Mid-Atlantic Tidal Wetland Rapid Assessment Method

Version 4.1

June 2017

Program Contacts:

Alison Rogerson
Delaware Department of Natural Resources and Environmental Control
Division of Watershed Stewardship
100 W. Water St. Suite 10B
Dover, DE 19904
Alison.Rogerson@state.de.us

LeeAnn Haaf
Partnership for the Delaware Estuary
110 S. Poplar Street, Suite 202
Wilmington, DE 19801
lhaaf@delawareestuary.org

Table of Contents

Method Development..1
Changes In This Version..4
Use of Method……………………………………………………………….2

A. Time and Effort Involved…………………………………………………3
B. Experience and Qualifications Needed…………………………………...…3

Field Preparation……………………………………………………………….3

A. Landowner Permission……………………………………………………3
B. Field Map Production……………………………………………………..3
C. Equipment List……………………………………………………...…4

Classification of Tidal Wetlands…………………………………………………4
Establishing the Assessment Area………………………………………………..7

A. Moving or adjusting the location and/or dimensions of the AA…………………..8
B. Locating subplots within the AA……………………………………………..9

Metric Overview……………………………………………………….…11
Data Collection—Characterization Metrics……………………………………12
Data Collection—Condition Metrics……………………………………………16

Attribute 1: Buffer/Landscape……………………………………………...…...16

B1. Percent of Assessment Area Perimeter with 10m Buffer………………..16
B2. Natural Land Uses in Buffer…………………………………………18
B3. Altered and High Impact Land Use between AA Edge and 250m………..20
B4. 250m Landscape Condition……………………………………….21
B5. Barriers to Landward Migration…………………………………...21

Attribute 2: Hydrology…………………………………………………...24

H1a. Ditching & Excavation (OMWM) for saltwater/brackish sites only……..24
H1b. Point Sources for freshwater tidal sites only…………………………26
H2. Fill……………………………………………………………..26
H3. Wetland Diking/Tidal Restriction…………………………………….27

Attribute 3: Habitat………………………………………………………28

HAB1. Bearing Capacity……………………………………………..29
HAB2. Horizontal Vegetative Obstruction……………………………...31
HAB3. Number of Plant Layers……………………………………….32
HAB4. Plant Species Richness………………………………………..33
HAB5. Percent Invasive Cover………………………………………..34

Appendix A. Identifying Native *Phragmites*……………………………………35

METHOD DEVELOPMENT

The Mid-Atlantic Tidal Wetland Rapid Assessment Method was developed as part of a collaborative effort among the Delaware Department of Natural Resources and Environmental Control, Maryland Department of Natural Resources, and the Virginia Institute of Marine Sciences to assess the condition of tidal wetlands in the Mid-Atlantic region. We are very grateful to the developers of the New England Rapid Assessment Method (NERAM) and the California Rapid Assessment Method (CRAM) from which we borrowed metrics, indicators, and index development. We would like to thank Erin McLaughlin from the Maryland Department of Natural Resources Riparian and Wetland Restoration Services and Kirk Havens from the Virginia Institute of Marine Sciences Center for Coastal Resources Management for helping with the development of these metrics.

This protocol was originally developed based on data collected in the Indian River watershed (DE), Nanticoke watershed (MD), and York River watershed (VA) in 2006 and 2007. We collected a range of data including vegetation composition and structure, soil attributes, above and below ground biomass, soil stability, macroinvertebrate composition, bird community composition, hydrology, surrounding land use, and stressors. Additionally, we used both the NERAM and CRAM on the same sites. Based on our data analysis we selected metrics from both NERAM and CRAM that were suitable to the Mid-Atlantic region and were able to discriminate sites along a disturbance gradient. The scaling of individual metrics was then adjusted to fit the range of conditions found in Mid-Atlantic tidal wetlands. In 2010, we updated the metric content and scaling based on additional assessments in the Inland Bays, St. Jones River, and Murderkill River watersheds in Delaware. **This protocol is a living document and will continue to be updated periodically as we collect more information and continue to learn more about tidal wetland processes and stressors and how these impact the ecological integrity or condition of wetlands.**

The overall formatting follows that of CRAM to depict the major wetland attributes including Plant Community (biotic and physical structure), Hydrology, and Buffer. Each metric is given a score between 3 and 12 and then combined into attribute scores by summing the metric scores and dividing by the total possible value, depending on the number of metrics in that group. That value is adjusted to be on a 0-100 scale since each metric can only score a minimum of 3:

$$\text{Buffer} = ((((\textstyle\sum(B1\ldots B5))/60)*100)-25)/75)*100$$
$$\text{Hydrology} = ((((\textstyle\sum(H1\ldots H3))/36)*100)-25)/75)*100$$
$$\text{Habitat} = ((((\textstyle\sum(HAB1\ldots HAB5))/60)*100)-25)/75)*100$$

Final MidTRAM condition scores range from 0-100 and are calculated by averaging the 3 attribute group scores:

$$\text{MidTRAM} = ((\text{Buffer} + \text{Hydrology} + \text{Habitat})/3)$$

CHANGES IN THIS VERSION

In Version 4.1 changes were made to several metrics to reflect a growing reference data set. Some metrics were removed and replaced with metrics that better reflect wetland conditions.

Also the method was updated to represent natural conditions in tidal freshwater wetland sites. Data and scores from 341 sites in 10 watersheds throughout Delaware, New Jersey, and Pennsylvania were used to evaluate metric performance and scoring variation. Version 4.1 attempts to minimize user subjectivity and clarify instructions on how metrics should be performed. Metric scoring has been updated to represent the range of conditions in all watersheds to date.

There were changes made to several buffer metrics. B1, Percent of Assessment Area Perimeter with 10m Buffer, increased from 5m to 10m because using 5m captured very little scoring variation. Increasing to 10m separated sites more effectively. B2 changed from Buffer Width measured by averaging 8 'spokes' around the AA to Natural Land Uses in the 250m Buffer, which measures the proportion of the buffer area that is in a natural state. This change better represents land use in the entire buffer area and removes user variation related to placing the measured 'spokes'. Metric B3, High Impact Land Uses in the Buffer, changed from estimating the percent of surrounding development from an aerial image to a calculation completed by using the most recent Land Use Land Cover (LULC) data and clipping it to the 250m buffer in GIS. Although this adds to office time, it removes user variability. In the 250m Landscape Condition metric (B4), the scoring descriptions were updated to add mention of point source inputs such as agricultural ditches, storm water ponds, and polluted sources.

For Hydrology metrics, Point Sources (H1) was removed as a tidal saltwater wetland metric due to low occurrences in the reference data set. Point Sources remains a metric for tidal freshwater sites only. Ditching and Excavation (H1) and Fill (H2) now include more detailed scoring descriptions with an added emphasis on measuring the width and length of the ditches and the area of any fill piles. Ditching and Excavation is scored for saltwater sites only; it is not scored as a metric for tidal freshwater sites because of extremely low occurrence in the reference dataset. The updated Wetland Diking and Tidal restriction (H3) metric now includes field examples for the scoring descriptions instead of an estimation of the effect of the stress.

Several changes were made to the Habitat metrics as well. Scoring for Bearing Capacity (HAB1) was updated to include separate scoring scales for tidal saltwater sites and tidal freshwater sites, as analysis of reference data showed a significant difference in bearing capacity between these habitat types. For Horizontal Vegetative Obstruction (HAB2), measurements at heights 1.0m and 1.25m were added to capture conditions in very tall vegetation. The scoring was updated to incorporate the 8 additional measurements per site when necessary. A scoring table for tidal saltwater sites is provided, but scoring for tidal freshwater sites is still under development. The Plant Community Worksheet was redone to reduce both user confusion and repetition. The Number of Plant Layers (HAB3) was simplified into a checklist. Percent Co-dominant Invasive Species (HAB4) was removed and replaced with a Plant Species Richness checklist. Percent Invasive Cover (HAB5) remains unchanged.

USE OF METHOD

This method was developed for the primary purpose of assessing the condition of tidal wetlands at the watershed scale using a probabilistic survey. Therefore, the assessment is based on the evaluation of a fixed area of tidal wetland (50m radius circle). We believe that the method also has wider applicability for other uses. Multiple assessment areas may be required to assess larger areas to accurately depict the condition of the site.

***The development team would appreciate any feedback from users on how they are using the method, the applicability in different areas, and suggestions for improvement.**

A. Time and Effort Involved

The time to sample a site with MidTRAM will vary depending on the number of field crewmembers, the familiarity with MidTRAM, and site conditions. Based on our experience, a trained crew of 2-3 people requires approximately 1-2 hours to complete the method once on site.

B. Experience and Qualifications Needed

MidTRAM should only be performed by individuals who have completed a training course on how to properly perform this method. Users of this method should have experience in the identification of tidal wetlands, an understanding of the various stressors that impact different wetland types, native flora of the region, and soil properties. For information on training opportunities contact one of the program contacts listed above.

FIELD PREPARATION

A. Landowner Permission

Permission should be obtained before accessing private property. Our experience is that if contact can be made with the landowner there is a high probability that they will allow access to their property. Georeferenced parcel data can be obtained through the state intranet for Delaware and landowner information can be found using the following websites:

Delaware Counties

Sussex County: **http://www.sussexcountyde.gov**

Kent County: **http://www.co.kent.de.us**

New Castle County**:** **http://www.nccde.org/defaulthome/home/webpage1.asp**

Maryland Counties

http://sdatcert3.resiusa.org/rp_rewrite/

Virginia Counties

http://www.dof.virginia.gov/gis/parcel-data.shtml

B. Field Map Production

Field maps should be produced before the initial site visit. They should include the outline of the 50m assessment area(AA), the outline of the 250m buffer area, NWI or state wetland boundaries, and roads including names if applicable. If an unusual feature exists in the AA or 250m buffer, review and print older maps to convey site history and disturbance considerations. Maps should illustrate the site at multiple levels and dates:

- Wetlands and hydrology (1:2,000)
- Wetlands and hydrology (1:24,000)
- Tax parcels (1:5,000)
- Road map (1:24,000)
- Soils (1:5,000)
- Old aerial photos as available dating back several decades (1:3,000)

C. **Equipment List**

Printed protocol	Plastic folding ruler
GPS	Compass
Printed Maps	Datasheets
Clipboard	Pencils
Guide to identifying tidal wetland plants	Sunscreen
Shovel	Slide Hammer & PVC
Two 100m Tapes	Vegetation Profile Board
Waders	YSI
Two 1.25m marked PVC veg height poles	Water
Camera	

CLASSIFICATION OF TIDAL WETLANDS

Because this assessment method is only appropriate for tidal wetlands, it is first important to determine whether a site is tidal or non-tidal. Tidal wetlands can then be further broken down into subclasses. See the key below to determine which subclass a wetland site belongs to.

Key to determining tidal wetland subclass in the Mid-Atlantic region (see Figure 1)

I. Is the wetland influenced by tidal cycles from a bay or ocean?
   A. No—site is non-tidal; please refer to the Delaware Rapid Assessment Protocol (DERAP) for assessment methods for non-tidal wetlands
   B. Yes—go to step II

II. Is the wetland bordered by ocean on at least one side?
   A. Yes—Marine Tidal
   B. No—go to step III

III. Is the wetland located on the estuary side of a barrier island?
   A. Yes—Back Barrier Estuarine Tidal
   B. No—go to step IV

IV. Is the wetland a narrow fringing marsh along the estuary, bay, or tidal river?
   A. Yes—Fringing Tidal
   B. No—Expansive Tidal

Figure 1. Examples of tidal wetland classification (L to R): tidal freshwater, fringing, expansive, and back barrier.

Table 1. Factors to consider when classifying fringing tidal and expansive tidal wetlands as tidal freshwater or brackish/saltwater.

	Tidal Fresh	Tidal Salt/Brackish
Salinity	≤2.0 ppt	> 2.0 ppt
Plant community	Dominated by tidal fresh plant species (see Table 2a)	Dominated by tidal salt/brackish species (see Table 2b)
Cowardin Maps	Palustrine wetlands with tidal modifiers (S, Q, R, T, V=freshwater tidal)	Estuarine wetlands
LLWW Maps	Palustrine wetlands with tidal waterbody type modifier ("5"=tidal) and tidal water flowpath modifier ("BT"=bidirectional-tidal)	Estuarine wetlands
Final subclass classification	**Expansive Palustrine Tidal** or **Fringing Palusrine Tidal**	**Expansive Estuarine Tidal** or **Fringing Estuarine Tidal**

Once a tidal wetland is classified as fringing tidal or expansive tidal, the next step is to determine whether the site is tidal freshwater (i.e. palustrine tidal) or brackish/saltwater (i.e. estuarine). **This determination can be made using best professional judgement by examining three factors (Table 1): salinity, dominant plant community (Tables 2a, b, c), and wetland maps. Once these factors are considered, wetlands can be classified as expansive palustrine tidal, fringing palustrine tidal, expansive estuarine tidal, or fringing estuarine tidal (Table 1).**

The first factor that should be considered is the salinity of the surface or creek water. For the purpose of this protocol, anything 2.0 ppt or below is considered tidal freshwater, and anything greater than 2.0 ppt is considered brackish/saltwater. This cutoff point was chosen using field data collected from tidal freshwater wetlands in Delaware, Pennsylvania, and New Jersey. These data showed that a salinity of 2.0 ppt was a breaking point, at or below which tidal freshwater plant communities dominated, and above which brackish/saltwater plant communities dominated. Surface water salinity, however, can be variable because of influences such as tides, droughts, or storm events. As such, other factors should be considered in combination with salinity to make the most accurate determination possible.

The second factor to consider is the dominant plant community in the wetland (Table 1). Many plant species are sensitive to salinity and only exist in lower salinity environments. Because you are only taking one reading, and salinity can be variable, plant communities are likely to provide a better idea of the salinity regime in an area. Below are lists of plants that are commonly found in tidal freshwater environments (Table 2a), brackish/saltwater environments (Table 2b), and plants that are more versatile and can exist in both tidal fresh and brackish/saltwater environments (Table 2c). Note that this is not an all-inclusive list, and that this list can be supplemented with a wetland plant field guide. If a combination of freshwater tidal and brackish/saltwater plants is present in a wetland, determine which community type is dominant (i.e. >50% cover). Note in particular the presence or absence of smooth cordgrass (*Spartina alterniflora*)*;* this plant tends to dominate brackish/saltwater wetlands, whereas it is absent from most tidal freshwater wetlands (although it can be present in tidal freshwater wetlands, it is not likely dominant).

The third factor to consider is how the site is classified on a wetland map. Take note to see if wetlands are mapped as freshwater (palustrine) or brackish/saltwater (estuarine) environments, and see if freshwater habitats have tidal modifiers (Table 1). It may also be useful to map the salt line (i.e. the boundary between freshwater and saltwater) if data are available to see what salinity regime the site is likely to have. Maps should only be used as a supplement to salinity readings and plant community observations in the field, however, as sometimes wetlands are incorrectly classified on wetland maps.

Table 2a. Common Mid-Atlantic plant species of tidal freshwater wetlands.

Common Plants of Tidal Freshwater Wetlands	
Common name	**Scientific name**
Swamp milkweed	*Asclepias incarnata*
Smooth beggartick	*Bidens laevis*
River bulrush	*Bolboschoenus fluviatilis*
Jewelweed	*Impatiens capensis*
Common rush	*Juncus effusus*
Rice cutgrass	*Leersia oryzoides*
Spatterdock	*Nuphar luteum*
Arrow arum	*Peltandra virginica*
Halberdleaf tearthumb	*Polygonum arifolium*
Dotted smartweed	*Polygonum punctatum*
Pickerelweed	*Pontederia cordata*
Broadleaf arrowhead	*Sagittaria latifolia*
Softstem bulrush	*Scirpus tabernaemontani*
Narrowleaf cattail	*Typha angustifolia*
Broadleaf cattail	*Typha latifolia*
Annual wild rice	*Zizania aquatica*

Table 2b. Common Mid-Atlantic plant species of brackish/saltwater wetlands.

Common Plants of Tidal Saltwater/Brackish Wetlands	
Common name	**Scientific name**
Triangle orache	*Atriplex prostrata*
Saltmarsh bulrush	*Bolboschoenus robustus*
Spikegrass	*Distichlis spicata*
Dwarf spike-rush	*Eleocharis parvula*
Marsh elder	*Iva frutescens*
Black grass	*Juncus gerardii*
Seashore mallow	*Kosteletzkya virginica*
Northern sea lavendar	*Limonium carolinianum*
Sweetscent	*Pluchea odorata*
Virginia glasswort	*Salicornia virginica*
Seaside goldenrod	*Solidago sempirvirens*
Smooth cordgrass	*Spartina alterniflora*
Salt meadow hay	*Spartina patens*

Table 2c. Common Mid-Atlantic plant species that can be found in tidal fresh, brackish, and saltwater wetlands.

Common Plants of Tidal Fresh, Brackish, and Saltwater Wetlands	
Common name	**Scientific name**
Water hemp	*Amaranthus cannabinus*
Sea myrtle	*Baccharis halimifolia*
Rose mallow	*Hibiscus moscheutos*
Switchgrass	*Panicum virgatum*
Common reed	*Phragmites australis*
Big cordgrass	*Spartina cynosuroides*

ESTABLISHING THE ASSESSMENT AREA

The Assessment Area (AA) is the area within a tidal wetland that will be sampled using MidTRAM. Data collection will be performed in the AA or in the adjacent buffer to the AA. The center point of the AA is either randomly located when using a probabilistic sampling design or can be subjectively selected based on the goals of the assessment.

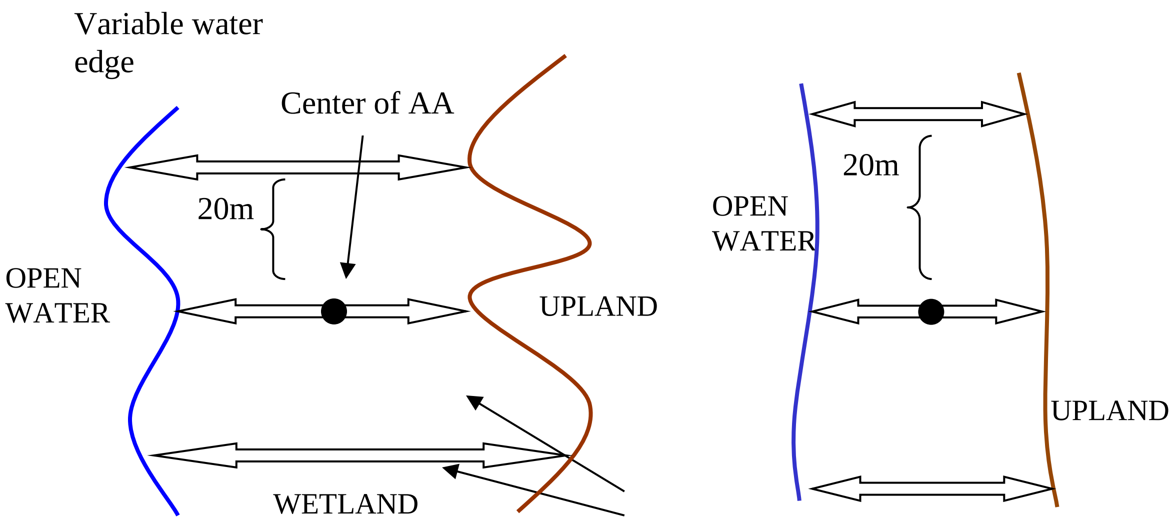
- Establish the center of the AA by marking a map, creating a point on the GPS and writing the coordinates on the datasheet.
- Establish the AA as a 50-m radius circle centered on the sample point (0.8ha=8,000m² area). Using two 100m tapes, run one transect perpendicular from the open water edge to the upland edge, and locate the 2nd transect perpendicular to the first. Walk the tapes out from the center with the tapes on the right side. Look ahead to an approximate destination and try not to trample the wetland surface on the right. Walk back to the center point keeping the tapes on the left.

Helpful tips: Walk away from center with tapes on the right, walk towards center with tapes on the left. This will prevent walking through and trampling areas that will become the AA subplots. Leave the tape reel in the direction you will exit the wetland to save walking time and energy.

A. Moving or adjusting the location and/or dimensions of the AA

Several situations may occur that would require that the AA to be positioned differently than above. The following circumstances are for adjustments during a probabilistic survey site. **If the location of the AA is moved or adjusted, be sure to make detailed notes on the datasheet explaining why the AA was moved, by how far, in what direction, and record the new lat/long.**

1. If the wetland does not extend 50m in all directions without touching upland or if >10% of the AA would include a natural open water feature (water >30m wide):
   - Move the center point *the least necessary distance* <50m until the entire AA is within the wetland boundaries.
   - If >50m is needed the site should be rejected for a probabilistic survey.
   - If moving the AA away from upland or open water on one side results in a conflict on the other side see item 4 below.
2. If the AA is within or contains a naturally occurring upland inclusion in the wetland:
   - If the upland inclusion is due to a disturbance (e.g. a pile of fill) do not move the center of the AA because you want to include the disturbance in the assessment.
   - If the original point is determined to be natural upland, examine the entire 50m radius circle around the original point for a wetland.
     - If a wetland is found within this area, move the center point *the least distance necessary* <50m to establish an AA entirely in the wetland.
     - If no wetland is found within the bounds of the original AA, the site should be dropped and recorded as upland for a probabilistic survey.
3. If the wetland is ≤ 0.8ha (8,000m^2):
   - The AA becomes the same size as the wetland. Detail this carefully in the site sketch.
4. If the wetland is ≥0.8ha, but is oddly shaped and 50m radius will not fit without touching upland or without covering >10% natural open water (800m^2; Figure 2):
   - Configure the AA as a 0.8ha rectangle positioned long ways across the wetland with the width being from the edge of the open water to the upland. Find the average wetland width by measuring 3 transects, at least 20m apart, perpendicular from the open water to the upland. This average will be the width of the AA. Use the calculated average width to determine the length of your rectangle to equal 0.8ha.
   - Rectangle should be no longer than 150m long due to habitat variability and may be curved to fit along upland and open water edges. Note the new dimensions and shape of the AA on the datasheet.



Left: ∑ 3 transects/3=60; ~8000m²/60m wide =133.3m long
Right: ∑ 3 transects/3=75; ~8000m²/75m wide =106.6m long

Figure 2. Illustration of how to determine the dimensions of a rectangular AA. Use the average distance between the channel edge and upland as determined from the 3transects to calculate length and achieve a 0.8 ha rectangle.

B. Locating subplots within the AA

Subplots will all be located within the 0.8ha assessment area to assess vegetation structure and bearing capacity.

1. Circle plot (Figure 3)
   - Eight 1m^2 subplots will be placed along two 100m transects, dissecting the AA perpendicularly.
   - Subplots should be placed 25m and 50m from the center of the AA along each transect.
   - Subplots should be located in a dominant vegetation type of the AA (makes up ≥10% cover in the AA). If the given plot is *not* representative of a dominant vegetation type (< 10% cover in the AA; e.g., on a small mud flat or in a ditch), move the sub-plot 1 meter along the transect and note the new location.
2. Rectangle plot (Figure 4)
   - Eight 1m^2 subplots will be placed along three transects within the AA, within a dominant vegetation type (covering ≥10% of AA).
   - Divide the AA in half length-wise, and into thirds width-wise.
   - Spread the 8 subplots out along the transects depending on the size of the rectangular AA, with 6 subplots along the outside edges and 2 subplots where the transects cross.
   - If the given plot is *not* representative of a dominant vegetation type (< 10% cover in the AA; e.g., on a small mud flat or in a ditch), move the subplot 1 meter along the transect and note the new location.

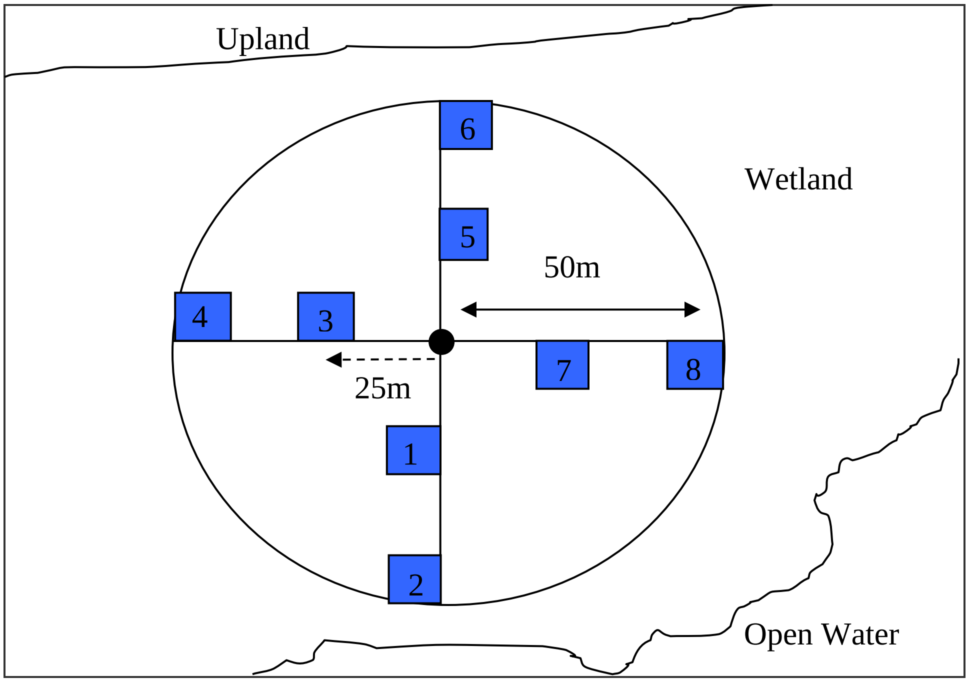


Figure 3: Location of Subplots in a circular assessment area.

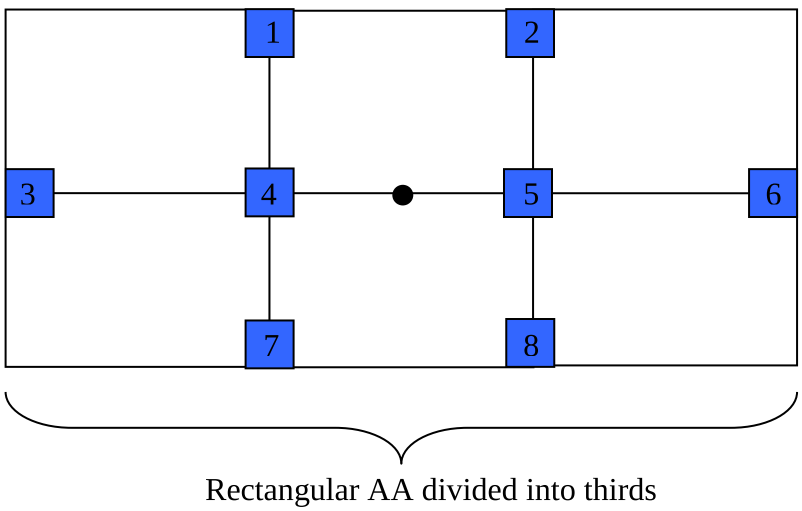


Figure 4. Location of Subplots in a rectangular assessment area.

METRIC DEFINITIONS

Table 3. Overview of metrics in the buffer/landscape, hydrology, and habitat attribute categories.

Attribute	***Metric***	***Description***
Buffer 1	Percent of AA Perimeter with 10m-Buffer	Percent of AA perimeter that has at least 5m of natural or semi-natural condition land cover that is at least 10m in width
Buffer 2	Natural Land Use in Buffer	Percent of the buffer area that is contiguous between the AA and 250m buffer edge and in a natural or semi-natural state
Buffer 3	Altered and High Impact Land Use	Percent of the buffer area that is an altered or high impact land use
Buffer 4	250m Landscape Condition	Landscape condition within 250m surrounding the AA center point based on the nativeness of vegetation, disturbance to substrate and extent of human visitation
Buffer 5	Barriers to Landward Migration	Percent of landward perimeter of wetland within 250m that has physical barriers preventing wetland migration inland
Hydrology 1	Ditching and Excavation (a) **or** Point Sources (b)	The presence of excavated ditches or OMWM pools in the AA for tidal saltwater sites (a), **or** The presence of point source inputs in tidal freshwater sites (b)
Hydrology 2	Fill	The presence of fill or wetland fragmentation from anthropogenic sources in the AA
Hydrology 3	Diking and Tidal Restriction	The presence of dikes or other tidal flow restrictions
Habitat 1	Bearing Capacity	Soil resistance measured using a slide hammer and veg height poles
Habitat 2	Horizontal Vegetative Obstruction	Visual horizontal obstruction by vegetation at 0.25-1.25m heights measured in 0.25 intervals with a cover board
Habitat 3	Number of Plant Layers	The presence of up to 5 distinct vertical plant zones
Habitat 4	Species Richness	Count of plant species found in the AA
Habitat 5	Percent Invasive Cover	Percent cover of invasive species in the AA

DATA COLLECTION – CHARACTERIZATION METRICS

SITE INFORMATION DATASHEET

Site #
Unique number for the site

Site Name
Select a unique name for the site

Date and Time
Month, day, year, and hour and minutes of start and finish of sampling

Field Crew
All names of the members of the field crew

Reference or Assessment Site
Circle which applies. Reference sites are subjectively selected to provide baseline condition values for a particular geographic area or watershed and are selected to represent the highest and lowest condition for comparison prior to assessing randomly selected sites. Assessment sites can be project related or are randomly selected using a probabilistic sampling design for a watershed study.

Marine Tidal, Back Barrier Estuarine Tidal, Fringing Estuarine Tidal, Expansive Estuarine Tidal, Fringing Palustrine Tidal, Expansive Palustrine Tidal
Based on wetland shape and location – see pages 4-7 for guidance and examples.

Natural, Re-Establishment, Establishment, Rehabilitation, Enhancement
Select appropriate classification based on the below definitions.

Natural- wetland that is un-manipulated

Re-establishment- the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland. Example: re-establishing a previously farmed wetland.

Establishment- the manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist on an upland or deepwater site.

Restoration- the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing a degraded wetland to natural condition and historic functions.

Enhancement- the manipulation of the physical, chemical, biological characteristics of a wetland site to heighten, intensify, or improve specific function(s) or for a purpose such as water quality improvement, flood water retention or wildlife habitat. Example: Water control structure impoundments for migratory waterfowl habitat.

Watershed/Sub-Watershed
Watershed and sub-watershed in which the site is located.

Lat/Long
Latitude and longitude coordinates in digital degrees.

AA Moved From Original Location?

The AA should only be shifted the minimum necessary distance from the original point in order to be able to assess the AA. See page 5 for more descriptions. Circle 'yes' or 'no' to indicate if the center of the AA was moved from its original location. If the center was moved, record the reason and the distance that the AA was moved. This only applies to assessment sites that are based on a randomly located point.

Tidal Stage
Tidal stage that best represents the AA during the site visit. Estimate tidal stage based on wrack lines and water marks.

high= 5, mid-high= 4, mean= 3, mid-low= 2, and low= 1

Photos
The photos should be taken from the center point out each transect. Also document prominent stressors. Record the photo id number, time, and relevant comments.

Assessment Area Sketch
Sketch the AA and surrounding area. Include the assessment area, transect orientation, subplots, direction to open water, major habitat features, adjacent land types and note stressors and approximate distances.

Low Marsh/High Marsh
Indicate if the AA in a saltwater/brackish wetland is dominated by low marsh plants (e.g. *Spartina alterniflora,*) or high marsh species (e.g. *Spartina patens, Iva frutescens, Baccharis halmifolia*, *Juncus gerardii*, *Distichlis spicata*)

or

Indicate if the AA in a tidal freshwater wetland is dominated by low marsh plant species (e.g. *Nuphar luteum, Pontedaria cordata*) or high marsh species (e.g. *Impatiens capensis, Typha spp., Hibiscus moscheutos, Polygonum arifolium, Leersia oryzoides*)

**Note that marsh zonation tends to be much less distinct in freshwater tidal marshes compared with salt marshes. Many plant species tend to occur in both high marsh and low marsh zones (e.g. *Peltandra virginica, Spartina cynosuroides, Zizania aquatica*). Make a note on the datasheet if low/high marsh cannot be distinguished at a particular tidal freshwater site and describe the plant species distribution in your site sketch.

Distance to Upland
Estimate the distance from the edge of the AA to the closest major upland body (not an island).

Distance to Open Water
Estimate the distance from the edge of the AA to the closest source of open water (>30m wide).

Stability of Assessment Area
Estimate the current physical stability of the wetland within the AA based on the below descriptions.

Healthy & stable- wetland surface is mostly covered by vegetation mats, and vegetation is healthy (green and robust).

Beginning to deteriorate and/or some fragmentation- wetland surface is moderately covered by vegetation root mats with moderate amounts (~25%) unvegetated

unconsolidated muck or open water. Vegetation is showing some signs of stress as indicated by yellowing tips of the vegetation or stunted plants.
Severe deterioration and/or severe fragmentation- wetland surface covered by sparse vegetation root mats with large areas of unvegetated unconsolidated muck or open water. Vegetation is severely stressed as indicated by yellowing or browning of leaves and stems, severely stunted plants, or early senescence of plants in the growing season.

Soil Profile
Extract a soil sample with shovel from the center point area at least 18cm deep. Examine the core and determine the depth of the organic layer using the folding tape measure. Note if organic layer appears to be shallow (<16cm deep) or deep (>16cm deep).

Salinity
Salinity in parts per thousand (ppt) of the surface or creek water using a YSI or other digital water quality instrument. Digital meters are preferred over refractometers because refractometers are generally not as accurate at very low salinities.

Vegetation Communities and Features
After completing the subplot measurements and walking the AA, estimate the percent cover of plant communities and wetland features present in the AA. Use the cover class and midpoint table for assistance. The values will not add up to 100% but should roughly describe the features in the AA. Common species/features are listed; if a vegetation type or wetland feature is present that is not listed, use the "other" box and write in a description of the type/feature. If a vegetation type or feature is not present record a "0". These responses will help guide the plant layer worksheet in the Habitat group for future revisions. The amount of root mat can be affected by deep ditches, hummocks, or mucky ponds. Dead vegetation (e.g. sprayed Phragmites) can be accounted for in 'unhealthy marsh'.

Qualitative Disturbance Rating: To be agreed upon by the entire field crew once the assessment is complete. Through observation of stressors and alterations to the vegetation, soils, and hydrology in the wetland site, and the land use surrounding the site (Table 3), the field crew determines the overall level of disturbance. Observers should use best professional judgment (BPJ) to assign the site a numerical Qualitative Disturbance Rating (QDR) from least disturbed (1) to highly disturbed (6) relative to other sites in the watershed. General description of the minimal disturbance, moderate disturbance, and high disturbance categories are provided below.

Minimal Disturbance Category (QDR 1 or 2): Natural structure and biotic community maintained with only minimal alterations. Minimal disturbance sites have a characteristic native vegetative community unmodified water flow into and out of the site, undisturbed microtopographic relief, and are located in a landscape of natural vegetation (250m buffer). Examples of minimal alterations include a small ditch that is not conveying water, low occurrence of non-native species, individual tree harvesting, and small areas of altered habitat in the surrounding landscape, which does not include hardened surfaces along the wetland/upland interface. Use BPJ to assign a QDR of 1 or 2.

Moderate Disturbance Category (QDR 3 or 4): Moderate changes in structure and/or the biotic community. Moderate disturbance sites maintain some components of minimal disturbance sites such as unaltered hydrology, undisturbed soils and microtopography, intact landscape, or characteristic native biotic community despite some structural or biotic alterations. Alterations in moderate disturbance sites may include one or two of the following: a large ditch or a dam either increasing or decreasing flooding, mowing, grazing, moderate stream channelization, moderate presence of invasives, forest harvesting, high impact landuses in the buffer, and minimal hardened surfaces along the wetland/upland interface. Use BPJ to assign a QDR of 3 or 4.

High Disturbance Category (QDR 5 or 6): Severe changes in structure and/or the biotic community. High disturbance sites have severe alterations to the vegetative community, hydrology, and/or soils. This can be a result of one or several severe alterations, or more than two moderate alterations. These disturbances lead to a decline in the wetland's ability to effectively function in the landscape. Examples of severe alterations include extensive ditching or stream channelization, recent clear cutting or conversion to a non-native vegetative community, hardened surfaces along the wetland/upland interfaces for most of the site, and roads, excessive fill, excavation, or farming in the wetland. Use PBJ to assign a QDR of 5 or 6.

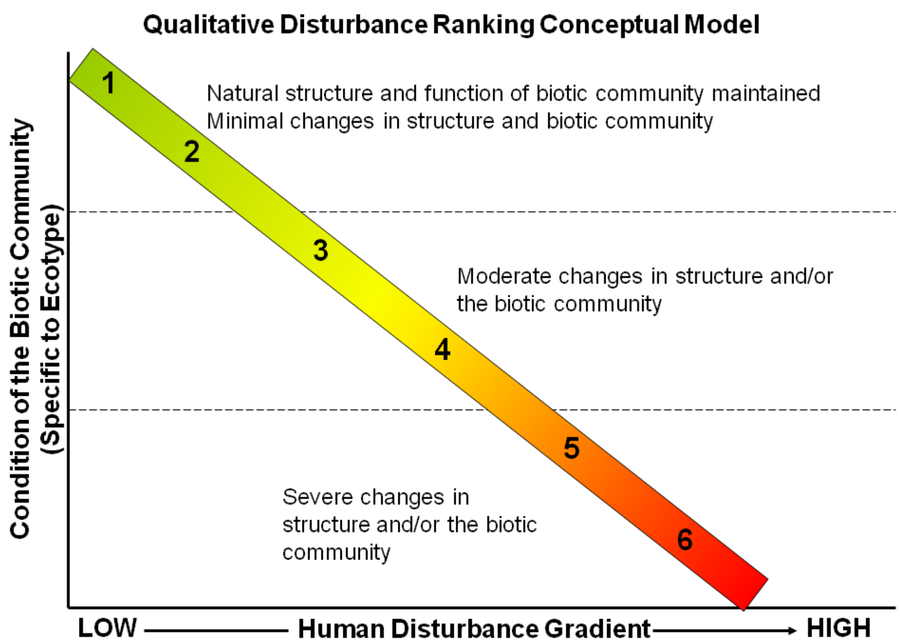


Figure 5. Diagram of narrative criteria for qualitative ranking of disturbance.

Comments
Information that would otherwise be undocumented, such as notations about observed wildlife or local features

DATA COLLECTION - CONDITION METRICS

Attribute 1: Buffer/Landscape

The area surrounding a wetland is a critical transition zone that is important to the overall health and continued existence of a wetland. The surrounding landscape can control runoff and improve water quality by processing pollutants from upland areas before it enters the wetland. The surrounding landscape will also determine if a wetland has the ability to migrate inland with increasing sea-levels. Wetland buffers can provide protection from adjacent anthropogenic stressors (e.g. development), protect against outside human activities (e.g. farming), and can serve as habitat corridors for movement and recolonization of plants and wildlife.

Five metrics are used to characterize and rate the buffer and surrounding landscape of the assessment area:

1. Percent of assessment area perimeter with a 10m buffer in a natural or semi-natural state
2. Natural land uses surrounding the AA
3. Altered and high impact land uses surrounding the AA
4. Landscape condition surrounding the AA
5. Barriers to landward migration

The following definitions should be used when evaluating metrics in the Buffer/ Landscape Attribute:

Buffer – The buffer is the area adjoining the AA that is in a natural or semi-natural state and is not currently dedicated to anthropogenic uses. To be considered as buffer, a suitable land cover type as defined in Table 4 must be at least 10m wide and extend along the perimeter of the AA for at least 5 m. The buffer width is evaluated out to 250m from the edge of the AA.

Landscape – The surrounding landscape is defined as matrix of land in a natural or semi-natural condition as well as those dedicated to anthropogenic uses within 250m from the edge of the AA.

B1. Percent of Assessment Area Perimeter with 10m Buffer

Metric Source: California Rapid Assessment Method (CRAM), modified
Extent: 10m band around AA edge (3,456 m^2)
Definition: The buffer is the area adjoining the AA that is in a natural or semi-natural state and is not currently dedicated to anthropogenic uses. To be considered as buffer, a suitable land cover type as defined below and must be at least 10m wide and extend along the perimeter of the AA for at least 5m.

Assessment Protocol: Using aerial photos or GIS evaluate the land use within 10m of the edge of the AA and determine the percent of the AA perimeter that has a buffer meeting the following criteria:

- Adjacent to the AA
- Natural or semi-natural land use (see Table 4 for examples)
- Is present for at least 5m along the edge of AA

- Not Open Water- open water ≥ 30m wide that is in or adjacent to the AA (e.g. lake, bay, large river, or large slough) is considered to be neutral- neither part of the wetland nor part of the buffer, because although water is natural and undeveloped it can also be a source of stress (e.g. destructive wave energy, erosion).

Follow guidelines below:

- Draw a perimeter around the AA 10m wide.
- Exclude open water from the equation as neither buffer nor non-buffer.
- Consider the rest of the perimeter to be 100%.
- Determine the proportion of the perimeter that is buffer versus non-buffer perimeter. Refer to Table 4 for examples.
- Record the estimated percent and circle the correct score based on the alternative states listed.

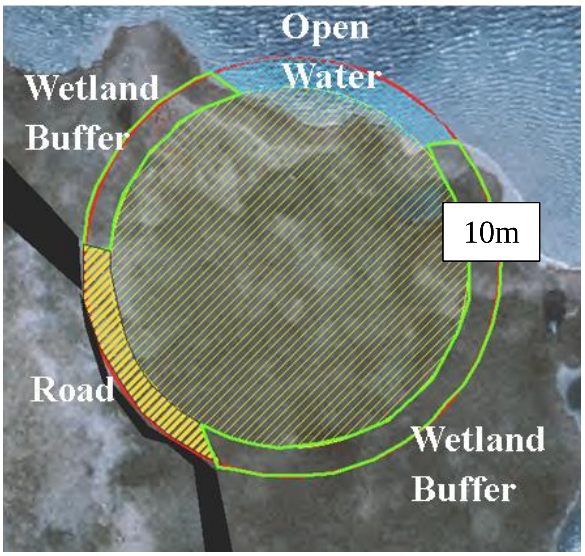


Figure 6: Examples of determining % of AA with 10m buffer. In both examples above, a portion of the perimeter is open water and is not counted. Of the remaining perimeter, 70% is natural wetland buffer, 30% is non-buffer (road or developed).

Table 4: Guidelines for identifying wetland buffers and breaks in buffers.

Examples of Land Covers *Included* in Buffers	**Examples of Land Covers *Excluded* from Buffers** Notes: buffers do not cross these land covers	
bike trails	commercial developments	residential areas
foot trails	fences that interfere with the movement of wildlife	sports fields
horse trails	agriculture	golf courses
natural upland habitats	roads	urbanized parks with active recreation
nature or wildland parks	lawns	pedestrian/bike trails with nearly constant traffic
Raised dock or walkway	parking lots	impoundments or berms

B1 Scoring: Percent of Assessment Area Perimeter with 10m-Buffer

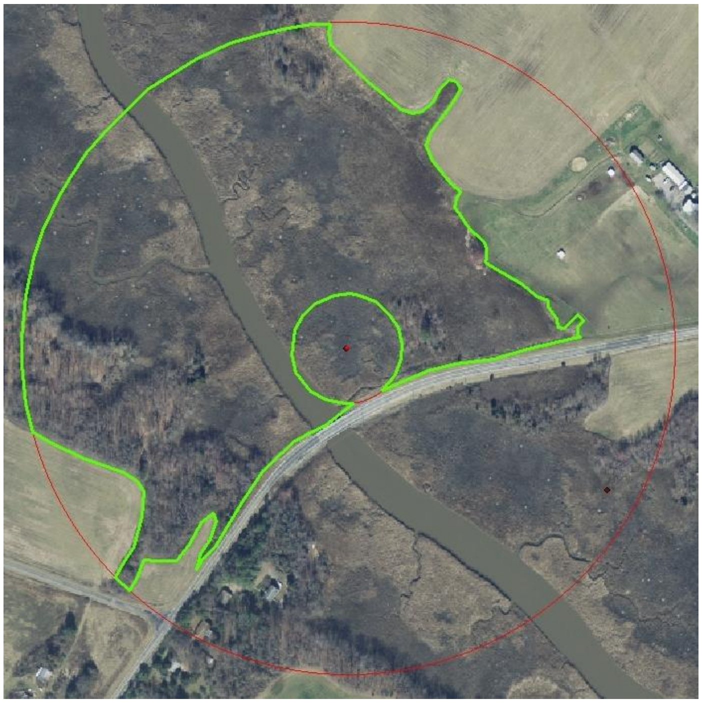
Record Raw Percent ______________%	
Alternative States (not including open-water areas)	**Rating (circle one)**
Buffer is 100% of AA perimeter.	**12**
Buffer is 94-99.9% of AA perimeter.	**9**
Buffer is 80-93.9% of AA perimeter.	**6**
Buffer is <80% of AA perimeter.	**3**

B2. Natural Land Uses in Buffer

Metric Source: DNREC/PDE
Extent: 250m buffer (274,889m²)
Definition: This metric assesses the percent of the buffer area that is contiguous between the AA and 250m buffer edge and in a natural or semi-natural state (see Table 1). Desktop determinations should be confirmed in the field to detect recent disturbances, depending on the age of aerial imagery used.

Assessment Protocol:

1. Use the results of B1 and an aerial image of the AA and 250m buffer to determine the areas considered to be buffer. Be sure to exclude open water (≥ 30m wide) and non-buffer habitat.
2. Use the 'draw polygon' tool in ArcMap to create a polygon that includes any adjacent habitat in natural land use. Do not include the AA in your buffer polygon (if the AA falls in your created polygon, subtract 7,854m² from your polygon area). Multiple polygons are not permitted. Non-buffer features should not be crossed.
3. Right click on the polygon to determine the area (m²). Divide that area by total buffer area (274,889m²).
4. Assign a metric score based on the percent buffer area.



Example 1. The natural buffer area extends out to the edge of the ag. field and to the road/bridge. Area inside the green perimeter equals 130,857m² which represents 48% and would be awarded a score of 3.

Example 2. The natural buffer area extends out to the edge of the ag. field, to the river's edge where the distance across is ≥ 30m and across the river to the field edge where the river is < 30m across. The area inside the green perimeter equals 87,505m² which represents 32% and would be awarded a score of 3.

Example 3. The natural buffer area extends out to the edge of the ag field and around to the access road to the field. This polygon contained the AA so 7,854m² would be deleted from the total area. The area inside the green perimeter equals 237,606m² which represents 86% and would be awarded a score of 9.

B2 Scoring: Natural Land Uses in Buffer

Alternative States	Rating (circle one)
100%	**12**
75-99.9%	**9**
55-74.9%	**6**
≤ 54.9%	**3**

B3. Altered and High Impact Land Use between AA Edge and 250m

Metric Source: Delaware Comprehensive Assessment Protocol (DECAP) modified
Extent: 250m buffer (274,889m²)
Definition: Percent of the buffer area in altered or high impact land use
Assessment Protocol: Evaluate the surrounding land from the edge of the AA out to 250m. Use GIS analysis and Table 5 below to find any altered and high impact land uses and calculate the percent of area in each. All high impact land uses are considered altered land uses.

1. Use aerial photo of sites with AA and a 250m buffer from the edge of the AA.
2. Estimate the percent of developed area within 250m of the edge of the AA.
3. Confirm field estimates in office with ArcGIS and the latest land use Land Cover data available.

Table 5. Guidelines for determining altered and high impact land uses.

Examples of Altered Land Uses	**Examples of High Impact Land Uses**	
Cropland	Residential	Industrial/ Commercial
Fallow Fields	Golf Course	Utilities
Orchards/ Pine Plantation	Park	Railroad
Rangeland	Roads/ Parking Lots	Transitional Lands

B3: Scoring: Land Use Impacts

Area in Altered ________% Area in High Impact _________ %	
Alternative States	**Rating (circle one)**
No Altered or High Impact Land Uses	**12**
0-20% Altered Land Use *and* <5% High Impact Land Use	**9**
20-50% Altered Land Use *and/or* 5-20% High Impact Land Use	**6**
>50% Altered Land Use *or* >20% High Impact Land Use	**3**

B4. 250m Landscape Condition

Metric Source: California Rapid Assessment Method (CRAM), modified
Extent: 250m buffer
Definition: The presence and severity of alterations to the surrounding landscape based on the extent and nativeness of the plant community, disturbance to soil substrate, presence of point source pollution, and human visitation.

Assessment Protocol: Evaluate the landscape condition within 250m of the edge of the AA using aerial photos and field observations. Use professional judgement to assign a metric score.

B4 Scoring: 250m Landscape Condition

Alternative States	Rating (circle one)
AA's surrounding landscape is comprised of *only* native vegetation, has undisturbed soils, no point source discharges, and there is no evidence of human disturbance.	**12**
AA's surrounding landscape is dominated by native vegetation, has undisturbed soils, receives water from a stormwater pond drain, and there is little or no evidence of human visitation.	**9**
AA's surrounding landscape is characterized by an intermediate mix of native and non-native vegetation, and/or a moderate degree of soil disturbance/compaction, and/or receives water from one or more agricultural field ditch(es), and/or there is evidence of moderate human visitation.	**6**
AA's surrounding landscape is characterized by barren ground and/or dominated by invasive species, and/or highly compacted or otherwise disturbed soils, and/or receives discharge directly from a polluted source, and/or there is evidence of intensive human visitation.	**3**

B5. Barriers to Landward Migration

Metric Source: New England Rapid Assessment Method (NERAM)
Extent: 250m Buffer
Definition: Barriers to landward migration (BLM) are physical barriers along the shoreline that would prevent the wetland from migrating inland with rising sea levels. Barriers can include hardened surfaces on the landward perimeter of the wetland such as sea walls, rip rap, debris or rock stabilization, a road or driveway that would be maintained, or other development within 50m of wetland/ upland edge.

Assessment Protocol: Determine the proportion of wetland/upland shoreline within the 250m buffer that is obstructed from future marsh migration in the event of sea level rise.

1. Determine the nearest source of open water.
2. On a map, originating on the open water source side of the AA, draw a 90º wedge directed landward to the limit of the 250 buffer (see examples below) to identify the evaluation area. The wetland/upland shoreline or the 250m buffer line within the pie wedge is the perimeter to evaluate, whichever is encountered first. Do not include islands in this calculation. Draw this perimeter line on the map. (Drawing the pie and perimeter lines allow for verification and Quality Assurance checks.)
3. Visually estimate the percentage of that perimeter that is obstructed by a barrier to marsh landward migration. Use aerial photography to estimate barriers and use field visits for confirmation. Perimeter that is not hardened or maintained and would allow for marsh migration in the future is considered unobstructed. If there is a barrier present in the upland (e.g. yard, berm, raised road) but there are >50m of unobstructed land (e.g. forest, scrub shrub, ag field) between the upland edge and the barrier, do not include as a barrier. If the wetland/upland edge is >250m from the edge of the AA (the entire 250m buffer is marsh), record no barriers present and estimate the nearest distance to a barrier from the <u>center</u> of the AA.

Example 1. An example of BLM scoring. The black center point is surrounded by the red AA and yellow 250m buffer. The green arrows point landward to create the 'pie' area to be evaluated. The pink dashed line follows the wetland/upland perimeter along forest and is unobstructed. A small portion of the 250m perimeter is included in this perimeter. 0% of the landward perimeter is obstructed.

Example 2. An example of BLM scoring. The green arrows create the 'pie' of area to be evaluated. The blue dashed line follows wetland/upland perimeter that is obstructed by development. The pink dashed line follows wetland/upland perimeter along forest and is unobstructed. A small portion of perimeter line runs along the 250m buffer boundary and is not obstructed. A measurement verified that nearby houses on the left are >50m from the perimeter line and do not count as obstructed. About 45% of the perimeter is obstructed.

Example 3. An example of BLM for a rectangular AA. The black center point is surrounded by the red AA and yellow 250m buffer. The green arrows point landward to create the 'pie' area to be evaluated. The pink dashed line follows the wetland/upland perimeter along forest >50m wide and is unobstructed. The blue dashed line follows the wetland/upland perimeter that is obstructed by either adjacent. In this example, 60% of the perimeter is obstructed by road or yard.

Scoring: Barriers to Landward Migration

% Perimeter Obstructed ____________%	**Estimated distance from center of AA ________m**
Alternative States	**Rating (circle one)**
Absent: no barriers, 0%	**12**
Low: <10% of perimeter obstructed	**9**
Moderate: 10-25% of perimeter obstructed	**6**
High: >25% of perimeter obstructed	**3**

Attribute 2: Hydrology

Hydrology is the driving force that maintains the unique characteristics of wetlands, including hydrophytic vegetation and hydric soils, which differentiate wetlands from uplands. Hydrology is integral to supporting numerous functions which define the wetland's plant and animal composition and richness, physical borders, and nutrient cycling.

The hydrology attribute is composed of four metrics. Ditching & Excavation or Point Sources, Fill, and Wetland Diking/Tidal Restrictions. Ditching is measured within the 50m assessment area; Wetland Diking/Tidal Restriction and Point Sources are measured in the AA and the surrounding 250m buffer.

H1a. Ditching & Excavation (OMWM)--*for saltwater/brackish sites only* **Metric Under Development

Metric Source: New England Rapid Assessment Method (NERAM; modified)
Extent: 50m AA (7,854m²)
Definition: The extent of ditches and artificial excavation (such as open marsh water management, or OMWM) within the AA. Ditches increase or decrease the residency of water in the AA. This metric does not include natural ponds or interior marsh opening.

Assessment Protocol: Evaluation of this variable is performed using recent aerial photographs of the site and a field visit to verify the presence and functionality of ditches. Three width measurements should be taken per ditch in the field; ditch width is difficult to measure using GIS because of variable overhanging vegetation on ditch banks. Length is less variable on aerial imagery, so a length measurement can be taken either in the field or using GIS. Examples below should be used as a reference for scoring.

1. Use an aerial photo of the site that is zoomed to the extent of the AA. Identify ditches within the AA, noting the number and size of ditches.
2. Confirm presence and functionality of ditches in the field during the site visit. Then, take 3 evenly-spaced width measurements along each ditch in the field to calculate average width for each ditch. Record these values on Page 4 of the datasheet.
3. Take one length measurement of each ditch either in the field or using GIS, and record on Page 4 of the datasheet.
4. Calculate ditch area for each ditch using length and average width. If there are multiple ditches in the AA, sum the areas of the ditches to get a total area of AA that is ditched.
5. Calculate the percent of the AA that is ditched by dividing the total area ditched by the area of the AA (7,854m²).

Examples: Refer to the 4 examples below for depictions of various degrees of ditching & excavation.

Example 1: Natural stream channels, no ditching or excavation. Score: 12

Example 2: Single ditch running through AA. 123.2 m²: 1.6% of AA is ditched: Score: 9

Example 3: Multiple narrow ditches throughout AA. 312.9 m²: 3.9% of AA is ditched: Score: 6

Example 4: Multiple ditches and created interior OMWM ponds. 808.5 m²: 10.3% of AA: Score: 3

Scoring: Ditching & Excavation

Alternative States	Rating (circle one)
No Ditching or Excavating	**12**
0-2.5%	**9**
2.6-5%	**6**
> 5%	**3**

H1b. Point Sources--*for freshwater tidal sites only*

Metric Source: New England Rapid Assessment Method (NERAM), modified

Definition: The presence of localized sources of pollution that are entering the wetland through a confined pathway (i.e. pipe, culvert, or ditch). Point sources can contribute significant amounts of polluted waters from adjacent land practices.

Assessment Protocol: Evaluate the AA and 250m buffer using aerial photography for point sources such as outfalls and drains entering the AA or 250m buffer. Field validate to confirm sources. Determine if the source of the input is from a ‘developed’ or ‘natural’ land use. Examples of inputs from a natural land use include those from a forest or through a fallow field. Inputs from developed land are those from lands that are dedicated to anthropogenic uses, such as urban, suburban, or industrial buildings, agriculture, lawns, yards, and golf courses. Man-made water bodies that drain from developed land (e.g. a storm water retention pond) and exit into a wetland should be considered as a developed source.

Scoring: Point Sources

Alternative States	Rating
Absent: No Discharge	**12**
Low: 1 small discharge from a natural area	**9**
Moderate: 1 discharge from a developed area or 2 discharges from a natural area	**6**
High: $\geq$ 2 discharges from a developed area or $\geq$ 3 from a natural area	**3**

H2. Fill

Metric Source: New England Rapid Assessment Method (NERAM; modified)
Extent: 50m AA (7,854m^2)
Definition: To measure the presence and extent of fill within the AA that could be affecting the natural hydrology and plant community of the wetland.

Assessment Protocol:
Evaluation of this variable is performed using recent aerial photographs of the site and then a field visit to verify the presence of fill affecting hydrology in the AA.

1. Use an aerial photo of the site that is zoomed to the extent of the AA (1:2000) to identify possible sources of fill (e.g. row of small hummocks along a grid ditch)
2. Validate observations in the field by walking the entire AA and recording the presence of fill in the AA
3. Estimate and record the dimensions (length x width) of the surface area that fill is covering (e.g. 10 piles, each 1m x 3m)
4. Determine appropriate score for site based on percent of AA that contains fill.

Scoring: Fill and Fragmentation

Estimate amount of fill ____________% of AA		Comments
Dimensions of Fill Pile ___________________		
Alternative States	**Rating (circle one)**	
0%, No Fill	**12**	
>0 - <5%	**9**	
≥5% - <10%	**6**	
≥10%	**3**	

H3. Wetland Diking/ Tidal Restriction

Metric Source: New England Rapid Assessment Method (NERAM)
Extent: 250m buffer
Definition: The presence of wetland diking and/or other tidal restrictions that interfere with the natural hydrology of the wetland. Knowledge of local tide regimes is critical in determining the severity of tidal restrictions.

Assessment Protocol: Observe the AA and the surrounding 250m for sources of restrictions. Look for wrack lines and water lines near structures as a sign that they cause restrictions. If a significant restriction is detected outside of the 250m buffer, it may also be scored down if it is known to cause restriction at the sampling location. Note the distance and provide a description. Examples of diking and tidal restriction:

- Under-sized culverts or bridge crossings
- Roads
- Man-made berms and dikes

Example 1. The scouring on the west side of the bridge and the size difference of the width of the river on each side of the bridge is evidence that this is an undersized bridge, and is therefore a tidal restriction. This site would score a 3.

Example 2. This is an example of a wetland with a dike surrounding it. If a point was found in this wetland it would score a 6.

Scoring: Diking and Restriction

Description of restriction: ______	
Alternative States	**Rating (circle one)**
no restrictions	**12**
Elevated path	**9**
dike, levee, bridge or berm	**6**
Undersized culvert or bridge	**3**

Attribute 3: Habitat

Wetlands provide habitat for a diverse array of plants and animals ranging from large mammals to invertebrates in the soil. These species are dependent on the availability of resources provided by the wetland, including vegetative structure and standing water. Additionally, the wildlife communities that are supported provide valuable social and economic benefits to society through hunting and non-consumptive activities (e.g. bird watching).

The habitat attribute is composed of five metrics: bearing capacity, horizontal vegetative obstruction, number of plant layers, plant species richness, and percent invasive cover. These metrics characterize the biotic and abiotic shelter and structure components of the wetland. All measurements for habitat are taken within the assessment area only.

HAB1. Bearing Capacity

Metric Source: New England Rapid Assessment Method (NERAM)

Extent: Measured at subplots 1-8 within the 50m AA

Definition: Bearing capacity is the ability of soil to support the loads applied to the ground, as measured by the penetration of a capped 2" PVC tube into the wetland soil surface by applying a standard force with a slide hammer. Bearing capacity assesses the below-ground stability of the wetland with the assumption that as a wetland deteriorates due to natural and anthropogenic influences, below-ground organic material and the soil bearing capacity will also decrease. Thus, the more the PVC tube penetrates the marsh surface after slide hammer blows, the lower the below-ground marsh stability is. Reduced below-ground organic material may precede above-ground changes in the plant community and other indicators of stress. Water depth is measured at each sub-plot to characterize the site, but is not used in any bearing capacity calculations.

****Note that the procedure is the same but the scoring is different for salt/brackish and tidal freshwater wetlands for this metric.**

Assessment Protocol: The base of the instrument is a 2-inch capped PVC tube with a centimeter scale marked on its side. The PVC pipe is one meter long and has a flat cap on the bottom. The slide hammer is placed on top; it weighs 7.4 pounds and is attached to a PVC ring with a 5/8th inch bolt. The percent cover of hummocks and hollows in the AA will determine how you proceed with this metric. If unvegetated areas void of root mat (i.e. hollows) make up < 10% of the AA, measure bearing capacity in 8 sub-plots following the directions below:

1. Record the percent of the AA wetland in hummocks.
2. At subplots 1-8, determine a sampling spot to place the flat cap bottom of the base. Push aside all vegetation (live and dead) to reveal bare ground.
3. Measure and record the depth of surface water (if any) at each subplot, in centimeters, in the location where the flat cap bottom of the PVC pipe will rest.
4. Assemble the PVC tube and the slide hammer together first, and then place gently on bare ground on the wetland surface at the determined location. Make sure the PVC is vertical and not tilted.
5. Measure initial compaction using the centimeter scale on the PVC pipe by recording how deep the PVC penetrates into the ground without exerting any force. Record this as 'Initial depth' to the nearest 0.25cm (e.g. if it is between 4cm and 5cm, record as 4.25cm, 4.5cm, or 4.75 cm, whichever it is nearest to).
6. Lift and extend the slide hammer fully while ensuring that the PVC tube is in a straight, upright position. Release the hammer and allow it to fall freely with gravity. Then, for the safety of your fellow field crew members, stabilize the slide hammer in place (without exerting any extra force on it) so that it does not fall off of the PVC pipe onto another field crew member.
7. Without moving the slide hammer, measure compaction by reading where the marsh surface aligns with the centimeter scale on the PVC pipe, again to the nearest 0.25cm. Record the depth as 'blow 1'.
8. Repeat steps 6-7 for blows 2-5. Record values in the space provided (see example table below).

9. Subtract the initial depth from the final depth for subplots 1-8. Average these values for the 8 subplots and use that average to score the site using the scoring table. In this case, because hollows make up < 10% of the AA, the table for hollows remains blank on the data sheet. We recommend waiting to do any sort of calculations until you are out of the field and back in the office to avoid errors.

If hollows make up >10% of the AA, bearing capacity readings should also be taken in hollows within the 8 subplots. If a hollow is not present within the subplot, take bearing capacity readings in the hollow closest to the subplot up to, but not more than, 3m away from subplot.

1. Take the 'hummocks' readings as directed above.
2. In addition, record the percent hollows in the AA. Percent hollows and percent hummocks should add up to 100%.
3. While at each subplot, repeat the sampling procedure at the nearest spot void of vegetation and root mat (unvegetated hollow) that falls ≤ 3m from the subplot. This means that at each subplot, both hummock *and* hollow bearing capacity readings should be recorded. Separate tables are provided on the data sheet for hummock readings and hollow readings.
4. Subtract the initial depth from the final depth for subplots 1-8, and then average the 8 subplots. Use the hummocks/hollows workspace on page 3 of the datasheet to calculate weighted bearing capacity for hummocks and hollows based on percentages of each in the AA. Add these 2 weighted values to get a final value (X) to use for scoring, as in the equation below:

X= (hummock subplot average*hummock %) + (hollow subplot average*hollow %)

We recommend waiting to do any sort of calculations until you are out of the field and back in the office to avoid errors.

Bearing Capacity (Hummocks)

% Hummocks ________%	**Mark Depth (cm)**							
	Subplot 1	Subplot 2	Subplot 3	Subplot 4	Subplot 5	Subplot 6	Subplot 7	Subplot 8
Water Depth								
Initial depth								
Blow 1								
Blow 2								
Blow 3								
Blow 4								
Blow 5 (Final)								
Blow 5 - Initial								

Scoring: Bearing Capacity (saltwater/brackish only)

Average of Final – Initial Over the Eight Sub-plots	Rating
≤1.80	**12**
1.81-4.00	**9**
4.01-6.20	**6**
>6.21	**3**

Scoring: Bearing Capacity (tidal freshwater only)

Average of Final – Initial Over the Eight Sub-plots	Rating
≤4.40	**12**
4.41-6.70	**9**
6.71-11.40	**6**
>11.41	**3**

HAB2. Horizontal Vegetative Obstruction

Metric Source: This parameter was a test metric in 2008-09 and was added to the protocol as a scored metric in 2010.
Extent: Measured at subplots 1, 3, 5, and 7 within the 50m AA
Definition: A measure of vegetation thickness by determining the amount of visual obstruction through the subplot area due to vegetation at 5 height levels using a profile board. The profile board is 1m long, is divided into 10-decimeter painted sections that alternate between red and white, and has a rope 4m in length tied to one end. Measurements are taken as the amount of board visible horizontally through vegetation from 4m away.
**Note: scoring for tidal freshwater wetlands is still under development.
Assessment Protocol:

1. The recorder stands along the 100m tape at the subplot with a 1.25m-tall dowel or PVC pole and the profile board. Two dowels should be marked at heights 0.25m, 0.5m, 0.75m, 1.0m, and 1.25m.
2. The observer stands 4m away from the recorder (measured using the 4m rope attached to the board), perpendicular to the tape, with the other 1.25m dowel that is marked at the same 5 height intervals listed in Step 1. The observer should walk out and around the subplot when walking 4m away from the recorder to be sure not to trample the vegetation you will be measuring visual obstruction through.
3. The recorder holds the profile board horizontally at 0.25m above the wetland surface by using the premarked dowel or PVC, with the top edge of the profile board even with the 0.25m dowel mark.
4. The observer positions themselves so that they are eye level with the profile board at 0.25m above the wetland surface using the second premarked dowel or PVC. Then, the observer counts how many of the decimeter segments on the profile board are visible through vegetation (i.e. unobstructed). If *any* part of a decimeter segment is seen through the vegetation, it counts as being seen. Record the number of visible decimeter segments at 0.25m (see data table example below). (Helpful Hint: sometimes it helps to wiggle the profile board so the observer can get a better view.)
5. Repeat Steps 3-4 at 0.5m, 0.75m, 1.0m, and 1.25m. At minimum, readings should be done at.25m, .5m, and .75m heights for all subplots. If the vegetation community is not growing at all to 1.0m or 1.25m at a subplot, do not take a reading; instead, put an X at that height in the data table to note that vegetation is not growing that tall. Also note the dominant vegetation found between the observer and the recorder.
6. Back in the office, sum the values for each subplot. Then, find the total number of visible decimeter segments for the whole site by adding the four subplot totals together. Divide that by the total amount of decimeter segments (visible + invisible) for the site in order to calculate a percentage of decimeter segments that were unobstructed. Ex: If a site has vegetation growing to 1.25m in all subplots, divide the total visible by 200 (10 decimeter segments x 5 plant heights x 4 subplots= 200 total possible decimeter segments to see in a site). If a site has 4 X's in the data table denoting that vegetation does not grow to certain heights at certain subplots, then the total visible for the site would instead be divided by 160 (4 X's means 40 fewer possible decimeter segments because readings were not taken at those heights).
7. Subtract the percent unobstructed from 100 to get the percent obstructed. Use the percent obstructed to score the site using the scoring table on the data sheet (see example below).

Horizontal Vegetative Obstruction
Place a 0 in boxes where board is obstructed completely by vegetation and an X where vegetation does not grow tall.

Sub-plot	**1**	**2**	**3**	**4**
0.25m				
0.50m				
0.75m				
1.0m				
1.25m				
SUM				
Dominant vegetation				

Scoring: Horizontal Vegetative Obstruction

Out of:_______________

% unobstructed:__________

100-% unobstructed = % obstructed____

Average of 4 Subplot Totals	**Rating**
≥ 60%	**12**
45% - 59.9%	**9**
30% - 44.9%	**6**
≤ 29.9%	**3**

HAB3. Number of Plant Layers

Metric Source: California Rapid Assessment Method (CRAM), modified
Extent: 50m AA
Definition: The number of plant forms in the AA based on plant height. A plant layer must cover ≥ 10% of the AA to be counted.

Assessment Protocol:

Plant Height *(covers ≥ 10% of AA)*	
☐	Submerged or floating aquatic vegetation
☐	Short <0.3m
☐	Medium 0.3-0.75m
☐	Tall 0.75-1.0m
☐	Very Tall >1.0m

Scoring: Number of Plant Layers

Alternative States	**Rating**
4-5 layers	**12**
2-3 layers	**9**
1 layer	**6**
0 layer	**3**

HAB4. Plant Species Richness

Metric Source: California Rapid Assessment Method (CRAM), modified
Extent: 50m AA
Definition: Walk your AA and mark presence of each species found in the AA at >10% coverage. Also record any species not listed in the provided blank spaces as long as they are found in >10% of the AA. This is best done towards the end of your assessment after you have had a chance to get a feel for the site.

Assessment Protocol:

Amaranthus cannabinus		*Polygonum arifolium*	
Asclepias incarnata		*Polygonum punctatum*	
Atriplex prostrata		*Polygonum ramosissimum*	
Baccharis halimifolia		*Pontederia cordata*	
Boehmeria cylindrica		*Sagittaria latifolia*	
Bolboschoenus robustus		*Salicornia virginica*	
Clethra alnifolia		*Saururus cernuus*	
Distichlis spicata		*Schoenoplectus americanus*	
Echinochloa walteri		*Solidago sempervirens*	
Hibiscus moscheutos		*Spartina alterniflora*	
Impatiens capensis		*Spartina cynosuroides*	
Iva frutescens		*Spartina patens*	
Juncus effusus		*Symplocarpus foetidus*	
Juncus gerardii		*Typha angustifolia*	
Kosteletzkya virginica (pentacarpos)		*Typha latifolia*	
Leersia oryzoides		*Zizania aquatica*	
Limonium carolinianum			
Nuphar luteum			
Panicum virgatum			
Peltandra virginica			
Phragmites australis			
Pluchea odorata			

Scoring: Species Richness

Alternative States	Rating
> 5 species	**12**
4 or 5 species	**9**
2 or 3 species	**6**
1 species	**3**

HAB5. Percent Invasive Cover

Metric Source: California Rapid Assessment Method (CRAM), modified
Extent: 50m AA
Definition: Percent cover of invasive species in the AA.

Assessment Protocol: Survey the AA for live invasive species and estimate total percent cover of all invasive species combined. For a complete list of Mid-Atlantic Invasive species, refer to your state's invasive species list (see links below). Use the cutoffs below to assign a metric score. You can also make note of any dead invasive species in the AA, such as sprayed *Phragmites*; however, dead invasive species are not included in the scoring of this metric.

Scoring: Percent Invasive

Alternative States	Rating
0%	**12**
>0-25%	**9**
26-50%	**6**
>50%	**3**

Invasive Species Present: ______________________ ____%

______________________ ____%

______________________ ____%

Please look for the current invasive species list for your state:

Delaware: http://www.wrc.udel.edu/de-flora/?l=3

Maryland: http://dnr.maryland.gov/Invasives/Pages/default.aspx

Virginia: http://www.dcr.virginia.gov/natural-heritage/invspinfo

New Jersey: http://www.njisst.org/fact-sheets.htm

Other Resources: https://plants.usda.gov/java/

https://www.invasive.org/maweeds.cfm

https://www.doi.gov/invasivespecies

APPENDIX A. Identifying Native *Phragmites*

Phragmites australis subsp. *americanus* Saltonstall, Peterson & Soreng

Adapted from Key Field Characteristics in the Tidal Mid-Atlantic Region

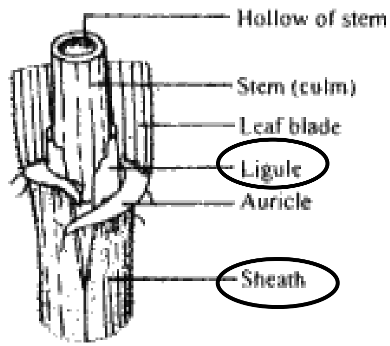
By Robert Meadows - Delaware Division of Fish & Wildlife, Newark, Delaware (robert.meadows@state.de.us)

No.	Characteristic	Native	Introduced	Remarks
1[a]	**Leaf Color**	Lighter Green	Darker Blue Green	Summer
2	**Leaf Texture**	Smoother	Coarse (midrib apparent)	Late Summer
	Leaf Sheath:			
4[a]	Clasping Stem	Very loosely wrapped	Very tightly wrapped	Late Summer, Fall and Winter
5[ab]	Retention on stem	Caducous: most fall off.	All are still tightly wrapped	If in doubt, look at dead reeds!
6[b]	Ligule width	Wider (1.0-1.7 mm)	Narrower (0.4-0.9 mm)	See Diagrams
	Culm: *Remember to remove leaf sheath first!*			
7[a]	Color in Summer	Maroon ("sunburnt")	Light Green	In exposed portions of stand
8	Color in Winter	Chestnut	Tan	
9[a]	Spots	Distinct Black Spots	None	On culm, not sheath (at node)
10	Height	Shorter, to ca. 12-ft	Taller, to ca. 15-ft	
12	Stem smoothness	Glossy (polished)	Ridged, can feel with fingernail	
b	**Flower**: Lower Glumes	Longer 3.0-6.5 mm	Shorter 2.5-5.0 mm	See Diagrams
c	Upper Glumes	5.5-11.0 mm	4.5-7.5 mm	
d	Lemmas	8.0-13.5 mm	7.5-12.0 mm	Flower at nearly same time
14	**Rhizome**	Less dense, softer/fewer root hairs	Denser, firmer/thicker root hairs	
15	**Senescence**	ca. mid to late September	ca. Late October- November	Best times to survey for native
	Habitat:			
16	Salinity	Fresh to Oligohaline (<8ppt)	Fresh to Mesohaline ($\leq$18ppt)	Native historically occurred in mesohaline
17	Disturbance	Undisturbed wetlands	Highly disturbed to pristine	
18	Biodiversity	Other plant sp. common	Monotypic stands common	

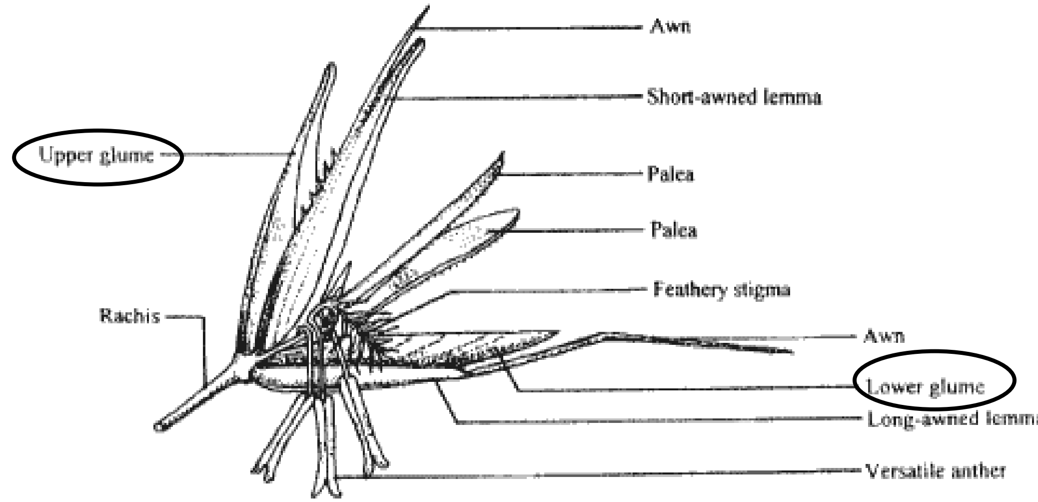
[a] Characteristics 1, 4, 5, 7, and 9 are additional key field traits (the remaining traits are not required to make a positive ID).

[b] Leaf Sheath Retention (5) and Ligule width (6) are universal traits; always check these on dead stems to confirm a presumptive ID.

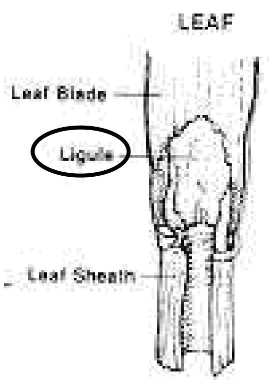
Leaf Sheath Parts

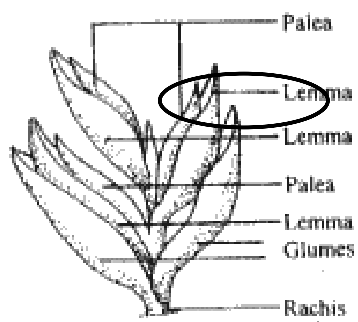


Flower Parts



Spikelet Parts (containing 3 Florets)





APPENDIX B. MidTRAM Datasheets