellite imagery) that is used to directly create wetlands data. Base imagery must be rectified to a national standard and be a minimum of 0.6m resolution. Attempting to map to imagery that does not meet resolution requirements to detect features below the NWI standard TMU will not meet data requirements.

Maximum zoom

This is the maximum magnification an analyst should use for wetland delineation and classification purposes. For producing line features the maximum zoom is 1:2,500.

Working Scale

The working scale is the scale where reviews and/or edits are done, and at which the delineations are quality controlled. The working scale should range between 1:3,000 and 1:6,000.

Product Scale

The objective of mapping Narrow Linear Habitats remains to produce medium resolution information on the location, type, and size of these habitats such that they are accurate at the product scale of 1:6,000.

Ancillary Data

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 to assist in 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.

Derived Data

Automated feature generation using ancillary data can be extremely useful in identifying streams and other narrow habitats. Using ancillary source data to identify features is acceptable and encouraged where datasets exist for an entire project area. Feature widths and horizontal accuracy are ultimately determined by the imagery, so it is important that all features be an accurate representation of the wetland and align with the source imagery. Features generated using ancillary data can remain in their original position if they meet horizontal accuracy requirements.

Quality Control and Quality Assurance

All data producers are required to coordinate to the maximum extent possible with the National Wetlands Inventory staff for data reviews and quality assurance steps prior to submission to the Service's Wetlands Geodatabase. Preliminary data can be submitted for review and comment by NWI at any time. Prior to submission, internal review and quality control of line features should be performed on 100% of the project area by a qualified image analyst who did not perform the original work. Data producers are encouraged to follow the QA/QC plan outlined [here](#). QC and QA by NWI staff will be performed to ensure requirements for inclusion into the national dataset are met including:

1. Consistent mapping of line features across the project area. The minimum Producer's Accuracy for lines above the TMU is met: 98% of features greater than or equal to 7 feet (2.1m) wide or visible at 1:6,000 are mapped. The TMU and Producer's Accuracy for each project area are listed in the metadata, along with an associated justification and description of the quality assurance process used.
2. Lines are clipped to the project boundary. Lines extending beyond the boundary will not be accepted.
3. Features are not flagged by the [QA/QC tool](#) that identifies geospatial errors, digital anomalies and performs logic checks. Any features flagged by the tool but deemed accurate need to be justified in the tool's table.
4. Attribute and spatial accuracy requirements are satisfied.

Feature Creation and Topology

The NWI Program has developed topology rules and mapping convention requirements for line features that must be met for data to be included in the national dataset. This line mapping convention closely mirrors that of the National Hydrography Dataset, enabling individual line edits to be performed and allows for specific reach lengths to be obtained. To accomplish this, line features should be submitted as single part features with multiple vertices as shown below (Figure 2).

Note: To assist in data formatting the updated NWI Verification toolset includes a tool that dissolves features by attribute and then explodes features into multiple parts. This is provided to streamline the line production process, and to also ensure data are delivered in the correct format.

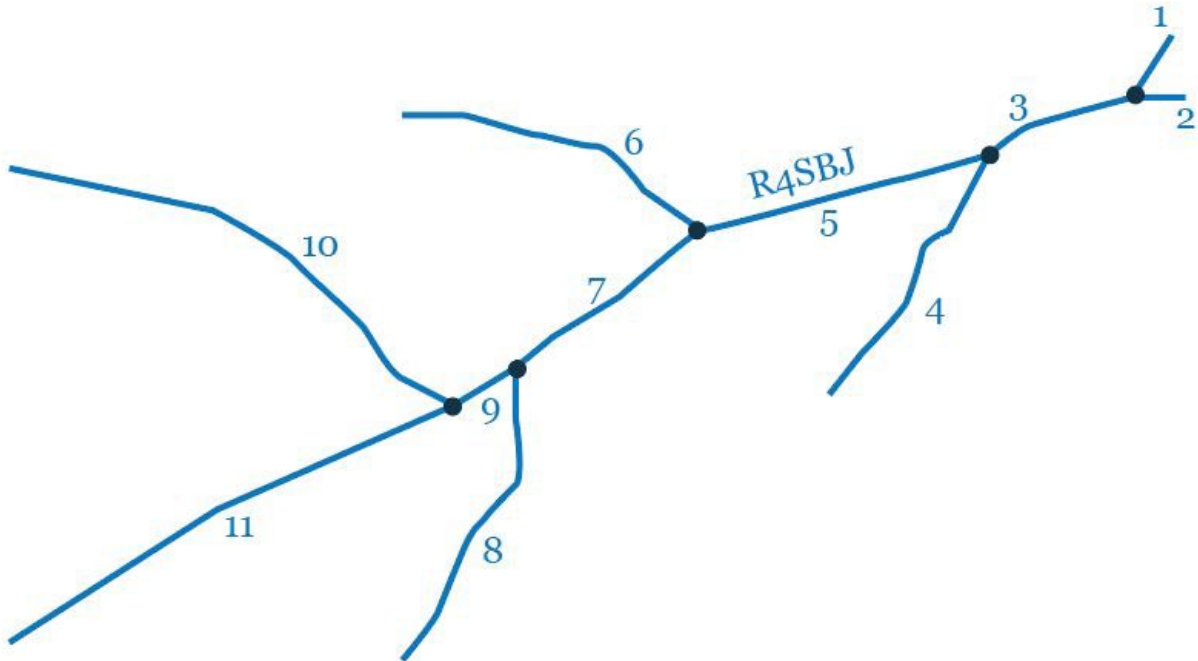


Figure 2 - Lines are required to be submitted as multi-part features. Each number in this figure corresponds to an individual feature that begins and ends with black nodes.

NWI Line Topology Rules and QA/QC Check Requirements

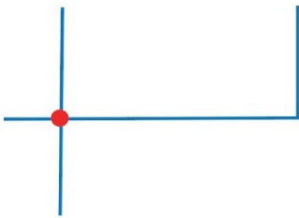
NWI has developed the following topology rules and mapping conventions that must be adhered to before submission into the national dataset. These consist of topology rules that the NWI Verification Toolset will perform logic checks on, as well as those that will require visual inspection during the QA/QC process. Note that the **red** feature denotes an error.

Topology Rules

Must not self-intersect

Line features may not intersect themselves.

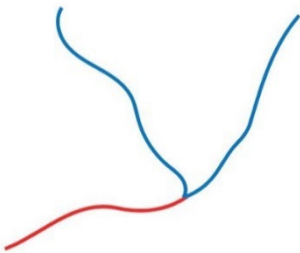
Self-intersects will be resolved by running the QA/QC Data Prep Tool



Must not overlap

Coincident line segments are not allowed.

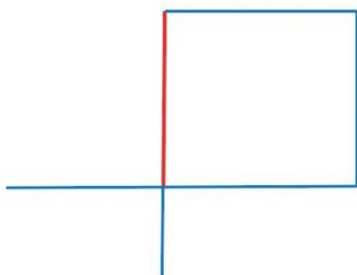
Overlaps will result in QA/QC tool error 'O'



Must not self-overlap

Features may not overlap themselves.

Self-overlaps will result in QA/QC tool error 'O'

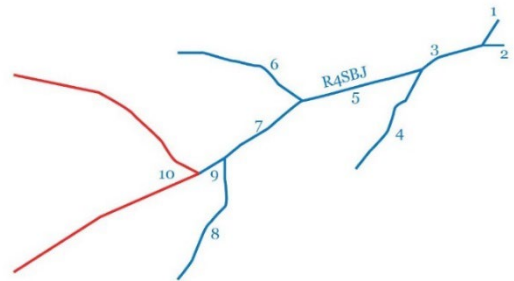


QA/QC Checks

Must be multi-part

Individual line segments must be single part making each stream network one large multipart feature.

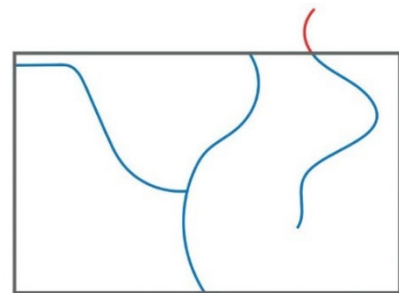
Merged features must be exploded before submission.



Must be inside

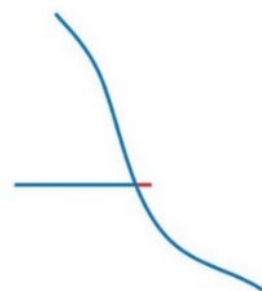
Line features may not extend beyond the project boundary.

Line features must be clipped to the project boundary.



Must not be a dangle

Lines should be snapped to coincident features and not extend beyond. QA/QC should visually check for these anomalies.

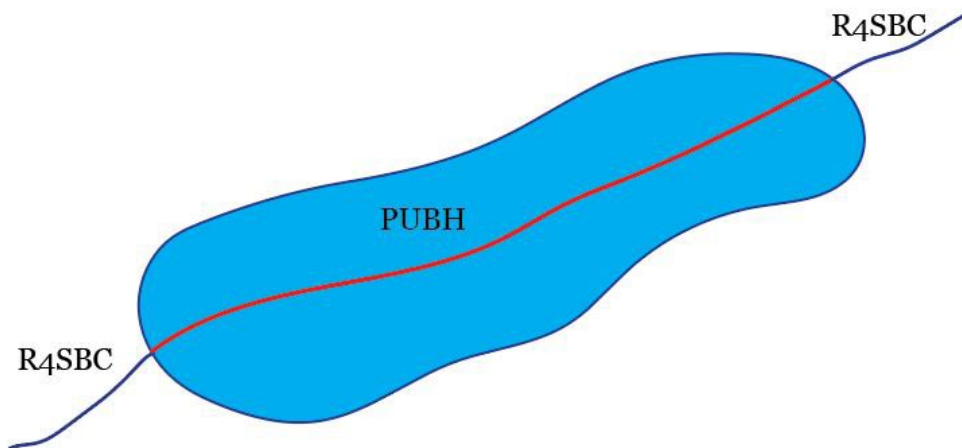


NWI Line and Polygon Interaction Requirements

The following mapping conventions and topology rules must be followed by data producers to ensure that the line and polygon feature classes interact consistently and are topologically sound. These conventions and rules will be enforced using the NWI Verification Toolset, as well as visual inspections. Note that the **red** feature denotes an error.

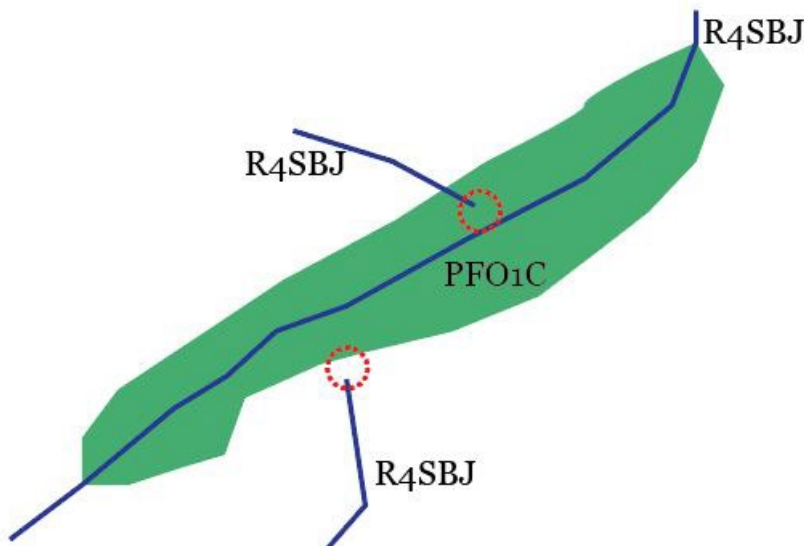
Lines Overlapping Polygons

Line features may only overlap with vegetated wetlands such as PEM, PSS, PFO, E2EM, and L2EM or any riparian classification, **Line overlaps with any other features will result in a QAQC error of 'O.'**



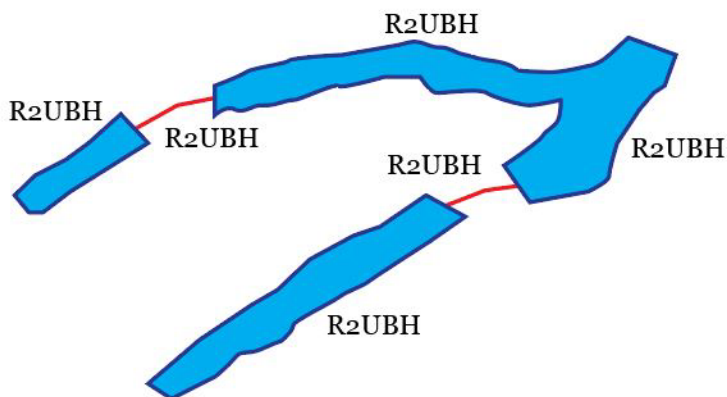
Snapping lines to Polygons

Line features must be snapped to the most appropriate linear or polygonal feature to ensure there are no gaps between coincident features. **Lines should be inspected as part of the QA and QC process to ensure no incorrect gaps are present.**



Continuity of Feature Type

Data producers should avoid going back and forth between feature types, and instead should map the feature in its entirety using a consistent feature type whenever possible. Short line segments will be flagged by the QAQC tool for inspection.



Verification Tools

Customized data verification tools are provided to automate (to the extent possible) the technical quality control functions necessary to ensure that line features are accurate. A suite of functions has been designed to address geospatial errors, digital anomalies, and some logic checks that ensure compliance and interoperability with the polygonal dataset. The latest version of the verification tools and accompanying user documentation can be found at <https://www.fws.gov/program/national-wetlands-inventory/data-verification-tools>.

There are five functions executed by the automated Verification Toolset. At a minimum, digital data must pass the critical tests for topology and attribution to be considered acceptable. Due to the challenge of identifying all geospatial anomalies, some tools could flag an accurate feature. In this case the data producer must indicate that the flagged error was verified to be correct during the QC process.

- **Incorrect Codes** – This tool cross-references the list of valid NWI line codes and identifies line features with invalid codes, or null or blank values in the ‘attribute’ field. Users should change the attribute of the identified feature to a valid linear code. The tool will return an error code “C” to indicate an error.
- **Line/Polygon Overlapping Features** – This tool has two associated error codes. An error code of ‘R,’ indicates that the linear feature is connecting two riverine polygons and, in most cases, should be a polygonal feature. An error code of “W” indicates that the linear feature overlaps a polygonal feature classified as: RB, UB, AB, RF, SB, or RS which is not permissible. Overlapping features should be edited or clipped to be removed, or justification would need to be added to the QAQC table.
- **Line/Line Overlaps** – This tool indicates that a line feature overlaps with another line feature with a different attribute. An error code of ‘O’ will be returned.
- **Linear Slivers and Dangles** – This tool identifies linear features less than 7 feet (2.1m). Genuine features flagged as linear slivers may be justified as correct in the comments field of the summary table associated with the toolset if deemed ‘real.’
- **Linear Type Calculation** – This model populates the ‘WETLAND_TYPE’ field based on the linear code in the ‘attribute’ field. The ‘WETLAND_TYPE’ field provides a general description of a feature and is used in the cartographic representation of features in the Wetlands Mapper

- **Linear Gaps** - This tool identifies gaps between features. An error code of 'G' indicates there is a possible gap between it and another feature. That gap should be investigated to see if it's intended and real.

Field Work

Field work plays a critical role in verifying the accuracy of remotely sensed image interpretation. When mapping line features, information collected during field visits should be used to ensure that features are mapped accurately and consistently across the entire project area. Documentation of how decisions were made using fieldwork that may otherwise not be clear, should be incorporated into the Supplemental Map Document.

Consistency in Feature Type

When mapping both polygon and linear wetland features, the NWI Program is looking for consistency in feature type. Mapping back and forth between polygons and lines for the same wetland feature should be avoided whenever possible. If the majority of a wetland feature meets the TMU for a polygon, it should be mapped as such. If the majority of the feature falls below the standard for wetland polygons, then it should be represented as a line.

Metadata Requirements

Project-level metadata must be assembled and submitted for each wetland mapping project and contain information about the project's scope and mapping conventions. NWI provides a template [Supplemental Map Information Report](#) that can be used. Projects that include line features should reference TMU and mapping conventions specific to the mapping and classification of linear features within the project area.

References

- Cowardin, L., Carter, V., LaRoe, E., & Golet, F. (1979). *Classification of Wetlands and Deepwater Habitats*. Washington D.C.: USFWS.
- Dahl, T., & Bergeson, M. (2020). *Data Collection Requirements and Procedures for Mapping Wetland*,. Washington D.C.: USFWS.
- Federal Geographic Data Committee. (2009). *Wetlands Mapping Standard*. Washington D.C.
- Federal Geographic Data Committee. (2013). *Classification of wetlands and deepwater habitats of the United States. FGDC-STD-004-2013. Second Edition*. Washington D.C.