# N.C. Stream Assessment Method (NC SAM)

# Draft User Manual

**Prepared by the N.C. Stream Functional Assessment Team**

**Draft**
**March 2013**

# EXECUTIVE SUMMARY

The North Carolina Stream Assessment Method (NC SAM) is the culmination of a process begun in 2003 by an interagency team of federal and state agency staff – the N.C. Stream Functional Assessment Team (SFAT). The goal of the SFAT was to develop an accurate, reproducible, rapid, observational, and science-based field method to determine the level of stream function relative to reference condition for each of 29 general categories of North Carolina streams. The SFAT defined "rapid" as taking no more than 15 minutes for a trained observer to evaluate subsequent to a jurisdictional determination/delineation.

The SFAT identified 28 general stream categories based on four watershed sizes (< 0.1 square mile, 0.1 to < 0.5 square mile, 0.5 to < 5.0 square miles, and ≥ 5.0 square miles), four geographic areas based on ecoregions (Mountain, Piedmont, Inner Coastal Plain, and Outer Coastal Plain), and two valley shapes (broad and narrow). In these categories, the evaluation of intermittent streams is treated somewhat differently from the evaluation of perennial streams. In addition, Tidal Marsh Stream is recognized as a 29th stream category.

Function ratings were developed for each stream category in comparison to reference streams of the same category. For the first 28 stream categories, three primary functions are recognized with eight sub-functions (in parentheses) as follows: hydrology (baseflow and flood flow), water quality (baseflow, streamside area vegetation, indicators of stressors, aquatic life tolerance), and habitat (In-stream habitat and stream-side habitat). For Tidal Marsh Stream, three primary functions are recognized with seven sub-functions (in parentheses) as follows: hydrology (stream/intertidal zone interaction, longitudinal tidal flow, and stream stability), water quality (pollutant filtration and indicators of stressors), and habitat (in-stream habitat and intertidal zone habitat).

Sub-functions and functions are evaluated using 25 field metrics listed on a Field Assessment Form. These metrics were designed and tested to be appropriate to North Carolina stream categories. Data from a completed Field Assessment Form are entered into a computer program to generate High, Medium, and Low ratings for each sub-function, function, and overall for the assessment area. The computer program was developed based on an iterative Boolean logic process and then field tested at more than 280 sites of various levels of stream condition statewide.

This user manual provides conceptual background information essential to implementing NC SAM. Each of the 25 metrics is described with examples to calibrate the user. A comprehensive glossary, as well as other detailed appendices, is included. The SFAT expects that a multi-day training class, coupled with subsequent field experience with the methodology, will be needed to use NC SAM properly.

NC SAM was created to be used for project planning, alternatives analysis, compliance and enforcement, watershed planning, stream monitoring, and mitigation planning. This method was not developed for determining mitigation success on constructed stream sites. Details of how NC SAM will be used will be developed by the regulatory agencies after appropriate public notice and comment.

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## Appendices in the User Manual

**NC SAM FIELD ASSESSMENT FORM**
**Accompanies Draft User Manual: March 2013**

USACE AID #: NCDWQ #

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): ____ 2. Date of evaluation: ____
3. Applicant/owner name: ____ 4. Assessor name/organization: ____
5. County: ____ 6. Nearest named water body on USGS 7.5-minute quad: ____
7. River basin: ____
8. Site coordinates (decimal degrees, at lower end of assessment reach): ____

**STREAM INFORMATION: (depth and width can be approximations)**

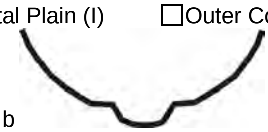
9. Site number (show on attached map): ____ 10. Length of assessment reach evaluated (feet): ____
11. Channel depth from bed (in riffle, if present) to top of bank (feet): ____ ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): ____ 13. Is assessment reach a swamp stream? ☐Yes ☐No
14. Feature type: ☐Perennial flow ☐Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☐Mountains (M) ☐Piedmont (P) ☐Inner Coastal Plain (I) ☐Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐a 
(more sinuous stream, flatter valley slope)

☐b 
(less sinuous stream, steeper valley slope)

17. Watershed size: **(skip for Tidal Marsh Stream)** ☐Size 1 (< 0.1 $mi^2$) ☐Size 2 (0.1 to < 0.5 $mi^2$) ☐Size 3 (0.5 to < 5 $mi^2$) ☐Size 4 (≥ 5 $mi^2$)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☐Yes ☐No If Yes, check all that apply to the assessment area.
- ☐Section 10 water
- ☐Classified Trout Waters
- ☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
- ☐Essential Fish Habitat
- ☐Primary Nursery Area
- ☐High Quality Waters/Outstanding Resource Waters
- ☐Publicly owned property
- ☐NCDWQ riparian buffer rule in effect
- ☐Nutrient Sensitive Waters
- ☐Anadromous fish
- ☐303(d) List
- ☐CAMA Area of Environmental Concern (AEC)
- ☐Documented presence of a federal and/or state listed protected species within the assessment area.
  List species: ____
- ☐Designated Critical Habitat (list species) ____

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☐Yes ☐No

**1. Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
- ☐A Water throughout assessment reach.
- ☐B No flow, water in pools only.
- ☐C No water in assessment reach.

**2. Evidence of Flow Restriction – assessment reach metric**
- ☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction <u>or</u> fill to the point of obstructing flow <u>or</u> a channel choked with aquatic macrophytes <u>or</u> ponded water <u>or</u> impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
- ☐B Not A

**3. Feature Pattern – assessment reach metric**
- ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
- ☐B Not A

**4. Feature Longitudinal Profile – assessment reach metric**
- ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
- ☐B Not A

**5. Signs of Active Instability – assessment reach metric**

**Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
- ☐A < 10% of channel unstable
- ☐B 10 to 25% of channel unstable
- ☐C > 25% of channel unstable

**6. Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no evidence of conditions that adversely affect reference interaction |
| ☐B | ☐B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] <u>or</u> too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) <u>or</u> floodplain/intertidal zone unnaturally absent <u>or</u> assessment reach is a man-made feature on an interstream divide |

**7. Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B <u>Excessive</u> sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach and causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc.)
☐I Other: ______________________ (explain in “Notes/Sketch” section)
☐J Little to no stressors

**8. Recent Weather – watershed metric (skip for Tidal Marsh Streams)**

For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.

☐A Drought conditions <u>and</u> no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions <u>and</u> rainfall exceeding 1 inch within the last 48 hours
☐C No drought conditions

**9. Large or Dangerous Stream – assessment reach metric**

☐Yes ☐No Is stream too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

**10. Natural In-stream Habitat Types – assessment reach metric**

10a. ☐Yes ☐No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 11)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**

☐A Multiple aquatic macrophytes and aquatic mosses (including liverworts, lichens, and algal mats)
☐B Multiple sticks and/or leaf packs and/or emergent vegetation
☐C Multiple snags and logs (including lap trees)
☐D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only

☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

**11. Bedform and Substrate – assessment reach metric**

11a. ☐Yes ☐No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es). (skip for Tidal Marsh Streams)**

☐A Riffle-run section
☐B Pool-glide section
☐C Natural bedform absent (skip to Metric 12, Aquatic Life)

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☐ | ☐ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Silt (< 0.062 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Detritus |
| ☐ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☐No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

********************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS****************************

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☐Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ______

12b. ☐Yes ☐No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

| 1 | >1 | Numbers over columns refer to "individuals" for Size 1 and 2 streams and "taxa" for Size 3 and 4 streams. |
|---|---|---|
| ☐ | ☐ | Adult frogs |
| ☐ | ☐ | Aquatic reptiles |
| ☐ | ☐ | Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats) |
| ☐ | ☐ | Beetles (including water pennies) |
| ☐ | ☐ | Caddisfly larvae (Trichoptera [T]) |
| ☐ | ☐ | Asian clam (*Corbicula*) |
| ☐ | ☐ | Crustacean (isopod/amphipod/crayfish/shrimp) |
| ☐ | ☐ | Damselfly and dragonfly larvae |
| ☐ | ☐ | Dipterans (true flies) |
| ☐ | ☐ | Mayfly larvae (Ephemeroptera [E]) |
| ☐ | ☐ | Megaloptera (alderfly, fishfly, dobsonfly larvae) |
| ☐ | ☐ | Midges/mosquito larvae |
| ☐ | ☐ | Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea)* |
| ☐ | ☐ | Mussels/Clams (not *Corbicula*) |
| ☐ | ☐ | Other fish |
| ☐ | ☐ | Salamanders/tadpoles |
| ☐ | ☐ | Snails |
| ☐ | ☐ | Stonefly larvae (Plecoptera [P]) |
| ☐ | ☐ | Tipulid larvae |
| ☐ | ☐ | Worms/leeches |

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no alteration to water storage capacity over a majority of the streamside area |
| ☐B | ☐B | Moderate alteration to water storage capacity over a majority of the streamside area |
| ☐C | ☐C | Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) |

**14. Streamside Area Water Storage – streamside area metric (skip for Tidal Marsh Streams and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Unaltered or majority of streamside area with depressions able to pond water ≥ 6 inches deep |
| ☐B | ☐B | Majority of streamside area with depressions able to pond water 3 to 6 inches deep |
| ☐C | ☐C | Majority of streamside area with depressions able to pond water < 3 inches deep |

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

| LB | RB | |
|---|---|---|
| ☐Y | ☐Y | Are wetlands present in the streamside area? |
| ☐N | ☐N | |

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**
**Check all contributors within the assessment reach or within view of and draining to the assessment reach.**

☐A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction that passes some flow during low-flow periods affecting assessment reach (ex: beaver dam, bottom-release dam)
☐D Evidence of bank seepage or sweating (iron oxidizing bacteria in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☐F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**
**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☐F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**
Consider aspect. Consider "leaf-on" condition.

☐A Stream shading is appropriate for the stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – assessment area metric (skip for Tidal Marsh Streams)**
**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated LB | Vegetated RB | Wooded LB | Wooded RB | |
|---|---|---|---|---|
| ☐A | ☐A | ☐A | ☐A | ≥ 100 feet wide or extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide or no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation or modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**
**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).
**If no stressors, check here and skip to Metric 22:** ☐No Stressors

| Abuts LB | Abuts RB | < 30 feet LB | < 30 feet RB | 30-50 feet LB | 30-50 feet RB | |
|---|---|---|---|---|---|---|
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer or predominantly herbaceous species or bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**
Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – First 100 feet of streamside area metric (skip for Tidal Marsh Streams)**
Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing or communities with non-native invasive species present, but not dominant, over a large portion of the expected strata or communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities composed of planted stands of non-characteristic species or communities inappropriately composed of a single species or no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**

25a. ☐Yes ☐No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ________________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

**Draft NC SAM Stream Rating Sheet**
**Accompanies Draft User Manual: March 2013**

Stream Site Name ______________________ Date of Assessment ______________________
Stream Category ______________________ Assessor Name/Organization ______________________

Notes of Field Assessment Form (Y/N) ____________
Presence of regulatory considerations (Y/N) ____________
Additional stream information/supplementary measurements included (Y/N) ____________
NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) ____________

| Function Class Rating Summary | USACE/ All Streams | NCDWQ Intermittent |
|---|---|---|
| (1) Hydrology | | |
| (2) Baseflow | | |
| (2) Flood Flow | | |
| (3) Streamside Area Attenuation | | |
| (4) Floodplain Access | | |
| (4) Wooded Riparian Buffer | | |
| (4) Microtopography | | |
| (3) Stream Stability | | |
| (4) Channel Stability | | |
| (4) Sediment Transport | | |
| (4) Stream Geomorphology | | |
| (2) Stream/Intertidal Zone Interaction | | |
| (2) Longitudinal Tidal Flow | | |
| (2) Tidal Marsh Stream Stability | | |
| (3) Tidal Marsh Channel Stability | | |
| (3) Tidal Marsh Stream Geomorphology | | |
| (1) Water Quality | | |
| (2) Baseflow | | |
| (2) Streamside Area Vegetation | | |
| (3) Upland Pollutant Filtration | | |
| (3) Thermoregulation | | |
| (2) Indicators of Stressors | | |
| (2) Aquatic Life Tolerance | | |
| (2) Intertidal Zone Filtration | | |
| (1) Habitat | | |
| (2) In-stream Habitat | | |
| (3) Baseflow | | |
| (3) Substrate | | |
| (3) Stream Stability | | |
| (3) In-stream Habitat | | |
| (2) Streamside Habitat | | |
| (3) Streamside Habitat | | |
| (3) Thermoregulation | | |
| (2) Tidal Marsh In-stream Habitat | | |
| (3) Flow Restriction | | |
| (3) Tidal Marsh Stream Stability | | |
| (4) Tidal Marsh Channel Stability | | |
| (4) Tidal Marsh Stream Geomorphology | | |
| (3) Tidal Marsh In-stream Habitat | | |
| (2) Intertidal Zone | | |
| Overall | | |

# NORTH CAROLINA STREAM ASSESSMENT METHOD (NC SAM)

# DRAFT USER MANUAL

## 1.0 INTRODUCTION

### 1.1 Background

This manual provides guidance for the use of a field-based, rapid stream assessment method – the N.C. Stream Assessment Method (NC SAM). NC SAM was developed as part of a collaborative effort by representatives of the U.S. Army Corps of Engineers (USACE), U.S. Department of Transportation Federal Highway Administration (USFHWA), U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), N.C. Division of Coastal Management (NCDCM), N.C. Department of Transportation (NCDOT), N.C. Division of Water Quality (NCDWQ), N.C. Wildlife Resources Commission (NCWRC), N.C. Natural Heritage Program (NCNHP), and the N.C. Ecosystem Enhancement Program (NCEEP). This method is the result of a process initiated through an interagency Memorandum of Agreement among individual members represented on the N.C. Stream Functional Assessment Team (SFAT). The method presented in this User Manual is endorsed by all of the SFAT agencies and is intended to be utilized by state and federal stream permitting programs in North Carolina.

In October 2003, the USACE, NCDWQ, and NCDOT, along with the active participation of several other state and federal agencies, established the N.C. Stream Functional Assessment Team (SFAT). SFAT members included the following:

N.C. Division of Water Quality – Dave Penrose (Co-Chair) (replaced by John Dorney [Co-Chair] and then Larry Eaton and Lori Montgomery [Co-Chair])
N.C. Department of Transportation – Bruce Ellis (Co-Chair) (replaced by LeiLani Paugh [Co-Chair]) and Steve Mitchell
U.S. Army Corps of Engineers – Todd Tugwell (Co-Chair), Scott McLendon (Coordination Group Representative), and Tyler Crumbley
U.S. Environmental Protection Agency – Kathy Matthews and Becky Fox
N.C. Division of Coastal Management – Steve Sollod
N.C. Wildlife Resources Commission – Travis Wilson
U.S. Fish and Wildlife Service – Marella Buncick
N.C. Ecosystem Enhancement Program – Kevin Miller (replaced by Greg Melia)
N.C. Natural Heritage Program – Sarah McRae
U.S. Department of Transportation, Federal Highway Administration – Rob Ayres

Development of this method was aided by the active assistance of staff currently with Atkins North America, Inc. (Matt Cusack, Brad Allen, and John Dorney) and Axiom Environmental, Inc. (Sandy Smith).

The SFAT met periodically from October 2003 to November 2011. During the development and testing of NC SAM, the SFAT visited approximately 280 stream sites across the state and spent more than 300 person-days in the field.

## 1.2 Organization of the User Manual

The main body of the User Manual provides an introduction to NC SAM, a conceptual discussion of the NC SAM approach to stream function classes, a general discussion of the stream category classification system, a discussion of informational questions and functional assessment metrics including guidance for conducting evaluations in the field, and guidance for use of NC SAM. To promote ease of reference, additional information necessary for the use of NC SAM has been organized into the attached appendices. The Table of Contents contains a complete list of information provided in the appendices. Many terms used in the manual and appendices are defined in the NC SAM Glossary of Terms (Appendix L). Acronyms and abbreviations used in the NC SAM manual and appendices are defined in Appendix A.

## 1.3 Purpose and Overview of NC SAM

The purpose of NC SAM is to provide the public and private sectors with an accurate, consistent, rapid, observational, and science-based field method to determine the level of function of streams within North Carolina. For the purposes of NC SAM, the terms "stream" and "tributary" are synonymous and used interchangeably, referring to an open conduit or conveyance of surface water, either naturally or artificially created, that periodically or continuously contains moving water from storm flow, overland flow, discharged ground water, or a combination of the aforementioned. Also included are man-made ditches in locations where a natural channel did not previously exist. Both of these terms (stream and tributary) imply federal and/or state jurisdictional status.

For this method, the term "rapid" is defined as taking no more than 15 minutes for a trained individual (assessor) to evaluate a subject reach of stream within an "assessment area" after federal and/or state jurisdiction has been determined or delineated. It is important to emphasize that NC SAM is a method to determine the level of stream function and is not a stream determination or delineation method.

This method will not replace more comprehensive stream evaluation methods that may be appropriate for other purposes. However, NC SAM is expected to replace other rapid assessment methods in North Carolina (such as the USACE Stream Quality Assessment Worksheet [USACE 2003]).

NC SAM generates a function rating for each stream assessed. It is recognized that direct measurement of stream function is impractical within the time limitations imposed on this rapid field assessment method. Therefore, NC SAM uses indicators of stream condition relative to a reference stream (if available) as a surrogate for stream function. These indicators are general measures (metrics) of the condition of the evaluated stream. In effect, observed stream condition is used to infer stream function. A "metric" is a specific inquiry used to evaluate the inherent characteristics of a stream that affect its ability to perform a given function. Many evaluated metrics are rated relative to a reference stream of the same category, but some metrics are used to rate characteristics that naturally vary among streams. The condition of a stream can range from reference (little apparent disturbance, indicating a fully functional stream) to severely degraded (disturbance has altered a stream's ability to perform most or all important functions).

The assessor completes the assessment method by collecting general information, making observations, and evaluating metrics on site (although some of this information can be gathered as a desk exercise). The NC SAM Field Assessment Form is included at the beginning of the User Manual (see pp. vii-x). The form contains an introductory box containing 19 informational questions (Information 1-19) followed by 25 metrics (1-25). A discussion of the informational questions is provided in Section 4.2.1: Introductory Information (p. 41), and a discussion of metrics is provided in Section 4.2.2: Metrics (p. 47). To complete the Field Assessment Form, the assessor selects the appropriate descriptor(s) for each informational question and metric. Descriptor selections recorded on the Field Assessment Form are entered into the computer-based NC SAM Rating Calculator. The Rating Calculator first identifies the stream category using information recorded in the introductory box and then uses the selected metric descriptors to develop a function rating for each metric. Metric ratings are combined to provide various sub-function ratings that are ultimately combined into an overall rating. The metric and sub-function rating combinations are developed by the Rating Calculator using a weighting strategy that reflects the relative importance of the metric to the stream sub-functions. Ratings are provided as “High,” “Medium,” and “Low” relative only to other streams of the same category. The results of the stream assessment are output by the Rating Calculator on a Stream Rating Sheet. A blank Stream Rating Sheet is included at the beginning of the User Manual (see p. xi) and its contents are discussed in Section 5.5.3: Final Product (p. 174).

Stream categories have been defined with stream function in mind (categories are determined by geographic location, valley shape, and watershed size – explained in Section 3.0). Functional emphases are considered to vary among stream categories but should be relatively consistent within each stream category in the same ecoregion. NC SAM generates function ratings for each assessed stream through analysis of observed conditions and the evidence of stressors specific to each stream category. This approach allows each stream to be located on a conceptual function continuum, ranging from relatively undisturbed examples of the stream category (function rating of “High”) to heavily disturbed examples of the same stream category (function rating of “Low”). The developers of NC SAM have reasoned that the generation of an in-kind functional assessment rating for each stream reach will give an accurate indication of the function or importance of that stream reach based on its ecoregion, condition, and level of disturbance. The function rating produced by NC SAM will thereby provide regulators, planners, and the general public with a more meaningful estimate of stream function than previously available for use when evaluating potential stream impacts and mitigation activities.

As a quality assessment/quality control check on one aspect of this method, the SFAT requested an analysis of the association between the three primary functions, the overall rating, and a metric that considers whether the assessment reach watershed is subject to equal to or greater than 24 percent impervious surface (Metric 17 [Baseflow Detractors], descriptor C). A discussion of this analysis and its results are provided in Appendix B. Additional analyses are anticipated to be conducted in the future as familiarity with the method increases with use. In general, this analysis provides strong statistical support for the approach taken by the SFAT during development and testing of the method.

NC SAM has been designed by the SFAT to provide a consistent tool to aid in consideration of project design, allowing for impacts to be avoided and/or minimized, and to provide information concerning assessed stream characteristics and functions that may be used at the discretion of the regulatory community. This method is intended to provide a consistent source of functional assessment information to support the regulatory review process. It is fully expected that the current method may be modified for more specific applications concerning project planning, alternatives analysis, watershed planning, compliance and enforcement, stream monitoring, and mitigation planning. Updates to the method itself may be applied by the SFAT as more scientific information, field experience, and calibration analyses become available. This method was not developed for determining mitigation success on constructed stream sites.

# 2.0 APPROACH TO STREAM FUNCTION

## 2.1 Stream Functions, Classes of Function, and Metrics

The SFAT identified primary and supporting stream functions and then sorted streams into categories (see Section 3.0: Stream Categories) based on capacity to perform these functions. Each stream category provides a different functional emphasis from the others. Using the extensive experience of the team and literature review of available stream functional assessments, the SFAT proposes three primary (Class 1) stream functions: Hydrology, Water Quality, and Habitat. Each Class 1 function is comprised of supporting sub-functions, referred to as Class 2 functions. Some of the Class 2 functions are also comprised of supporting sub-functions, referred to as Class 3 functions; and some of the Class 3 functions are comprised of supporting Class 4 functions. When referring to multiple classes of function, this User Manual will typically use the term "function classes." See Appendix C for a metric-function class diagram for each NC SAM stream category.

The SFAT developed a list of condition metrics for each of 29 stream categories (see Section 3.0: Stream Categories). This effort resulted in 54 metrics. These 54 original metrics were condensed into one field form with 25 metrics that is used to evaluate all stream categories (see the Field Assessment Form on pp. vii-x). Descriptors selected on the Field Assessment Form are sorted by a Rating Calculator into the original metrics to generate ratings for all metrics, classes of function, and the overall stream function. Due to the coarseness of the field evaluation method, ratings are qualitative (High, Medium, and Low) as opposed to quantitative (a specific numerical value). See Section 5.5.1: Conceptual Data Analysis (p. 170) for more detail concerning how ratings are generated.

## 2.2 Alterations and Stressors that Affect Stream Function

The functions provided by a stream are a product of the hydrological, geological, morphological, and vegetational setting of the stream and its drainage area or watershed (Gordon et al. 1992). The terms "alteration" and "stressor" are used in NC SAM to refer to both natural and anthropogenic activities that may result in degradation of one or more stream functions. An alteration/stressor is considered by the evaluator when there is evidence of it within the assessment area. An alteration/stressor can be located outside of the assessment area and degrade stream function(s) within the assessment area.

Natural alterations/stressors include, but are not limited to, storm damage, salt-water intrusion and associated vegetation die-off (when inappropriate for that stream setting), excessive vegetation restricting flow, beaver impoundment, stream migration, and sedimentation. Anthropogenic alterations/stressors include, but are not limited to, flow restrictions (undersized or perched culverts, causeways that constrict the channel, tidal gates, man-made berms/levees, bulkheads), increased amounts of impervious surfaces within the watershed, disturbances to/removal of riparian buffer vegetation, channel pattern modification (channel straightening and/or relocation), channel profile modification (dredging, excavation, artificial hardening), livestock with access to the stream, removal of wetlands or impacts to wetlands in proximity to streams, turbidity, and sedimentation. The response of a stream to an alteration/stressor depends on the stream size, setting, severity of the alteration/stressor, and time.

Common alterations/stressors associated with streams and their impact on stream functions are discussed below.

**Culverts**

The presence of a culvert in a stream may result in degradation of all Class 1 functions. The culvert itself results in a direct loss of bed and bank and may cause the restriction of flow (increasing floodplain access above a culvert and decreasing floodplain access below the culvert), channel destabilization, altered stream geomorphology, and degradation of natural in-stream habitat. Perched culverts may act as dams during low flows, resulting in a barrier to the movement of aquatic organisms and may cause scour pools at the downstream end that alter the natural pattern and profile (Photo 2-1). Straightening of the channel in the vicinity of each end of a culvert alters stream profile, pattern, and potentially destabilizes the bed and banks (Photo 2-2). Debris may pile up on the upstream side of culverts, altering flows, blocking aquatic life movement, and resulting in flows that destabilize bed and banks (Photo 2-3). Improperly sized, sloped, or elevated culverts may alter flow velocities and in-stream and flood flows, potentially resulting in destabilization of the downstream bed, banks, and streamside area (Photo 2-4). Such culverts may also create an unnatural grade control that will not be maintained if the culvert is removed. Concrete and rip-rap aprons eliminate potential habitat areas within the bed and lower banks.

**Ditching**

For the purposes of NC SAM, a "ditch" or "canal" is a man-made channel other than a modified natural stream constructed for drainage purposes that may be dug through geomorphic floodplains, natural topographic crenulations, and interstream divides. A ditch or canal may have flows that are perennial, intermittent, or ephemeral and may exhibit hydrological and biological characteristics similar to perennial or intermittent streams (15A NCAC 02B .0233(2)(d)).

Ditching in the vicinity of a natural stream may result in degradation of all Class 1 functions. Ditching disturbs the flow of water (both overbank flow and overland runoff) across the streamside area and may increase the flashiness of in-stream flows, thereby reducing stream stability. Ditches accelerate the rate of runoff from the streamside area into the stream (reducing streamside water storage capacity and duration which degrades the Baseflow component of all Class 1 functions) or redirect overland flow and surficial groundwater (Photo 2-5 and Photo 2-6). Ditches are more likely to affect a stream when connected to a receiving water. In the Coastal Plain, ditches are sometimes not connected. In this case, ditches provide storage with negligible drainage. An assessor should determine whether ditches are connected and draining an area prior to conducting a stream assessment.

Ditches and/or canals in interstream divides subject to federal or state jurisdiction will be evaluated using NC SAM regardless of whether the ditch occurs in a landscape position that is likely to support a natural stream in undisturbed conditions. In this landscape position, these features are anticipated to be characterized by degraded Class 1 functions, most notably through altered Streamside Area Interaction (primarily overland flow to the stream, with no

Photo 2-1

Photo 2-2

These photos provide evidence of some of the effects of culverts on streams. Photo 2-1 shows a plunge pool below a perched culvert draining an urban area on an unnamed tributary to Swift Creek (Pa1) in Wake County. Photo 2-2 shows a human-straightened stream reach downstream of a culvert on an unnamed tributary to the Pasquotank River (Oa2) in Camden County. Photo 2-3 shows an organic debris dam at the upstream end of a culvert on an unnamed tributary to Catawba Creek (Pb1) in Gaston County. Photo 2-4 shows channel destabilization resulting from perched pipes on Church Creek (Pa3) in Rowan County.

Photo 2-3

Photo 2-4

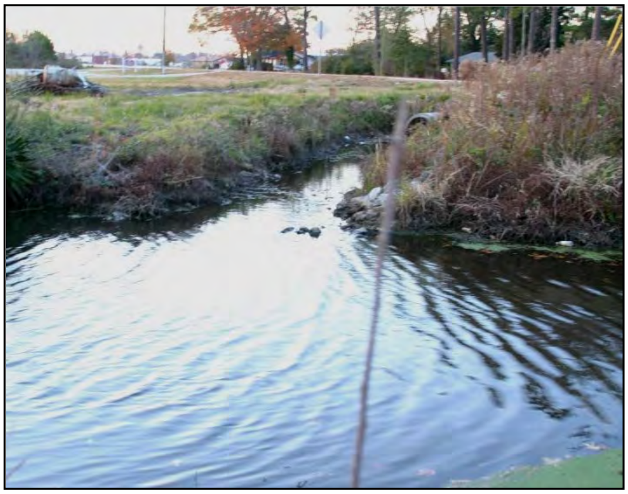


Photo 2-5

Photo 2-6

Photo 2-5 shows a streamside area ditch draining to an unnamed tributary to the Scuppernong River (Ia3) in Tyrrell County. The removal of streamside trees, saplings, and shrubs has resulted in an acceleration of streamside area drainage and stream shading being largely absent. Photo 2-6 shows a streamside area ditch draining to Back Creek (Pa4) in Mecklenburg County.

overbank flow expected to occur). Assessors will need to be familiar with guidance provided in this User Manual when implementing NC SAM on ditches.

**Beaver**

Beaver activity may have a substantial effect on all Class 1 stream functions, to the point of elimination, resulting in the conversion of the stream (a lotic system) into an open water area (a lentic system) or vegetated wetlands (Photo 2-7 and Photo 2-8). Beaver ponds are ecosystems that provide a suite of aquatic functions: however, from a stream function perspective, the effects of beaver on streams are negative and may include altered baseflow, increased floodplain access frequency and duration, reduced wooded riparian buffer, altered sediment transport, reduced thermoregulation, decreased dissolved oxygen, and an alteration in available in-stream and streamside habitats. Photo 2-9 shows beaver damage to streamside area hardwood trees. Photo 2-10 shows a streamside area barren of wooded vegetation. This site formerly supported a beaver impoundment, and the dam has been removed recently.

**Utility Corridors**

Streamside area vegetation stabilizes banks, acts to slow and hold flood flows, sequesters nutrients and toxicants, provides a source of aquatic habitat, provides organic matter for aquatic food chains, and provides shade that moderates surface water temperatures. Utility corridors are typically characterized by intensive management of vegetation and ground surface alteration. Mechanical vegetation maintenance may reduce surface roughness and compact

Photo 2-7

Photo 2-8

Both Photo 2-7 (unnamed tributary to Jimmy's Creek [Pa1] in Davidson County) and Photo 2-8 (Hominy Creek [Pa4] in Wake County) are beaver-impounded streams. The reach of stream above each dam has been converted by the presence of the dam from a lotic to a lentic system. Each of these dams acts as an "obstruction that passes some flow during low-flow periods," so each dam is considered a baseflow contributor to the downstream reach. Photo 2-9 shows a hardwood tree with beaver damage in the streamside area of an unnamed tributary to Knapp of Reeds Creek (Pa3) in Granville County. Photo 2-10 shows the streamside area of Cattail Creek (Pa4) in Johnston County shortly after a beaver dam has been removed.

Photo 2-9

Photo 2-10

soils, especially if conducted during wet conditions. Chemical treatments (from either ground or air spraying) may introduce pollutants and toxicants to the environment. Compaction of surface soils reduces surface water storage capacity and duration and increases potential for surface scour. A utility corridor in the vicinity of a stream alters the streamside area's ability to provide the aforementioned functions. Photo 2-11 and Photo 2-12 show maintained utility corridors parallel to roads making perpendicular crossings of streams. In the former photo, the lack of wooded buffer has resulted in the need for rip-rap to stabilize the banks of roadside ditches. Photo 2-13 shows a maintained gas line corridor that parallels a stream, while Photo 2-14 shows a maintained sewer line corridor that diagonally crosses a stream. The Photo 2-14 inset is an aerial view of the site.

**Livestock**

Livestock operations may negatively affect all Class 1 stream functions. Alteration of streamside area vegetation through grazing may increase erosion, reduce energy dissipation, reduce surface water shading, reduce habitat diversity, and degrade water quality. The presence of livestock on the banks of and within streams results in soil compaction, hoof shear, bed disturbance, and a source of turbidity. Photo 2-15 shows a stream that has been obliterated by cattle hoof shear. Photo 2-16 and Photo 2-17 show some results of livestock access to streams: streamside area vegetation alteration, bank shear, substrate disturbance, and turbidity. Livestock excrements, whether from retromingent (Photo 2-18) or promingent animals, are considered pollutants, but non-point source pollutants regardless.

**Hardening**

Channel hardening may negatively affect all Class 1 stream functions. Hardening is usually applied in response to channel instability but, in some cases, hardening is preemptively installed in channels in order to protect road and utility line crossings. Hardening is known to reduce aquatic habitat by removing diverse natural habitats and replacing them with artificial substrate such as standard-sized rip-rap (Photo 2-19 and Photo 2-20). In the extreme case of lining a channel with concrete (Photo 2-21) or masonry (Photo 2-22), hardening can increase flow velocities by decreasing surface roughness and remove sources of habitat in the channel. Note that energy from high flows has destabilized the masonry structure in Photo 2-22.

**Non-native Invasive Plants**

Non-native invasive plants can degrade the Class 1 function Habitat mainly through their effect on streamside vegetation composition and structure. For instance, many non-native invasives such as Chinese privet (*Ligustrum sinense* (Photo 2-23) and kudzu (*Pueraria lobata*) (Photo 2-24) can create semi-monocultures to the detriment of native plants, thereby drastically reducing streamside area diversity. Additionally, many of these species also affect stream function by altering the structure of the riparian buffer. Kudzu, for example, can overwhelm and kill a forest canopy resulting in increases in water temperature due to more sunlight, increased turbidity due to the loss of bank-stabilizing vegetation, and loss of woody inputs into the stream system.

Photo 2-11

Photo 2-12

These photos provide examples of the effects of maintained utility corridors. Photo 2-11 (Turkey Creek [Ia4] in New Hanover County) and Photo 2-12 (South Prong of Little River [Pb3] in Montgomery County) show perpendicular stream crossings by utility line corridors that are subject to regular vegetation maintenance. Note the use of rip-rap to stabilize banks in the former photo. Photo 2-13 (Black Creek [Pa3] in Wake County) shows a maintained utility line corridor situated parallel to a reach of stream. The removal of vegetation has resulted in degraded shading of the reach shown. Photo 2-14 (Back Creek [Pa3] in Mecklenburg County) shows a maintained sewer line corridor with a diagonal crossing of a stream. The inset is an aerial photograph of the same site.

Photo 2-13

Photo 2-14

Photo 2-15

Photo 2-16

Photo 2-15 shows the near obliteration by cattle shear of an unnamed tributary to Newfound Creek (Pa1) in Alamance County. Photo 2-16 shows an active goat pasture abutting Belch Branch (Ia2) in Lenoir County. The streambed is regularly disturbed by goat hooves, and the herb and shrub vegetation in the wooded buffer have been removed by grazing. Photo 2-17 shows streamside area vegetation alteration, bank shear, turbidity, and point source pollution resulting from cattle access to Middle Prong Hammer Creek (Pa3) in Montgomery County. This photo provides a good example of how stream shading has been degraded. Photo 2-18 shows livestock excrement being discharged directly into South Muddy Creek (Pa3) in McDowell County.

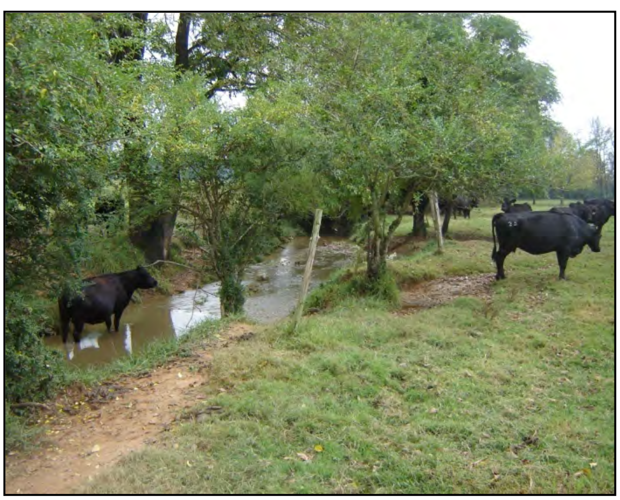


Photo 2-17

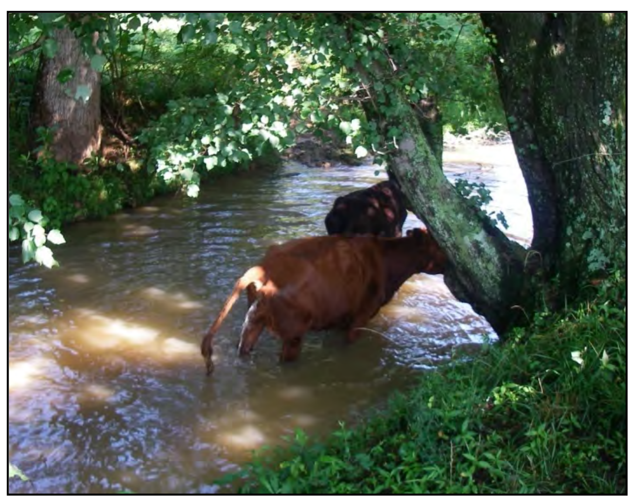


Photo 2-18

Photo 2-19

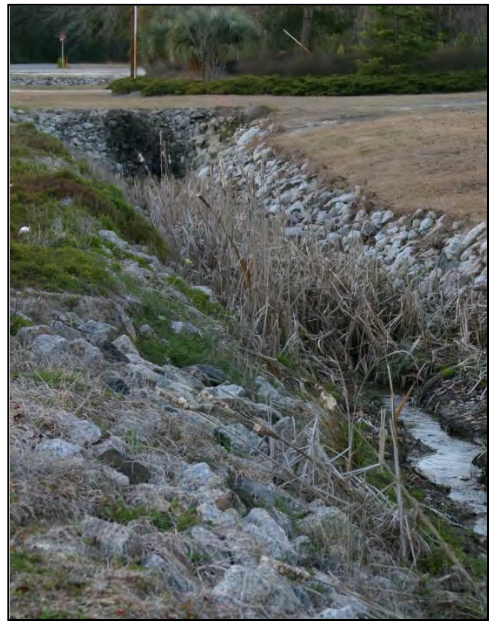


Photo 2-20

Photo 2-19 and Photo 2-20 are streams hardened with standard-sized rip-rap on an unnamed tributary to Little River (Pa3) in Montgomery County and an unnamed tributary to Lockwood Folly River (Oa2) in Brunswick County, respectively. Photo 2-21 shows hardening by concrete of the bed and banks of Skewakee Gut (Ia3) in Martin County, and Photo 2-22 shows hardening by stone blocks of the bed and banks of an unnamed tributary to Grant's Creek (Pa2) in Salisbury's City Park, Rowan County. Stream shading is degraded in Photo 2-19 and Photo 2-22 . Stream shading is gone or largely absent in Photo 2-20 and Photo 2-21, due in part to maintained turf abutting these streams in a residential area and a community park, respectively.

Photo 2-21

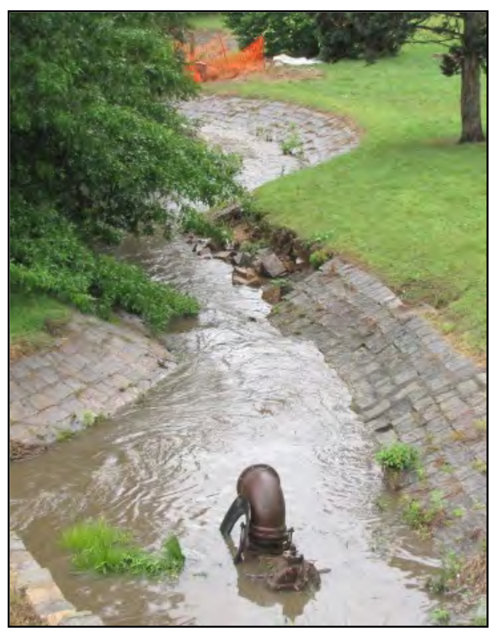


Photo 2-22

Photo 2-23

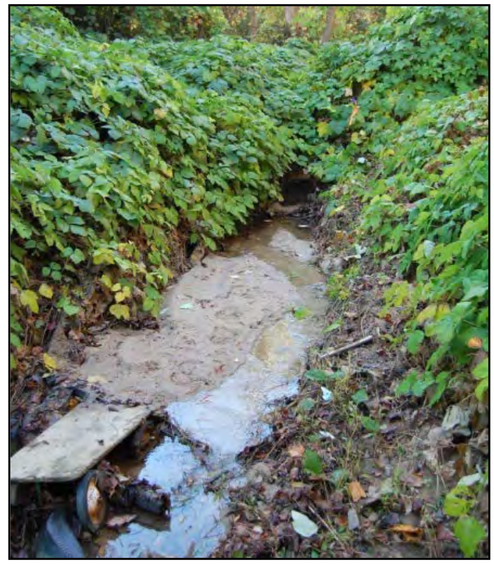


Photo 2-24

Photo 2-23 shows a straightened and deepened unnamed tributary to Beaverdam Swamp (Ia2) in Sampson County under a dense thicket of Chinese privet. This dense thicket has formed following removal of the tree and sapling strata, resulting in degraded shading for the reach shown. Photo 2-24 is an unnamed tributary to South Fork Catawba River (Pb1) in Gaston County that is situated in an area dominated by kudzu.

**Dredging**

In-channel dredging directly degrades the Class 1 function Habitat through alterations to or removal of the Substrate, Stream Stability, and In-stream Habitat components of this function. Dredging may also degrade the Class 1 function Hydrology by reducing Floodplain Access and Stream Stability. Dredging can be either periodic (such as sand dipping along some major rivers [Photo 2-25]) or infrequent (such as some gravel mining in mountain streams [Photo 2-26]). In the latter case, streams can partially recover from infrequent dredging through transport of bed material from upstream and the gradual, natural reforming of channel structures such as riffles and pools. In the case of infrequent dredging, it may be difficult for the assessor to determine if dredging has occurred. Landowners and state permitting agencies may be good sources of information about local dredging operations.

**Mowing**

Mowing degrades the Upland Pollutant Filtration and Thermoregulation components of the Class 1 Water Quality function as well as the Streamside Habitat and Thermoregulation components of the Class 1 Habitat function. Vegetation maintenance within the streamside area serves to remove the natural woody and non-woody vegetation that grows alongside streams (Photo 2-21 and Photo 2-22). High-quality streamside vegetation is crucial to the functioning of the stream itself, and periodic removal of this vegetation negatively affects stream health through thermal effects, removal of deep-rooted, woody vegetation and removal of sources of leaves and woody debris for aquatic habitats. Mowing of salt marsh can negatively

Photo 2-25

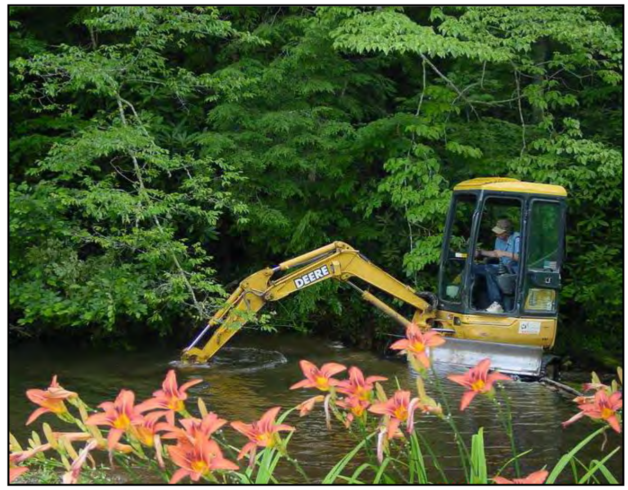




Photo 2-26

Photo 2-25 shows a sand-dipping operation on Clark Creek (Pa4) in Catawba County (photo courtesy of Tom Yocum). Note the tongue of sand filling the sand dipper area. Photo 2-26 shows a gravel-mining operation on Little Buck Creek (Ma4) in McDowell County.

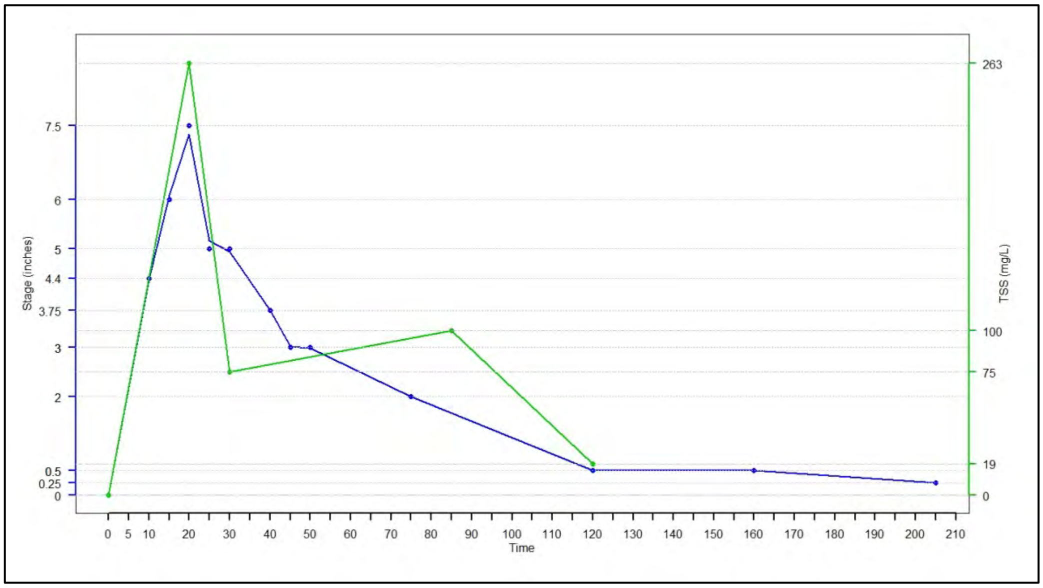
affect the health and functioning (primarily the Water Quality and Habitat functions) of Tidal Marsh Streams as well.

**Stormwater Discharges**

Stormwater can negatively affect all Class 1 stream functions by delivering high levels of sediment, nutrients, bacteria and heavy metals to streams via overland runoff over the land and especially over impervious surfaces (Bradford 1977). Indeed, non-point sources of pollution are overwhelmingly the major source of impairment of North Carolina's freshwaters, especially urban runoff from municipalities (C. McNutt, NCDWQ, personal communication, October 17, 2011). Stormwater is usually delivered to streams via stormwater pipes, although overland runoff from ditches or flow crossing urban and agricultural landscapes is common. Stormwater discharges can also affect stream hydrology by delivering higher-energy flows to stream channels, thereby increasing stream instability and stream bank erosion. The "first-flush phenomenon" is commonly found whereby the largest concentration of pollutants is found in the first part of the storm during the rising hydrograph since this is when the highest amounts of pollutants are flushed off urban landscapes. Therefore, non-treated initial runoff is considered to be a stream stressor.

An example of the first-flush phenomenon is provided by Figure 1, which depicts data from a 2011 storm draining a 15.3-acre urban watershed with approximately 34 percent impervious surfaces in Raleigh, NC (Edmonds and Dorney 2011). For this storm, the level of total suspended solids (TSS) was highest in the early part of the runoff but quickly declined along with the hydrograph as the runoff declined. Therefore, treatment of the initial runoff from urban landscapes is crucial in protecting downstream waters from the impacts of stormwater discharges. In this case, the stormwater runoff drained directly to a 0.2-acre bottomland hardwood forest wetland that served to reduce the peak concentration of TSS by 84 percent. This is a demonstration that even relatively small wetlands (or other best management practices) can have significant effects on the quality of urban stormwater runoff.

Figure 1 – An example of the stormwater "first-flush" phenomenon. The relationship between urban storm runoff (stage, in inches) and total suspended solids (TSS, in milligrams per liter [mg/l]) is depicted for a March 6, 2011 storm in Raleigh, NC.




Many new projects in urban areas are now required to install stormwater Best Management Practices (BMPs) such as wet detention ponds (Photo 2-27), bioretention (rain gardens) (Photo 2-28), and porous pavements (Photo 2-29). These BMPs may not be obvious to the assessor since they are often located behind commercial areas and are often fenced off from public access due to safety concerns. In addition, agricultural BMPs such as grassed swales (Photo 2-30), contour farming (Photo 2-31), and no-till agriculture (Photo 2-32) are common in the rural landscape and can significantly reduce pollutant input into local streams. These BMPs are usually readily observable in the agricultural landscape. Finally, silvicultural BMPs such as flashboard risers are often installed in the ditch network draining intensive forestry operations with significant benefits with respect to modifying the draining of surface and ground water to nearby streams. These silvicultural BMPs may be harder to observe in the landscape since they are often located in densely wooded areas; however, the aluminum riser may be visible in some instances. All of these BMPs can serve to reduce the effect of stormwater discharges on streams, but since these urban BMPs are usually only present in fairly new developments, and the other types of BMPs are not often required (although they are encouraged), older developed landscapes usually do not have BMPs to ameliorate the impact of stormwater discharges. The assessor is encouraged to pay close attention to the presence of stormwater discharges and any associated BMPs while traveling to the site and during the site evaluation process.

Photo 2-27

Photo 2-28

These photos show stormwater Best Management Practices (BMPs) that treat initial runoff following precipitation events. Photo 2-27 shows a wet detention pond treating stormwater from a suburban shopping center in Wake County. This type of feature provides baseflow to the receiving tributary through slow runoff following precipitation events and groundwater infiltration thereafter. Photo 2-28 shows a rain garden in the parking lot of the Raleigh Wetland Center in Wake County. Photo 2-29 shows porous pavement in the parking lot of the N.C. Botanical Garden in Chapel Hill, Orange County. Photo 2-30 shows a grassed swale in a topographic crenulation between agricultural fields in Union County.

Photo 2-29

Photo 2-30

Photo 2-31

Photo 2-32

Photo 2-31 shows an agricultural field subject to contour farming in Randolph County. The wooded vegetation is growing along an unnamed tributary to Bob Branch (Pb1). In this example, active row crops occur within 30 feet of, but not abutting the stream. Photo 2-32 shows an agricultural field subject to no-till farming. The field on both sides of this unnamed tributary to Stonyton Creek (Ia1) in Lenoir County contains the roots and lower stalks of a corn crop from the previous year.

**Impervious surfaces**

Impervious surfaces, such as asphalt, concrete, and roof tops, can result in degradation of streams through interruption of the natural hydrologic cycle resulting in reduced to no infiltration and more rapid runoff from urban landscapes. This scenario results in degradation of both the Baseflow and Flood Flow components of the Class 1 Hydrology function, degradation of the Baseflow and Streamside Area Vegetation components of the Class 1 Water Quality function, and degradation of the Baseflow and Streamside Habitat components of the Class 1 Habitat function.

Photo 2-33 shows the Little Tennessee River (Ma4) passing through Franklin in Macon County. Flashy flows from the high percentage of impervious surfaces are likely contributors to the concentration of woody debris at the bridge crossing. Photo 2-34 shows Town Creek (Pa4) passing through Salisbury in Rowan County. Runoff from the adjacent commercial development can move rapidly through the sparse buffer into this stream. In some cases, areas of compacted soils (such as those often found in pastures) can act as impervious or partially impervious surfaces by reducing infiltration and increasing rates of runoff. From the scientific literature, it is clear that increased levels of impervious surfaces are associated with degraded aquatic ecosystems, and many studies of aquatic insect communities have found that degradation starts at a level between 8 to 12 percent impervious surfaces in a particular watershed (Stepenuck et al. 2002). However, the NCDWQ stormwater rules generally have a trigger of 24 percent impervious surface, 12 percent in watersheds characterized by more sensitive waters. Therefore, 24 and 12 percent are the thresholds used in NC SAM for Metric 17 (Baseflow Detractors, p. 112) in order to maintain regulatory consistency.


Photo 2-33

Photo 2-34

These photos show streamside areas with a high percentage of impervious surfaces. Photo 2-33 is the Little Tennessee River (Ma4) in Franklin, Macon County and Photo 2-34 is Town Creek (Pa4) in Salisbury, Rowan County. Such impervious surfaces decrease the streamside area's ability to contribute to baseflow by preventing infiltration of water into the soil and subsequent groundwater flow to the stream. The degradation of streamside area vegetation has resulted in shading being gone or largely absent in the reach shown.

Stormwater BMPs can mediate the effect of impervious surfaces to some extent, depending on the type and number of BMPs installed in a particular watershed.

**Dams**

The presence of dams results in degradation of all three Class 1 functions. Dams affect water flows, sediment transport, available habitats, water chemistry, and fish migration. Dams can affect both storm flow and baseflow in streams by altering the normal hydrograph of a channel, depending on the design of the dam. Photo 2-35 shows a dam on Crooked Branch (Ia4) in Jones County. This dam forms Brock Millpond, which has been in place since prior to the War of American Independence. Photo 2-36 shows a low dam on Flat Creek (Ma4) in Buncombe County. Note the deeper, lower-energy, impounded water upstream of the dam and shallower, higher-energy water below the dam. Older farm ponds, common in North Carolina, rarely have low-flow releases, and these dams often restrict low flow during droughts, which can lead to degraded aquatic communities and disruption in baseflow functions. Therefore, old pond dams are considered to be baseflow detractors in NC SAM (Metric 17: Baseflow Detractors, see p. 112 and the Field Assessment Form). On the other hand, dams designed with base-flow releases can result in a stable baseflow to downstream receiving waters and are therefore considered to be baseflow contributors in NC SAM (Metric 16: Baseflow Contributors, see p. 107 and the Field Assessment Form). Most new dams are required to have minimum flow releases in North Carolina. Dams also act as a barrier to sediment transport that may affect both upstream (through deposition) and downstream (through scour) channel dimensions.

Photo 2-35

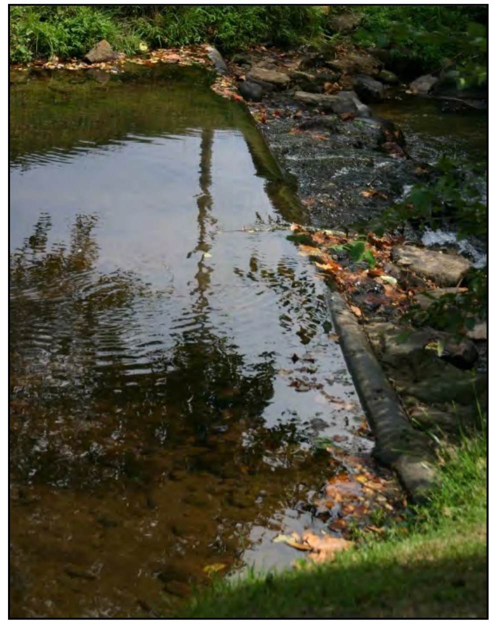


Photo 2-36

Photo 2-35 shows a dam and millhouse on Brock Millpond, an impoundment on Crooked Run (Ia4) in Jones County. Photo 2-36 shows a low dam on Flat Creek (Ma4) in Black Mountain, Buncombe County.

In addition, the change in the nature of the aquatic environment from lotic to lentic habitat in the ponded water upstream of a dam affects the physical (temperature, suspended solids, drift of organisms, etc.) and chemical dynamics (dissolved oxygen, cycling of organic matter and other nutrients, etc.) and hence the floral and faunal populations relative to the flowing water normally associated with streams (Smith 1980 and Gordon et al. 1992). Therefore, the presence of a dam can severely change aquatic communities in streams.

**Water Withdrawals**

Removal of water from streams can degrade all Class 1 functions, most notably through the change in the Baseflow component of all three functions. This effect is dependent on the stream size and the amount of the withdrawal. In severe droughts, water withdrawal can remove all baseflow, thereby devastating the aquatic community below the withdrawal. Usually, water withdrawal effects are less drastic and should be rated accordingly. In some cases, locations of withdrawals can be identified by piping and pumps or localized channel excavation that allows for water ponding and subsequent withdrawal. Photo 2-37 shows a weir and pipe used to transfer water from this unnamed tributary to Grant's Creek (Pa2) to a pond in Salisbury's City Park, Rowan County.

Photo 2-37

Photo 2-37 shows a weir and water transfer pipe on an unnamed tributary to Grant's Creek (Pa2) in Rowan County. This pipe is used to move water from the stream to an "off-line" pond within a public park.

**Agriculture/Maintained Turf (such as golf courses)**
Active row crops and maintained turf (Photo 2-38 and Photo 2-39, respectively) can act as significant stressors to aquatic ecosystems through degradation of all three Class 1 functions. These practices may result in unstable banks, which reduce water quality through excessive sediment inputs. These practices may also alter the normal wooded streamside area and thereby remove significant benefits of a wooded buffer abutting the stream (Baseflow, Streamside Area Attenuation, Stream Stability, Upland Pollutant Filtration, Thermoregulation, In-stream Habitat, and Streamside Habitat). These practices are also expected to be a source of pollutants such as sediment, nutrients, and pesticides. If these land uses are set back from the channel with a wooded buffer that can effectively treat this runoff, then these land uses will have a dramatically reduced impact on stream health. For instance, a 50-foot wide wooded buffer has been found to remove 62 percent of the total nitrogen entering the stream (Mayer et al. 2007). Mayer et al. (2007) also found a non-linear relationship of buffer width to nitrogen removal efficiency where wider buffers removed more nitrogen but at a reduced rate. NC SAM uses the width of wooded buffers adjacent to stream (Metric 19: Buffer Width and Metric 21: Buffer Stressors [see p. 119 and p. 129, respectively, and the Field Assessment Form]) as indications of the impact these land uses have on water quality and habitat.

Photo 2-38

Photo 2-39

Photo 2-38 shows agricultural land extending to the top of a man-made extension of Joyce Creek (Oa3) into an interstream divide in Camden County. The removal of woody vegetation from the streamside area results in stream shading being largely absent from the reach in view. Photo 2-39 shows a maintained lawn with low wooded stem density abutting the bank of an unnamed tributary to Pages Creek (Oa2) in New Hanover County.

## 3.0 STREAM CATEGORIES

Naturally occurring conditions and habitats of North Carolina streams vary substantially as a result of the diverse landscapes present within the state. Multiple stream categories have been established with the category separations based upon natural changes in stream function. Individual functions, as well as the relative importance of each function, are considered to vary among stream categories but should remain relatively consistent within individual stream categories represented in the same ecoregion.

Through professional experience, office discussions, and field trials the SFAT has divided North Carolina streams into 29 general categories for the purposes of NC SAM. The determination of 28 of the stream categories is based on geographic location, geomorphic valley shape, and watershed size (Table 1). For the remainder of this manual, these 28 stream categories will be referred to as "streams." The 29$^{th}$ stream category is Tidal Marsh Stream, and will hereafter be referred to by this name. Appendix D lists all streams shown in User Manual photos by stream category.

Table 1. NC SAM stream categories based on NC SAM zones (geographic location), valley shape, and watershed size

| | Geomorphic | | Watershed Size (square miles) | | | |
|---|---|---|---|---|---|---|
| NC SAM | Valley | | <0.1 | 0.1 to <0.5 | 0.5 to <5.0 | ≥5.0 |
| Zone | Shape | Designation | Size 1 | Size 2 | Size 3 | Size 4 |
| Outer Coastal Plain | broad | Oa | Oa1 | Oa2 | Oa3 | Oa4 |
| Inner Coastal Plain | broad | Ia | Ia1 | Ia2 | Ia3 | Ia4 |
| | narrow | Ib | Ib1 | Ib2 | Ib3 | Ib4 |
| Piedmont | broad | Pa | Pa1 | Pa2 | Pa3 | Pa4 |
| | narrow | Pb | Pb1 | Pb2 | Pb3 | Pb4 |
| Mountain | broad | Ma | Ma1 | Ma2 | Ma3 | Ma4 |
| | narrow | Mb | Mb1 | Mb2 | Mb3 | Mb4 |

The "assessment reach" is the defined reach of stream that is subject to functional assessment using NC SAM. Information questions in the Field Assessment Form introductory box (referred to in this User Manual as "Information 1," "Information 2," etc.) are used to identify the appropriate stream category for a given assessment reach. NC SAM generates stream ratings based on functions anticipated to be provided by a reference (unaltered to relatively unaltered) example of the assessment reach stream category. The SFAT determined that stream function varies sufficiently between the 28 categories to warrant distinct functional rating criteria.

## 3.1 Stream Category Determination

Stream categories are based on three characteristics: geographic position (NC SAM Zones), geomorphic valley shape, and watershed size. The following sections describe these three characteristics and provide guidance for making determinations. The results of the assessor's determinations will be recorded in the informational box at the beginning of the Field Assessment Form (p. vii; see Information 15, 16, and 17, respectively).

### 3.1.1 NC SAM Zones (Geographic Position)

The SFAT divided North Carolina into four zones (NC SAM Zones) (Figure 2) in consideration of stream function based upon level III and IV ecoregions (Appendix E, Griffith et al. 2002). The four NC SAM Zones are Mountain, Piedmont, Inner Coastal Plain, and Outer Coastal Plain.

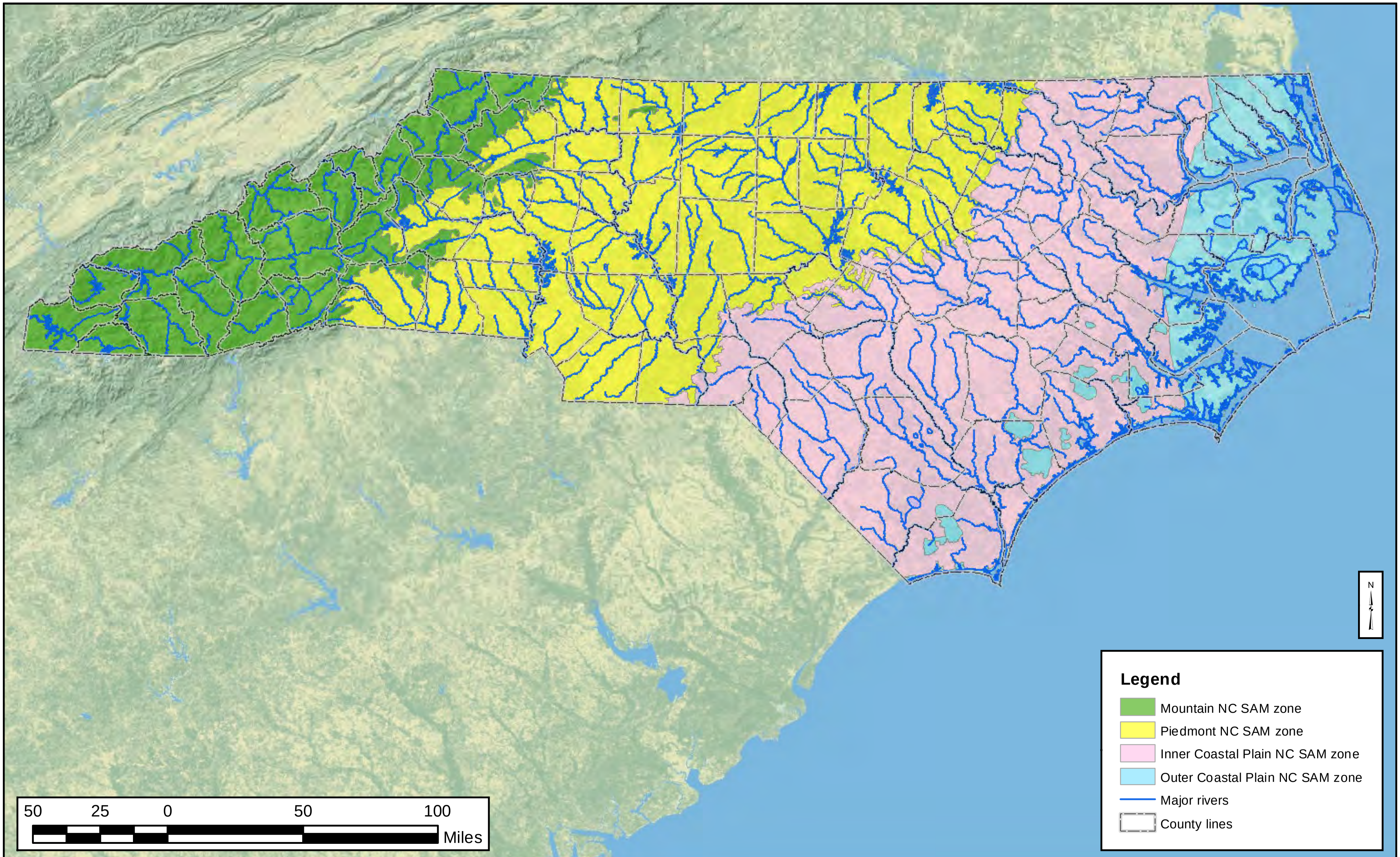
Mountain NC SAM Zone – occurs within the same footprint as the Blue Ridge level III ecoregion and varies in character from narrow ridges to hilly plateaus to more massive mountainous areas with high peaks.

Piedmont NC SAM Zone – occurs within the same footprint as the Piedmont level III ecoregion and is a transition between the Mountains and the Coastal Plain, and is a complex of irregularly dissected plains and some hills.

Inner Coastal Plain NC SAM Zone – comprised of the Southeastern Plains level III ecoregion and the Mid-Atlantic Flatwoods, Carolina Flatwoods, and the Mid-Atlantic Floodplains and Low Terraces level IV ecoregions. The Inner Coastal Plain varies from rolling to hilly terrain with sandy soils to lower, flatter terrain with broad, slow-draining flats of finer-textured soils and large, sluggish river systems.

Outer Coastal Plain NC SAM Zone – comprised of the Chesapeake-Pamlico Lowlands and Tidal Marshes and Nonriverine Swamps and Peatlands level IV ecoregions. The Outer Coastal Plain occurs on the lowest marine terrace east of the Suffolk Scarp in northeastern North Carolina and on flat, poorly drained areas containing organic soils along the full extent of the North Carolina coast.

The assessor records an assessment area's NC SAM Zone in Field Assessment Form Information 15 (p. vii).




NC SAM USER MANUAL

**NC SAM ZONES**

FIGURE 2

### 3.1.2 Geomorphic Valley Shape

The SFAT separated streams based on valley shape (designated “a” [broad, Figure 3A] and “b” [narrow, Figure 3B]). This division is based on a difference in the Streamside Area Attenuation component of the Class 1 function Hydrology provided by these two valley shapes. Broader valley shapes, characteristic of alluvial/unconfined valleys, typically result in flat, wide floodplains that provide more flood water storage, energy dissipation, and nutrient and toxicant retention. Narrower valley shapes, characteristic of colluvial/confined valleys, typically result in steep, confined floodplains, with floodwater energy dissipation as the primary streamside area hydrology function.

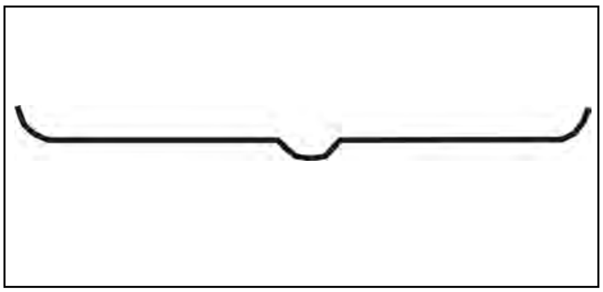


Figure 3A

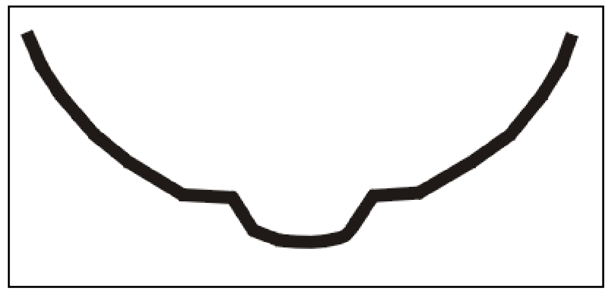


Figure 3B

Figures 3A and 3B are generalizations of the two NCSAM geomorphic valley shapes. Figure 3A depicts a flatter valley shape, which is designated an “a” valley shape. Figure 3B depicts a steeper valley shape, which is designated a “b” valley shape.

The valley shape decision is based on the cross-sectional shape of the geomorphic valley. The assessor records the assessment area valley shape in Field Assessment Form Information 16 (p. vii). Visual examples of “a” valley shapes are provided by Photo 3-1 through Photo 3-4. Visual examples of “b” valley types are provided by Photo 3-5 through Photo 3-9. When an assessor selects an “a” valley type, the evaluation of stream function considers Metrics 13 and 14 (Streamside Area Ground Surface Condition and Streamside Area Water Storage, respectively; see pp. 102 and 105, respectively, and the Field Assessment Form). These two metrics are combined to generate a rating for the Class 4 Microtopography function. When an assessor selects a “b” valley type, Metrics 13 and 14, and therefore the Class 4 Microtopography function, are not considered in the evaluation of stream function.

Selection of valley shape can be problematic in both unaltered and altered settings. To this end the assessor needs to use the best information available to make this decision, keeping in mind the difference in functional processes provided by the two valley types. Alteration of the valley shape cross section typically results in at least a temporary degradation of stream functions; however, with time, streams may adjust to some alterations.

Photo 3-1

Photo 3-2

These four photographs show streams characterized by "a" valley shapes. Photo 3-1 is an unnamed tributary to the Perquimans River (Oa2) in Perquimans County; this reach flows through a mature forest characterized by medium to high stem density. Photo 3-2 is an unnamed tributary to the Neuse River (Ia2) in Johnston County; the aquatic habitat within this reach is enhanced by the presence of multiple logs. Photo 3-3 is the confluence of two unnamed tributaries to Crabtree Creek in Wake County; these are Pa2 streams both above and below the confluence. Photo 3-4 shows Elk Creek (Ma3) on the Watauga/Ashe County line.

Photo 3-3

Photo 3-4

Photo 3-5

Photo 3-6

These photos show streams characterized by "b" valley shapes. Photo 3-5 is an unnamed tributary to the Cape Fear River (Ib2) in Cumberland County, and Photo 3-6 is an unnamed tributary to the Neuse River (Ib1) in Craven County. Both of these streams are cutting through high bluffs on the right banks of the large rivers. Photo 3-7 shows an unnamed tributary to Rogers Lake (Pb2) in Granville County, a stream that drains a series of agricultural fields. Photo 3-8 shows two unnamed tributaries to Elk Creek and their confluence within a residential development (characterized by low stem density) in Ashe County. These reaches, both above and below the confluence, are Mb1 streams.

Photo 3-7

Photo 3-8

Photo 3-9

Photo 3-10

These photos show streams characterized by "b" valley shapes. Photo 3-9 shows an unnamed tributary to Three Top Creek (Mb3) in Ashe County. Photo 3-10 shows Cold Springs Creek (Mb4) in Haywood County.

The following guidance is provided for making a valley shape determination in three general settings: when the valley shape cross section is relatively undisturbed, when the valley shape cross section is disturbed sufficiently to make the determination difficult, and when the assessment reach is part of a tributary that has been excavated in an interstream divide.

<u>When the valley shape is relatively undisturbed</u>

- Make valley shape decision based on the shape of a valley cross section, with the key characteristic being valley side slopes.
- If a stream contains step-pools or cascades, the reach is likely in a "b" valley type.
- Walk 100 feet down the valley and decide if the drop is > 2 feet ("b" valley type) or < 2 feet ("a" valley type).
- The valley shape decision can be difficult when an assessment reach is located high in the landscape/watershed or in a valley characterized by both "a" and "b" valley shapes (i.e. alternating facets of the valley bottom that describe steps). When high in the watershed, an assessment reach may have a narrow floodplain and still be considered to be in an "a" valley shape – since a smaller stream may have a correspondingly

smaller floodplain. In a valley characterized by both “a” and “b” valley shapes, the assessor should consider subdividing assessment reaches when valley shape changes. An assessor may take evidence of valley processes into consideration when making this determination (see discussion in the first paragraph of this section). Assessors should note that in situations where valley shape changes for only a short length, it is not necessary to break out a separate assessment reach.

- A stream may be characterized by a broad valley floor (“a” valley shape) on one side and a steep slope into the stream (“b” valley shape) on the other side (this situation might occur on a reach of a meandering stream located near the valley wall). In this case, the valley is providing “a” valley shape functions and should be rated as such.

<u>When the system is disturbed</u>

- A deeply incised channel in a broad, flat floodplain should be evaluated as an “a” valley (Photo 2-21).
- A broad, flat floodplain that has been narrowed by fill in the floodplain should be evaluated as a disturbed “a” valley.
- A stream may be characterized by a broad valley floor (“a” valley shape) on one side and a steep slope into the stream (“b” valley shape) on the other side (this situation might occur on a reach of stream relocated near the valley wall). In this case, the valley is providing “a” valley shape functions and should be rated as such.
- If the assessor cannot tell what type of valley existed prior to disturbance, topographic and/or soils mapping may prove useful in determining pre-disturbance valley shape (Photo 3-11 and Photo 3-12). If the pre-disturbance valley shape still cannot be determined, a decision should be made based on predominant evidence of the current valley shape. In addition, a similar nearby reference stream of similar watershed size, soil type, and watershed shape can be examined to determine if it would be an appropriate comparison.

<u>When the tributary has been excavated in an interstream divide</u>

- A human-excavated tributary (a ditch subject to federal and/or state jurisdiction) in an interstream divide (Photo 3-13 and Photo 3-14) should be evaluated as an “a” valley type. In this setting, the tributary would not be expected to provide overbank flooding function but would still function as a recipient of overland runoff.

An assessor may consider using other information/methods in order to make this valley type determination (example: valley width/channel width ratio). In this case, the assessor is invited to select “Yes” for Field Assessment Form Information 19 (Are additional stream information/supplementary measurements included in the “Notes/Sketch” section or attached?) (p. vii) and include this information with the completed stream functional assessment information package.

Photo 3-11

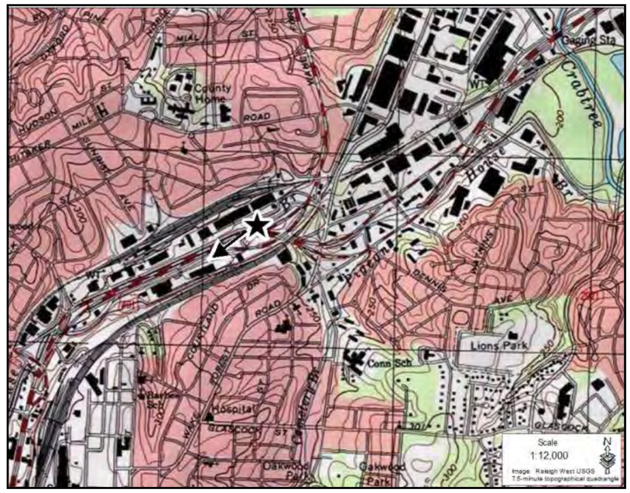




Photo 3-12

Photo 3-11 shows a view upstream (to the southwest) on Pigeon House Creek (Pa3) in Raleigh. This stream is bounded on the right bank by Capital Boulevard, a six-lane, divided highway, and on the left bank by a two-lane paved road and industrial warehouses. Superficially, this stream appears to be in a "b" valley shape, but a look at the topographic mapping (Photo 3-12, the star denotes the approximate location of the camera and the arrow is the direction of view in Photo 3-11) assists with the determination that this stream is incised and located in an "a" valley type characterized by heavy ground-surface manipulation of the floodplain terrace. The two lower photos are of tributaries that have been excavated in interstream divides. Photo 3-13 shows an unnamed tributary to the Pamlico Sound (Oa3) in Hyde County. The removal of woody vegetation from the streamside area has resulted in shading being largely absent from the reach shown. Photo 3-14 shows an unnamed tributary to the Albemarle Sound (Oa2) in Tyrrell County.

Photo 3-13

Photo 3-14

### 3.1.3 Watershed Size

The SFAT has separated streams into four groups based on the area of watershed draining to the lowest point of the stream being assessed. Watershed sizes are designated "Size 1," "Size 2," "Size 3," and "Size 4," from smallest to largest (Table 1, p. 23). For the purposes of NC SAM, the watershed sizes are defined as follows.

Size 1: < 0.1 square mile (< 64 acres)

Size 2: 0.1 to < 0.5 square mile (64 to < 320 acres)

Size 3: 0.5 to < 5.0 square miles (320 acres to < 3200 acres)

Size 4: 5.0 square miles or larger (≥ 3200 acres)

Based on years of field testing, the SFAT has found that within these categories, streams have generally similar characteristics in terms of function. The assessor records an assessment area's watershed size in Field Assessment Form Information 17 (p. vii).

Watershed size can be determined with the use of topographic mapping, which identifies geographical barriers that separate watersheds. The assessor should use contour lines to draw the outer limits of the drainage, from each side of the lowest portion of the stream being assessed, up slope to the nearest geographic barrier separating watersheds. These lines should trace the geographic barrier up the stream valley until meeting at the uppermost point of drainage to the stream being assessed. The area within this perimeter line is the watershed of the stream being assessed. Assessors can determine area of smaller watersheds by hand, while a GIS analysis can be used to determine area for any watershed size. The U.S. Geological Survey has a web utility called StreamStats available online at (http://streamstats.usgs.gov/north_carolina.html) that may prove useful for delineating watersheds for specific points on their stream network. More detailed guidance for determining watershed size is available as Appendix F (this information is also available at http://www.nh.nrcs.usda.gov/technical/Publications/Topowatershed.pdf [Ammann and Stone 1991]).

In regions characterized by poorly defined topography (such as the Coastal Plains) and altered drainage patterns (such as in the Coastal Plains or in urban areas throughout the state), assessors should utilize more detailed information than may be available on a USGS quadrangle, such as LiDAR data, soils mapping, piping schematics, and on-site investigations to determine drainage flow patterns. Roadside ditches and ditches within agricultural fields or forest plots may convey flow in unexpected directions relative to the ground surface topography. Therefore, additional information may be required before determining the actual contributing area to a catchment/watershed.

Watershed size is not considered for streams that meet the criteria of "Tidal Marsh Streams."

## 3.2 Tidal Marsh Streams

A Tidal Marsh Stream is subject to lunar and/or wind tides and is bounded by a tidal marsh. Tidal marshes include two NC Wetland Assessment Method (NC WAM) general wetland types: Salt/Brackish Marsh and Tidal Freshwater Marsh. NC SAM does not include separate watershed size designations or NC SAM Zone designations for Tidal Marsh Streams. Tidal Marsh Streams occur in both the Inner Coastal Plain and Outer Coastal Plain NC SAM Zones.

Tidal Marsh Streams are important conduits of organic export from tidal marshes to open waters as well as access corridors for aquatic life to intertidal zone habitats. As such, their level of connection to the streamside area is a crucial factor in their level of function. Photos 3-15 through 3-20 show examples of Tidal Marsh Streams.

Assessors should be aware that alterations to the intertidal zone may remove or degrade the natural marsh, complicating the identification of this stream category. Some examples of this scenario are the installation of a bulkhead for the purpose of extension of high ground toward a Tidal Marsh Stream and the dredging and widening of a Tidal Marsh Stream for boat access, both of which are shown in Photo 3-19. Examples of degradation include grazing, mowing, and removal of adjacent natural vegetation. The Tidal Marsh Stream shown in Photo 3-19 is both small and has been subjected to degradation.

Photo 3-15

Photo 3-16

These photos are Tidal Marsh Streams influenced by wind tides and bounded by the NC WAM wetland type Salt/Brackish Marsh. Photo 3-15 shows an unnamed tributary to Goose Creek in Beaufort County. Photo 3-16 shows Whitehurst Creek in Beaufort County.

Photo 3-17

Photo 3-18

Photo 3-17 shows an unnamed tributary to Hidden Lake in Tyrrell County. This stream has been excavated in a wetland dominated by the NC WAM wetland type Tidal Freshwater Marsh, and the water level is primarily influenced by wind tides. Photo 3-18 shows Russell Creek in Carteret County, a stream bounded by NC WAM wetland type Salt/Brackish Marsh. The water level in this stream is primarily influenced by lunar tides. Photo 3-19 shows a downstream view of an unnamed tributary to Pages Creek immediately downstream of a road crossing (Bayshore Drive) in New Hanover county. The reach of stream above the road crossing is characterized by a small channel within a Salt/Brackish Marsh wetland, providing evidence that the reach in the near view was likely formerly bounded by marsh as well. This reach downstream of the crossing has been altered by both the construction of bulkheads and docks on the right bank and the dredging and widening of the channel to allow boat traffic. Although little to no marsh wetland is currently abutting the stream, fragmentary remnants of salt marsh persist along the left bank, providing evidence that this is a Tidal Marsh Stream. Photo 3-19 shows an unnamed tributary to Pages Creek immediately upstream of a road crossing (Bayshore Drive, in a different location than is shown to the left) in New Hanover County. This reach of stream is bounded to each side by a narrow band of Salt/Brackish Marsh, and the adjacent uplands are maintained as lawns.

Photo 3-19

Photo 3-20

# 4.0 FIELD EVALUATION PROCESS

NC SAM is applied only to streams that are subject to federal and/or state jurisdictional status. For the purposes of NC SAM, the terms “stream” and “tributary” are synonymous and used interchangeably. Both terms imply federal and/or state jurisdictional status.

NC SAM assesses stream condition as an alternative to direct assessment of stream function. Stream condition can be observed and is more readily assessed than stream function, which must be measured or inferred, usually over an extended time period. Stream condition is determined by evaluating a series of metrics focused on observable evidence of stream condition. The Field Assessment Form provides 25 metrics that are used in different combinations for each stream category to infer the appropriate level of function that matches the current stream condition. Each metric is presented as one or more multiple-choice or yes/no questions. The selected descriptors will be used to determine stream functional ratings.

## 4.1 Evaluation Areas

Each metric requests the assessor to evaluate field indicators within one or more specific areas. The title line for each metric on the Field Assessment Form indicates the area(s) of evaluation for that metric. Four different areas may be evaluated: 1) assessment reach, 2) streamside area, 3) assessment area, and 4) watershed.

### 4.1.1 Assessment Reach

The “assessment reach” is the defined reach of stream that is subject to functional assessment using NC SAM. More specifically, this term refers to the area within the normal wetted perimeter of the stream reach subject to functional assessment.

Each distinct tributary within a project area should be assessed. No minimum length is suggested for an assessment reach. The following guidance is provided for determining the number and length of assessment reaches that may be evaluated for a project. Four features may be used to identify assessment reach termini: 1) project area boundary, 2) NC SAM stream category boundary, 3) the confluence of streams of equal NC SAM watershed size, and 4) a substantial change in in-stream and/or streamside area conditions. A change in any one of these features is sufficient reason for a change in assessment reach. See the following discussion for guidance in making assessment reach termini determinations.

1. The project area boundary is an assessment reach terminus.
2. NC SAM stream category boundaries as defined in Section 3.0. This includes a change in designation of any of the following: NC SAM Zone (Mountain, Piedmont, Inner Coastal Plain, and Outer Coastal Plain), geomorphic valley shape (broad [a] or narrow [b]), watershed size (Sizes 1, 2, 3, and 4), or Tidal Marsh Stream versus non-Tidal Marsh Stream. When circumstances result in a short reach of one stream category abutting a longer reach of another stream category (example: the location of the project area boundary near a confluence), the system can be treated as one assessment reach if there is no change in in-stream and/or streamside condition.

3. The confluence of streams of equal NC SAM watershed size is an assessment reach terminus. When two streams of unequal NC SAM watershed sizes meet, the assessor should consider guidance provided in item 4 below.
4. A substantial change in in-stream and/or streamside area conditions is an assessment reach terminus. Consideration should be given to project area characteristics as a whole relative to the extent of the effect of an alteration when making this decision. When determining assessment reach termini based on a difference between in-stream or streamside area characteristics, the assessor should document reasons for this decision on the Field Assessment Form.

   Small or limited changes in condition should not result in a break in assessment reaches (some examples may include a) a narrow utility line corridor, characterized by vegetation maintenance and little to no in-stream disturbance, that makes a perpendicular tributary crossing within a forested region and/or b) a greenway path that extends along a short reach of a project area tributary within an otherwise forested landscape).

   Examples of substantial changes in condition that should result in a break in assessment reaches include, but are not limited to, the following: a) a change in physical characteristics in the stream or streamside area resulting from one or more watershed disturbances, b) a change between perennial and intermittent stream flow regime, and c) the terminus of a swamp stream.

   a. A change in condition resulting from watershed disturbances is an assessment reach terminus.

      Larger scale or substantial changes in in-stream or streamside area conditions will result in a break in assessment reaches. For instance, a wide, maintained utility line corridor (Photo 4-1) will result in a break in assessment reaches.

Photo 4-1

Photo 4-1 shows a reach of Sycamore Creek (Pb4) within William B. Umstead State Park (Wake County) subjected to regular vegetation maintenance within a power line right-of-way. The length of the stream within this maintained corridor is long enough to be separated into a separate assessment reach from the reaches within woodlands to either side.

      When a stream of larger NC SAM watershed size has a confluence with a stream of smaller NC SAM watershed size, the assessor has the latitude to subdivide the larger stream assessment reach based on observed stream conditions. If there is little change observed in the condition of the larger stream channel from above the confluence to below the confluence, there is no reason to subdivide the larger stream into two assessment reaches (result: one assessment reach for the larger stream). However, if the larger stream drains a relatively undisturbed watershed and the smaller stream drains a disturbed watershed (some examples include: parking lots or buildings with maintained yards resulting in increased surface runoff, agricultural lands with increased surface runoff and/or increased sedimentation), and the effects of the disturbed watershed (some examples include: increased sedimentation in the channel and/or the streamside area, surface scouring of the bank and/or the streamside area) are visible in the larger stream below the confluence, the assessor should make the confluence an assessment reach terminus for the larger stream (result: two assessment reaches).

b. A change between perennial and intermittent stream flow regime is an assessment reach terminus.

NC SAM typically generates one set of ratings for the function classes and the overall assessment area. However, NC SAM recognizes that perennial streams exhibit typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water, while intermittent streams often lack one or more of these characteristics. In consideration of this, in combination with a difference in regulatory agency stream function purview, the SFAT has developed separate rating schemes (Boolean logic algorithms) to reflect a difference in function between perennial and intermittent streams. For perennial streams, NC SAM generates one set of ratings for the function classes and the overall assessment area. For intermittent streams, NC SAM generates two sets of ratings: one set that provides ratings relative to functional expectations of perennial streams, and a second set that provides ratings relative to functional expectations of intermittent streams (presented in the "Intermittent" column on the Stream Rating Sheet [see p. xi]).

c. The terminus of a swamp stream is an assessment reach terminus.

"Swamp streams" occur within the Coastal Plain NC SAM zones (both the Inner Coastal Plain and the Outer Coastal Plain), are wadeable at some point in the year (not too big), regularly use their large floodplains, may exhibit either an intermittent or perennial flow regime, and normally have no visible flow during a part of the year. The low-flow period usually occurs during summer months, but flowing water should be present in swamp streams during the winter months. Swamp streams include both multi-thread (Photo 4-2) and single-thread (Photo 4-3) channels. For the purposes of NC SAM, swamp streams are characterized by stable channels; unstable channels are not candidates for swamp streams. An excavated channel (such as a ditch or canal) within a natural topographic crenulation is not a swamp stream if it is deep enough to allow groundwater flow all year and/or it is disconnected from its floodplain. Ditches and canals on interstream divides are not candidates for swamp streams.

NC SAM recognizes that swamp streams exhibit low dissolved oxygen, low pH (high acidity), and aquatic life populations with low species diversity relative to non-swamp streams of the same NC SAM category. In consideration of this, the SFAT has developed a separate rating scheme (Boolean logic algorithms) for swamp streams to reflect a difference in function from non-swamp streams.

Photo 4-2

Photo 4-3

Photo 4-2 shows a multi-thread channel that is part of Honey Island Swamp (Oa3) in Brunswick County. This photo was taken in February. The channel is expected to have low-flow or be dry in the summer. Note in Figure 2 and Appendix E that while much of Brunswick County is in the Inner Coastal Plain NC SAM zone (I), the area mapped as Nonriverine Swamps and Peatlands level IV ecoregion is included within the Outer Coastal Plain NC SAM zone (O). Photo 4-3 shows an unnamed tributary to the Neuse River (Ia2) in Johnston County. This photo was taken in September, when the stream had no flow.

When practicable, the assessment reach should include at least a portion of a riffle-run section and/or a pool-glide section (Figure 4) to completely evaluate a full suite of in-stream bed features. See the Metric 11 (Bedform and Substrate, p. 85) text for a discussion of these streambed features. When not practicable to include both a riffle-run section and a pool-glide section in the assessment reach, and when a portion of at least one of these bedforms occurs within the assessment reach, a riffle-run section and/or a pool-glide section outside of, but still within sight of the assessment reach may be used in the evaluation. This may be necessary if a short assessment reach does not include all of these bedforms. However, it is recommended that the assessor only utilize extra assessment area bedforms when in-stream and streamside conditions are similar to those of the assessment reach; more specifically, do not use extra-assessment reach bedforms located beyond any of the other assessment reach terminus features listed above with the exception of item 1 (project boundary). Also, an assessor should not use extra-assessment reach bedforms if natural bedform is absent from the assessment reach.

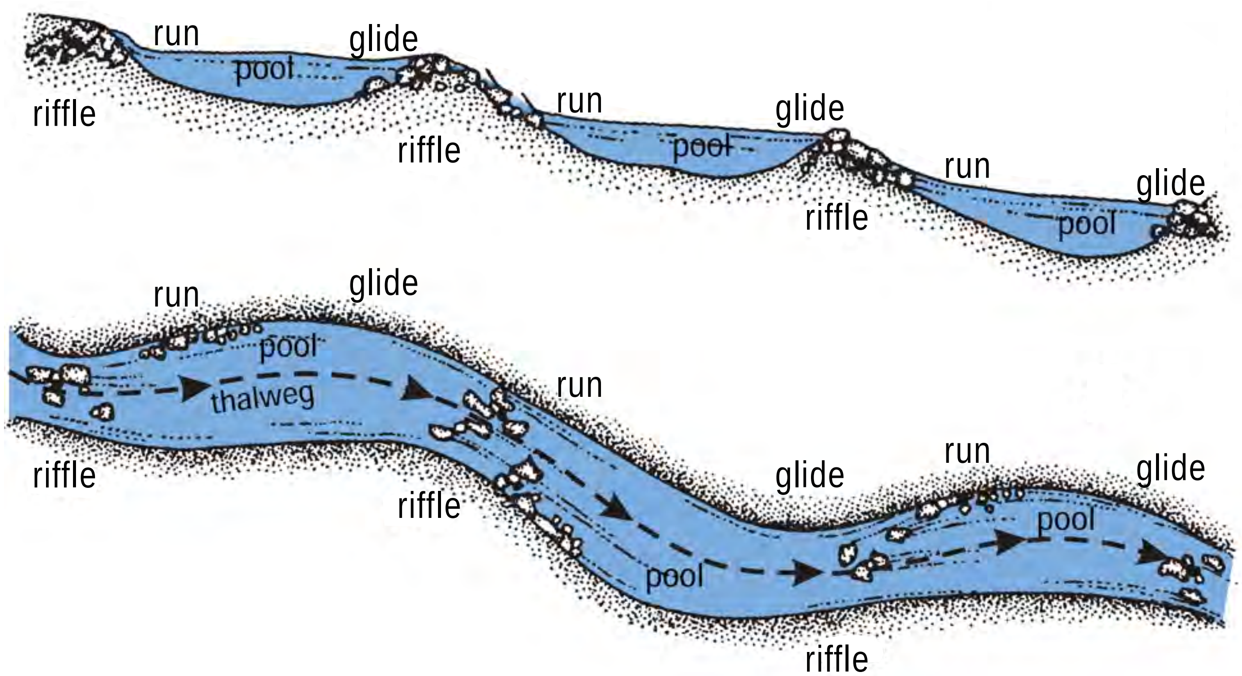



Figure source: Harmon and Jennings 1999a

| NC SAM USER MANUAL | EXAMPLE STREAM BEDFORM | FIGURE 4 |
|---|---|---|

### 4.1.2 Streamside Area

NC SAM considers the "streamside area" to be the area of land contiguous with the assessment reach, extending perpendicular to elevation contour lines to a distance of 300 feet or to the natural topographic high point, whichever is reached first. For multi-channel systems, the streamside area is the area of land contiguous with the outermost channels, extending perpendicular to elevation contour lines to a distance of 300 feet or to natural topographic high point, whichever is reached first.

The assessor should include portions of the streamside area that artificially drain away from the assessment reach. Examples of such alterations include curb-and-gutter roads and parking lots, ditches, berms, stormwater diversion, and grading. Therefore, in order to capture alterations from reference, the streamside area may extend outside of the assessment reach watershed.

The following guidance is provided for determining the streamside area in instances where more than one tributary shares a common floodplain. This typically occurs in "a" valley shapes and is much less common in "b" valley shapes (Figures 3A and 3B on p. 26).

- When two or more equally dominant tributaries share a floodplain, the streamside area of each tributary extends to the top of the near bank of the other tributary or, if present, to a natural high point within the floodplain that separates the tributaries.
- However if one tributary is dominant, the streamside area of the dominant tributary is not interrupted by the subordinate tributary. The dominant tributary is the tributary that clearly exerts the most influence over the in-stream and/or streamside character at the confluence. The streamside area of the subordinate tributary extends to the top of the near bank of the dominant tributary or, if present, to a natural high point within the floodplain that separates the tributaries. When an "a" valley tributary has a confluence with a "b" valley tributary, the "a" valley tributary is always dominant.

For Tidal Marsh Streams, streamside area is equivalent to the marsh intertidal zone extending perpendicular from the assessment reach to the edge of marsh or to a distance of 300 feet, whichever is reached first. It is important to note that the marsh intertidal zone will consist of either of two NC WAM wetland types: Salt/Brackish Marsh or Tidal Freshwater Marsh.

### 4.1.3 Assessment Area

The "assessment area" is a defined area of stream and contiguous land that is subject to functional assessment using NC SAM. The assessment area comprises an assessment reach and the associated streamside area.

### 4.1.4 Watershed

The NCDWQ (and NC SAM) considers the watershed to be the entire land area contributing surface drainage to a specific point (15A NCAC .02B .0200). The USACE uses the term "catchment" to refer to this same concept. For the purposes of NC SAM, the "watershed" of an assessment area typically includes the area draining to the lowest point of the assessment reach. The watershed is considered only twice in NC SAM: 1) for the evaluation of Information

17 (Watershed size [p. vii]) and 2) in the evaluation of Metric 17 (Baseflow Detractors, descriptor "C" [p. ix]).

## 4.2 Field Assessment Form

The most current version of the Field Assessment Form as of the date of generation of this User Manual is provided as pp. vii-x at the beginning of the User Manual. The corresponding version of the User Manual is indicated at the top of the form. Below the User Manual version are two blank spaces for regulatory agency identification numbers (USACE Action Identification [AID] # and NCDWQ #).

The assessor is to evaluate the assessment area based on conditions present on the day of the field visit, not on previous conditions or anticipated future conditions. It is critically important that the assessor walk the entire assessment area prior to completing the Field Assessment Form. During this investigation, the assessor should identify the streamside area, make note of the presence of potential stream stressors (such as roads, utility lines, maintained vegetation, septic fields, and stormwater runoff), and consider the effect of potential stressors on the assessment area. The assessor should take notes liberally (taking photographs if appropriate), documenting important site features and best professional judgment on the Field Assessment Form. The assessor should consider representative portions of the stream and streamside area when evaluating the assessment area.

### 4.2.1 Introductory Information

The boxed area on the first page of the Field Assessment Form includes instructions and information about the assessment area and associated watershed. This section includes 19 informational questions referred to in this discussion, but not on the Field Assessment Form, with the term "Information" followed by an Arabic numeral.

**Instructions**

The assessor is urged to attach additional information pertinent to the stream assessment to the completed Field Assessment Form and Stream Rating Sheet. Examples of useful additional information include the following.

- Assessment area sketch and/or higher quality map (topography, aerial photography, soils, etc.)
- Notes regarding the locations of potential assessment area stressors (such as roads, utility lines, maintained vegetation, septic fields, livestock, and stormwater runoff) and the observed evidence of the effects of stressors within the assessment area.
- Photographs
- Optional information and supplementary measurements that may be useful in the site assessment (some examples include: assessment reach bankfull width, bank height ratio, valley width/channel width ratio, results of a more detailed macrobenthos survey than required by NC SAM guidance, water chemistry measurements compared to water-quality standards, NCDWQ Stream Identification Form [NCDWQ 2010], NC WAM Field Assessment Forms/Wetland Rating Sheets [WFAT 2010], etc.).

**Note Evidence of Stressors Affecting the Assessment Area**

The assessor is urged to record descriptions of stressors affecting the assessment area. Descriptions should be recorded on either the assessment area figure or in the "Notes/Sketch" section of the Field Assessment Form (or both). The assessor is reminded that stressors affecting the assessment area do not necessarily have to be located within the assessment area.

**Project/Site Information**

These blanks are used to record general information concerning the setting, time, and assessor involved in the stream assessment.

Information 1. Project name – Name used to identify the assessment area.

Information 2. Date of evaluation – Date of the field assessment.

Information 3. Applicant/owner name – Name of the authorized entity applying for a permit or the owner of the property.

Information 4. Assessor name/organization – Name and affiliation (agency, company) of the party responsible for the evaluation decisions. Please note that if the assessment is conducted by an authorized entity other than the applicant and submitted to the USACE in support of a permit application, the USACE must be in receipt of an agent authorization letter signed by the owner.

Information 5. County – Name of the North Carolina county in which the assessment area is located

Information 6. Nearest named water body on USGS 7.5-minute quad – Name of the nearest named water body as indicated on the USGS 7.5-minute quadrangle or other reliable resource.

Information 7. River basin – Name of the river basin. The assessor should provide the eight-digit catalogue unit (available from the U.S. Geological Survey (USGS) Watershed Boundary Dataset [http://nhd.usgs.gov/wbd.html] and NCDWQ basinwide management plans [http://portal.ncdenr.org/web/wq/ps/bpu]).

Information 8. Site coordinates (decimal degrees, at lower end of assessment reach) – Coordinates should be provided in decimal degrees to six significant figures (example: 35.123456°, -79.123456°).

**Stream Information**

These questions are used to record information specific to the channel and bank morphology.

Information 9. Site number (show on attached map) – Record the site number here if multiple stream assessments are conducted. The sites should be identified by number on the accompanying map.

Information 10. Length of assessment reach evaluated (feet) – Provide the approximate centerline length of the assessment reach. The unit of measure should be feet. Estimates of length, rather than exact measurements, are acceptable.

Information 11. Channel depth from bed (in riffle, if present) to top of bank (feet) – Record the approximate average vertical distance from the channel bed to the top of bank within the assessment reach. If the two banks are of uneven height, record the approximate average vertical distance from the channel bed to the top of the lower bank. The unit of measure should be feet. This measurement should be made in a riffle; but a measurement from another part of the stream is acceptable if there is no riffle within the assessment reach. Please note that this is not a request for vertical distance from channel bed to "bankfull, but rather a measure of vertical distance to the point where flows within the channel will spill over a bank of the channel on the lowest side;" however, if a bankfull height determination is made, this information may be recorded in the "Notes/Sketch" section of the Field Assessment Form if available (and "Yes" should be checked for Information 19). Estimates of channel depth, rather than exact measurements, are acceptable. A check box is provided to document circumstances where circumstances prevent a determination of channel depth.

Information 12. Channel width at top of bank (feet) – Record the horizontal distance between the tops of bank. The unit of measure should be feet. Please note that this is not a request for horizontal width at "bankfull" elevation; however, if a bankfull determination is made, this information may be recorded in the "Notes/Sketch" section of the Field Assessment Form. Estimates of channel width, rather than exact measurements, are acceptable.

Information 13. Is assessment reach a swamp stream? "Swamp streams" occur within the Coastal Plain NC SAM zones (both the Inner Coastal Plain and the Outer Coastal Plain), are wadeable at some point in the year (not too big), regularly use their relatively large floodplains, and normally have no visible flow during a part of the year. The low-flow period usually occurs during summer months, but flowing water should be present in swamp streams during the winter months. Other typical characteristics of swamp streams include low dissolved oxygen, low pH (high acidity), and aquatic life populations with low species diversity. Swamp streams include both multi-thread (Photo 4-2) and single-thread (Photo 4-3) channels. An excavated channel (such as a ditch or canal) within a natural topographic crenulation is not a swamp stream if it is deep enough so that groundwater flows all year and/or it does not regularly use its relatively large floodplain. Ditches and canals on interstream divides are not candidates for swamp streams.

Information 14. Feature type – Indicate whether the assessment reach is subject to perennial or intermittent flow, or is a Tidal Marsh Stream. NC SAM is only to be used on features that have already been evaluated as being subject to federal or state jurisdiction; therefore, this feature type determination should already be available to the assessor.

- Perennial flow/stream – A perennial stream has a well-defined channel that contains water year-round during a year of normal rainfall with the aquatic bed located below the water table for most of the year. Groundwater is the primary source of water for a perennial stream, but it also carries stormwater/overland runoff. A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water (15A NCAC 02B .0233 (2)(i)). When a determination between perennial and intermittent flow is in question, consider use of NCDWQ Stream Identification Form (NCDWQ 2010) for clarification. A completed Stream Identification Form may be attached as part of the assessment documentation.

- Intermittent flow/stream – An intermittent stream has a well-defined channel that contains water for only part of the year, typically during winter and spring when the aquatic bed is below the water table. The flow may be heavily supplemented by stormwater inputs. An intermittent stream often lacks the biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water (15A NCAC 02B .0233(2)(g)). When a determination between perennial and intermittent flow is in question, consider use of NCDWQ Stream Identification Method (NCDWQ 2010) for clarification. A completed Stream Identification Form may be attached as part of the assessment documentation.
- Tidal Marsh Stream – A Tidal Marsh Stream is a stream subject to lunar and/or wind tides that is bounded by a tidal marsh. Tidal marshes include NC Wetland Assessment Method (NC WAM) general wetland types Salt/Brackish Marsh and Tidal Freshwater Marsh.

**Stream Rating Information**

Results of the four questions comprising this section are used by the Rating Calculator to determine stream category.

Information 15. NC SAM Zone – Select the appropriate NC SAM Zone for the location of the assessment reach (Mountain, Piedmont, Inner Coastal Plain, Outer Coastal Plain; see Figure 2). Guidance for making the NC SAM Zone determination is provided in User Manual Section 3.1.1 (p. 24).

Information 16. Estimated geomorphic valley shape – Select the appropriate valley shape from the two options. Guidance for making the valley shape determination is provided in User Manual Section 3.1.2 (p. 26). This information is not used for Tidal Marsh Streams.

Information 17. Watershed size – Select the appropriate NC SAM watershed size (Sizes 1, 2, 3, or 4). Guidance for making the NC SAM watershed size determination is provided in User Manual Section 3.1.3 (p. 32). This information is not used for Tidal Marsh Streams.

**Additional Information**

These questions are used to provide additional information for regulatory personnel and are located within the introductory information box on the Field Assessment Form.

Information 18. Were regulatory considerations evaluated? Evaluation of regulatory considerations will likely require an office effort. Select "Yes" if the assessor considered each of the regulatory considerations in the list. Select "No" if the assessor did not take the time to consider each of the regulatory considerations in the list. The assessor should check the box for any regulatory consideration that applies to the assessment area. More than one of the listed considerations may apply and therefore may be checked. The results of this evaluation will not be used in functional rating calculations. The overall Stream Rating Sheet will indicate if any regulatory considerations were selected as applying to the assessment area.

- “Section 10 water” – Section 10 waters are those waters subject to Section 10 of the Rivers and Harbors Act of 1899, which include all navigable waters of the United States. Navigable waters of the United States are defined in 33 CFR Part 329 as those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the water body, and is not extinguished by later actions or events which impede or destroy navigable capacity. (Note, however, that “navigable waters of the U.S.” is only a subset of "waters of the United States," which include not only navigable waters of the United States, but also waters with "a significant nexus to navigable waters," both of which are covered under the Clean Water Act.).
- “Essential fish habitat” (EFH) – Important habitat for federally managed fishery species. EFH is protected in accordance with 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) in an effort to maintain sustainable fisheries. Within the area encompassed by the NMFS Southeast Region, EFH has been identified for hundreds of marine species. Additional information is available at http://sero.nmfs.noaa.gov/hcd/efh.htm.
- “Publicly owned property” – Property ownership should always be established prior to an assessor making a site visit.
- “Anadromous fish” – The assessor should select “anadromous fish” if there are either direct observations or documentation of the presence of anadromous fish within the assessment area. Anadromous fish spend their adult life at sea, but swim up-river to freshwater spawning grounds to reproduce. Examples include shad, herring, and striped bass. This term is often used interchangeably with “diadromous.” The term “diadromous” refers to any fish that migrates between saltwater and freshwater.
- “Classified Trout Waters” – For the purposes of NC SAM, this term refers to an NCDWQ supplemental classification intended to protect freshwaters for natural trout propagation and the survival of stocked trout (15A NCAC 02B .0301). To receive a Trout waters (Tr) classification, the proposed open water must have conditions that will sustain and allow for trout propagation and survival of stocked trout on a year-round basis (15A NCAC 02B .0202). NCDWQ Trout water mapping is available online at http://portal.ncdenr.org/web/wq/ps/csu/maps under the heading “GIS Downloads” in the bullet entitled “Named and Unnamed Water Bodies (w/ classifications).”
- “Primary Nursery Area” (PNA) – Tidal salt waters which provide essential habitat for the early development of commercially important fish and shellfish and are so designated by the Marine Fisheries Commission. Information concerning the location of Primary Nursery Areas is available in 15A NCAC 03R .0103. The assessor should use best professional judgment when considering if the distance between the assessment area and a designated PNA makes selection of this descriptor appropriate. Information concerning the identification and location of Primary Nursery Areas is available in 15A NCAC 03N 0.0104 and 15A NCAC 03R .0103, respectively. The assessor should use best professional judgment when considering if the distance between the assessment area and a designated PNA makes selection of this descriptor appropriate.

- "NCDWQ riparian buffer rule in effect" – The assessor should select "Riparian buffer rule in affect" only if the N.C. Environmental Management Commission (EMC) has instituted buffer rules that apply to the assessment area (can be found on-line at the following web site: http://portal.ncdenr.org/web/wq/swp/ws/401/riparianbuffers/rules) and the stream assessment reach is approximately shown on either the most recent version of the soil survey map prepared by the Natural Resources Conservation Service of the U.S. Department of Agriculture, or the most recent version of the 1:24,000 scale (7.5-minute) quadrangle topographic maps prepared by the USGS, or is otherwise subject to those rules. The NCDWQ maintains a list of most current soil surveys at the following web site: http://portal.ncdenr.org/web/wq/swp/ws/401/riparianbuffers/maps#Soil_Survey_Maps.
- "303(d) list" – Information concerning the names of current 303(d)-listed streams is available through NCDWQ N.C. Water Quality Assessment and Impaired Waters list located at the following website: http://portal.ncdenr.org/web/wq/ps/mtu/assessment.
- "Water Supply Watershed" (examples: WS-I, WS-II, WS-III, WS-IV, and WS-V) – Surface water quality classifications are available through NCDWQ stream classification schedules and other publications and can be found on-line at the following web site: http://portal.ncdenr.org/web/wq/ps/csu/classifications.
- "High Quality Waters/Outstanding Resource Waters" – High Quality Waters (HQW) is a supplemental classification intended to protect waters which are rated excellent based on biological and physical/chemical characteristics through NCDWQ monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Marine Fisheries Commission. All Outstanding Resource Waters (ORW) are a subset of HQW. This supplemental classification is intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance Outstanding Resource Waters (ORW). These definitions can be found on-line at the following web site: http://portal.ncdenr.org/web/wq/ps/csu/classifications.
- "Nutrient Sensitive Waters" – Nutrient Sensitive Waters (NSW) is an NCDWQ supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation (http://portal.ncdenr.org/web/wq/ps/csu/classifications).
- "CAMA Area of Environmental Concern (AEC)" – "CAMA" refers to "Coastal Area Management Act." Communication with a NCDCM representative or familiarity with the most current version of the "CAMA Handbook for Development in Coastal North Carolina" (located on the web at http://dcm2.enr.state.nc.us/) will aid the assessor in determining whether the assessment area includes an AEC.
- "Documented presence of a federal and/or state listed protected species within the assessment area" – If there are either direct observations or documentation of the presence of these species within the assessment area, the assessor should select this box and list the species. Sources for documentation include the U.S. Fish and Wildlife Service and the N.C. Natural Heritage Program.

- "Designated Critical Habitat (list species)" – Designated Critical Habitat are areas that have been determined by the U.S. Fish and Wildlife Service to be essential to the conservation of a species listed as either Endangered or Threatened under the Endangered Species Act. If the assessment area contains designated Critical Habitat, the assessor should check the box and list the species for which Critical Habitat has been designated.

Information 19. Are additional stream information/supplementary measurements included in notes or attached? Select yes if additional information has been included in the "Notes/Sketch" section of the Field Assessment Form or has been attached. This question refers to more detailed information concerning stream condition/function than is required in order to generate a stream rating. Examples include stream measurements (such as assessment reach bankfull width, valley width/stream width ratio, entrenchment ratio, and bank height ratio), a completed NCDWQ Stream Identification Form, and the results of a more intensive benthic survey.

### 4.2.2 Metrics

For the purposes of NC SAM, metrics are specific inquiries required to evaluate various stream functions. The Field Assessment Form (pp. vii-x) includes 25 metrics. The metric name and evaluation area are included in the metric title line. For example, Metric 1 (see below) is titled "Channel Water," and the evaluation area to be considered is the assessment reach. Also included on the title line are metric stream category limitations, if relevant. For example, in the case of Metric 1, an assessor may skip the evaluation of this metric for Size 1 streams and Tidal Marsh Streams. Each metric is composed of one or more questions. For each metric, the assessor is provided two or more possible descriptors for documentation of the evaluation. Each descriptor is accompanied by a box. The evaluation of each metric will involve the selection of one or more descriptors by checking the appropriate box(es). When applicable, the assessor will be instructed that more than one box can be checked.

The assessor is requested to evaluate individual banks for some metrics. In this case, left bank (LB) and right bank (RB) are named facing downstream on non-tidal streams and toward the mouth of tidal streams.

This section lists each of the 25 metrics in order of appearance on the Field Assessment Form, and includes a clarifying discussion of the metric intent and considerations for selecting the appropriate descriptor.

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**

☐A Water throughout assessment reach.
☐B No flow, water in pools only.
☐C No water in assessment reach.

This metric is used in the determination of Baseflow, an important component of all three Class 1 functions in Sizes 2, 3, and 4 streams.

The assessor should consider the assessment reach when evaluating this metric. The "channel water" evaluation should be based on conditions that exist on the day of the site visit. A typical situation in which descriptor "B" (No flow, water in pools only) is appropriate is an assessment reach with water only in pool sections. If water only occurs in a scour hole, descriptor "C" (No water in assessment reach) is appropriate. Photo 4-4 provides an example of a stream that is evaluated as descriptor "B." Photo 4-5 provides an example of a stream that is evaluated as descriptor "C."

Photo 4-4

Photo 4-5

Photo 4-4 is an unnamed tributary to Carvers Creek (Ia2) in Cumberland County. This stream drains a residential area characterized by maintained lawns and paved roads and driveways that increase surface runoff following precipitation events resulting in flashy flows in the stream. Channel water in the reach shown is characterized as "no flow, water in pools only." Photo 4-5 is Hector Creek (Ia3) on the Moore/Cumberland County line. This Sandhills stream is lacking channel water.

## 2. Evidence of Flow Restriction – assessment reach metric

☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction or fill to the point of obstructing flow or a channel choked with aquatic macrophytes or ponded water or impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).

☐B Not A

This metric is used for all streams in the determination of the In-stream Habitat component of the Class 1 Habitat function. For Tidal Marsh Streams, this metric is used in the determination of all three Class 1 functions. This metric requires that an assessor determine if there is a flow restriction that affects the assessment reach. Note that although the restriction itself can be located above or below the assessment reach, the assessor must observe evidence of the restriction within the assessment area.

To be evaluated as descriptor "A," the assessment reach must exhibit evidence that the flow restriction severely affects in-stream habitat, and the severe effect must be evident over at least 10 percent of the assessment reach. The source or reason for the flow restriction may be man-made or natural. Examples of flow restrictions that may severely affect in-stream habitat and/or riffle-pool sequence (resulting in a descriptor "A" for this metric) include undersized or perched culverts, man-made berms or causeways that constrict the channel and associated floodplain (Photo 4-6), beaver dams (Photo 4-7), fill in the channel that obstructs flow (Photo 4-8), man-made dams or weirs (Photo 2-37), dense vegetation in the channel (Photo 4-9 and Photo 4-10), ponding of water within the channel (Photo 2-36), locks, tide gates, and natural debris jams (Photo 4-11).

Photo 4-6

Photo 4-7

These photos provide examples of flow restrictions that have affected in-stream habitat. Photo 4-6 is Church Creek (Pa3) in Rowan County, a stream subject to flashy flows due to watershed disturbances. The restriction is caused by both a man-made berm across the floodplain and perched culverts, which have concentrated flow resulting in an unstable, down-cut channel. Photo 4-7 is an unnamed tributary to Jimmy's Creek (Pa1) in Davidson County and shows a reach of stream between a beaver dam and an undersized culvert. The dam acts as an obstruction that passes some flow during low-flow periods, and is therefore a baseflow contributor. Photo 4-8 is an unnamed tributary to the Davidson River (Mb1) in Transylvania County and shows a reach of stream above an undersized culvert that has created an organic debris "log-jam" at a culvert inlet. Photo 4-9 is an unnamed tributary to the Neuse River (Ia2) in Wayne County and shows a straightened channel choked with aquatic vegetation. The removal of streamside area woody vegetation has resulted in shading being largely absent from this reach.

Photo 4-8

Photo 4-9

Photo 4-10

Photo 4-11

These photos provide examples of flow restrictions that have affected in-stream habitat. Photo 4-10 is an unnamed tributary to the Neuse River (Ia2) in Craven County and shows a Riverine Swamp Forest, which has developed a dense root mat that acts as a natural dam at the confluence of the tributary and the Neuse River. Photo 4-11 is an unnamed tributary to Stonyton Creek (Ia2) in Lenoir County and shows a natural debris dam upstream of roots extending across the stream bed. Note the aquatic macrophytes just upstream of the debris jam.

### 3. Feature Pattern – assessment reach metric

☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
☐B Not A

For all streams, this metric is used in the determination of the Stream Geomorphology component of the Class 1 Hydrology function. An assessor should consider the entire assessment reach when evaluating this metric. In the case of a long assessment reach, this evaluation may involve a mapping exercise. In cases where the location of a project boundary results in a short assessment reach, an assessor may need to look at a portion of the stream outside of the assessment reach to evaluate this metric. It is recommended that the assessor only use extra-assessment reach pattern where conditions are similar to those of the assessment reach.

For the purposes of NC SAM, the term “altered” means a change resulting from human activity. “Appropriate pattern” refers to the sinuosity or meander geometry a stream naturally develops based on its landscape location. Typically, a steeper valley slope corresponds to streams with less sinuosity, while a flatter valley slope corresponds to streams with more sinuosity. An assessor should be able to document evidence to support evaluating an assessment reach as descriptor “A.”

Descriptor “A” provides examples of activities that may result in an alteration to stream pattern. This metric is concerned with the identification of alterations to the natural pattern of a stream, regardless of whether the alteration has resulted in instability. If a stream has been dredged but not straightened, it would likely be evaluated as descriptor “B.” If a stream has been straightened in place (Photo 4-12 through Photo 4-14) or relocated and straightened (Photo 4-15 and Photo 4-16), it should be evaluated as descriptor “A.” However, if a stream has been relocated but is currently characterized by appropriate pattern, it may still be evaluated as descriptor “B.” Also, if a stream has been subject to alteration and has subsequently recovered the appropriate pattern, it may be evaluated as descriptor “B.” For instance, if an appropriate pattern for the slope has developed in the bottom of an overly widened ditch, the stream may be rated as descriptor “B.”

Photo 4-12

Photo 4-13

Photo 4-14

These photos provide examples of alterations to stream pattern resulting in a rating of descriptor "A." Photo 4-12 is an unnamed tributary to Skewakee Gut (Ia1), and Photo 4-13 is an unnamed tributary to Beaverdam Creek (Ia2), both in Martin County. Both photos show straightened streams; the former is characterized by a concrete bed. Photo 4-14 is an unnamed tributary to the Pasquotank River (Oa2) in Camden County and shows the straightening of a stream reach downstream of a culvert to promote flow away from the culvert in a relatively flat, low-energy environment. Photo 4-15 is an unnamed tributary to Knap of Reeds Creek (Pa3) in Granville County that has been relocated and straightened at the toe of the valley wall to allow room for a wider community park. Photo 4-16 is Hewletts Creek in New Hanover County, a Tidal Marsh Stream. The large picture was taken looking north from the road crossing shown in the inset. This reach of Hewletts Creek has been relocated from the middle of the marsh to one side of the marsh; the photo inset confirms that the relocated reach is much straighter than the original channel.

Photo 4-15

Photo 4-16

## 4. Feature Longitudinal Profile – assessment reach metric

☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).

☐B Not A

For all streams, this metric is used in the determination of the Stream Geomorphology component of the Class 1 Hydrology function and the In-stream Habitat component of the Class 1 Habitat function. For the purposes of NC SAM, the term "altered" means a change resulting from human activity. The term "longitudinal profile" refers to the bed elevations of a channel along its length. "Appropriate" channel profile is somewhat dependent on the landscape location of a stream. Streams within steeper valleys may be characterized by a step-pool profile. Streams in flatter valleys may be characterized by alternating riffle-run and pool-glide sections. Riffles are expected to occur on straight sections of streams and are relatively steep in comparison with pools. Pools are expected to occur on the outside of meander bends or at the bottom of steps. Pool sections are relatively flat compared with riffle sections. See the discussion of Metric 11b (p. 86) for more details concerning these bedform types.

This metric requires an assessor to determine if a substantial alteration to the stream profile occurs within the assessment reach; the cause of the alteration may be located outside of the assessment reach. Descriptor "A" provides examples of conditions within the assessment reach that are indications of a substantial alteration to longitudinal profile. Examples of alterations beyond the assessment reach that may affect the longitudinal profile include a perched upstream culvert (Photo 4-6), a channel restriction downstream of the assessment reach (like a beaver dam, Photo 4-7), streamside area vegetation removal, and increased impervious surface within the watershed (Photo 2-33).

Photo 4-17 through Photo 4-19 are streams with substantially altered profiles (descriptor "A"). Photo 4-17 shows a stream with masonry banks and bed. Photo 4-18 shows a stream that has recently been cleaned out (dredged). Photo 4-19 shows a stream downstream of a recently constructed residential development that is currently characterized by sand deposits that have embedded riffles and filled pools. Photo 4-20 shows a stream with an altered pattern (Metric 3, descriptor "A") but not a substantially altered profile (Metric 4, descriptor "B"). Also, if an appropriate profile has developed in the bottom of a previously excavated channel, the stream may be rated as descriptor "B."

Photo 4-17

Photo 4-18

The first three photos provide examples of substantial alterations to stream profile resulting in a rating of descriptor "A." Photo 4-17 is an unnamed tributary to the Neuse River (Ia3) in Lenoir County that has been straightened and armored with masonry banks and a concrete bed. Photo 4-18 is an unnamed tributary to Conaby Creek (Oa1) in Washington County that has been straightened cleaned out as evidenced by the spoil piles. Photo 4-19 is an unnamed tributary to Buffalo Creek (Ma1) in Rutherford County in which excessive sediment deposition has embedded riffles and filled pools. Photo 4-20 is an unnamed tributary to Wesley Creek (Ma2) in Buncombe County that has been straightened and is subject to bank armoring, but is still characterized by an appropriate profile (descriptor "B").

Photo 4-19

Photo 4-20

## 5. Signs of Active Instability – assessment reach metric

**Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).

☐A < 10% of channel unstable
☐B 10 to 25% of channel unstable
☐C > 25% of channel unstable

This metric is used in the determination of the Stream Stability component of the Class 1 Hydrology and Habitat functions for all streams. This metric is concerned with the bed, toe of banks, and top of banks of the assessment reach.

As stated in the Field Assessment Form instructions (pp. vii), the assessor should document observed stressors that may contribute to assessment reach instability in the "Notes/Sketch" section of the Field Assessment Form. Descriptive information that may be helpful includes a statement as to whether observed instability is local or system-wide. Examples of local instability include a utility line crossing resulting in a weakening of the bank structure (Photo 2-11), livestock access (Photo 2-15 through Photo 2-18), removal of bank vegetation (Photo 4-21), and removal of bank vegetation upstream of the assessment reach (Photo 4-22). Examples of system-wide instability include bank erosion resulting from a change in pattern, such as a straightened channel that is re-establishing its sinuosity (Photo 4-23) or a channel subject to excessive stormwater runoff resulting from impervious surfaces in the watershed (Photo 4-24 through Photo 4-26). In the presence of system-wide stressors, other indicators include regular alternate bars, bank erosion on both banks at the same location, common occurrences of bank erosion in riffle-run reaches in addition to meanders, common occurrences of transverse bars and head-cuts.

In examples of instability listed in the metric text, the word "active" is important to evaluation of this metric. These examples apply to natural, man-modified, and man-made streams alike. Active bank failure and active widening of the channel may be characterized by unsustainable, undercut banks at the tipping point resulting in bank calving into the channel. In this scenario, undercut banks have become a mass wasting threat as opposed to a viable habitat feature. Photo 4-23 through Photo 4-28 provide examples of active bank failures, while Photo 4-29 and Photo 4-30 provide, for comparison, examples of undercut banks that are viable habitat features. Other indicators of active bank failure and active channel widening include tension cracks on top of banks; bank slumping, calving (Photo 4-27), or collapsing (Photo 4-23); sediment deposition along the bank toe; scarified sediments on the bank surface (Photo 4-31); and high rates of tree-fall into the channel. Active bank failure may occur along shorelines subject to regular boat traffic (Photo 4-21). Active head-cuts (Photo 4-32 and Photo 4-33) and active channel down-cutting (Photo 4-6) are characterized by many of the examples of instability listed above. Not all head-cuts are active instability, as many reflect normal landscape changes occurring at natural rates. Channel down-cutting is considered to affect both banks when considering the descriptor thresholds.

When the bed and/or banks are fortified with artificial hardening such as rip-rap (Photo 4-34 and Photo 4-35), gabions (Photo 4-36), a bulkhead (Photo 4-37), wing walls (Photo 4-38), masonry (Photo 4-17, Photo 4-20, and Photo 4-27), or concrete (Photo 4-12 and Photo 4-39), an assessor should consider the stream to be unstable unless best professional judgment indicates the contrary. The structure shown in Photo 4-37 is a bulkhead, a term for a constructed wall in an unstable environment. In this instance, the bulkhead is being undermined and is collapsing. The structure shown in Photo 4-40 is a retaining wall, a term for a constructed wall in a stable environment. In this instance, the abutting intertidal zone is stable and healthy, and the retaining wall is intended to extend the high ground toward the water for a residential yard, rather than preventing erosion. In many examples of walls along Tidal Marsh Streams, these structures are not indicators of instability (bulkheads), but are indicators of a stable extension of high ground toward the water (retaining walls).

The evaluation of this metric requires the assessor to determine a percentage of the assessment reach that is affected by active instability. The instability may only be observed on one or both banks or may include the stream bed. For the purposes of evaluating this metric, if active instability is limited to the banks, the assessor should consider the total length of both banks within the assessment area as 100 percent. If active instability includes the bed, the assessor should consider the length of the assessment reach as 100 percent.

There will likely be situations where an assessor may not be able to determine the difference between “artificial hardening” and “restoration.” In this case, some familiarity with site history will be helpful. Rocks and other structures placed in a channel for the purpose of ecological restoration are not considered artificial hardening.

Photo 4-21

Photo 4-22

These photos provide examples of signs of active instability. Photo 4-21 is a Tidal Marsh Stream (an unnamed tributary to Middle Sound in New Hanover County) just downstream of a public boat ramp. This bank has been subject to vegetation removal and is now under-cutting and collapsing due to the energy of boat wakes. Photo 4-22 is an unnamed tributary to Lake Rogers (Pa2) in Granville County and shows a stream subject to excessive sedimentation resulting from runoff from upstream agricultural fields. Photo 4-23 is an unnamed tributary to Skewakee Gut (Ia1) in Martin County, which is characterized by maintained turf abutting a straightened channel with a concrete bed. The banks are slumping as the stream is re-establishing sinuosity. The lack of woody vegetation in the streamside area has resulted in a loss of stream shading. Photo 4-24 is Hendricks Creek (Ia4) in Edgecombe County, a reach with actively eroding banks and excessive deposition of loose sand as the result of flashy flows from an urbanized watershed. The reduction of woody vegetation on the right bank shown in the photo has resulted in degraded shading for the reach.

Photo 4-23

Photo 4-24

Photo 4-25

Photo 4-26

These photos provide examples of streams characterized by active bank failure. Photo 4-25 is Sal's Branch (Pa2) in Wake County, and Photo 4-26 is Mosley Creek (Ia2) in Lenoir County. Both streams are subject to flashy flows following precipitation events and are characterized by actively eroding, undercut banks with little immediate root mass and with an undercut elevation well above the typical baseflow elevation. Photo 4-27 is Horse Creek (Pa3) in Wake County, and Photo 4-28 is Little Bugaboo Creek (Ma2) in Wilkes County. The streamside areas of both of these streams are characterized by degraded vegetation and ground surface compaction resulting in accelerated surface runoff into the streams and degraded shading. Stream banks are characterized by scalloped faces resulting from high sediment loss (mass wasting). Note the calved blocks of sediment at bank toes.

Photo 4-27

Photo 4-28

Photo 4-29

Photo 4-30

The top two photos provide examples of streams characterized by undercut banks that are viable habitat features, and not indicators of instability. Photo 4-29 is an unnamed tributary to Lyle Creek (Pa2) in Caldwell County, and Photo 4-30 is an unnamed tributary to Cane Creek (Pa2) in Alamance County flowing through a mature forest. Photo 4-31 is Horse Creek (Pa3) in Wake County, which is characterized by active surface scour and erosion with loose sediment on the bank face. Photo 4-32 is an unnamed tributary to the Cape Fear River (Ia2) in Cumberland County and shows an unstable gully resulting from concentrated stormwater runoff from adjacent impervious surfaces.

Photo 4-31

Photo 4-32

Photo 4-33

Photo 4-34

These photos provide examples of active stream instability. Photo 4-33 is an unnamed tributary to Ledge Creek (Pa1) in Granville County and shows an active head-cut down valley from a farm pond overflow outlet. This stream appears to be subject to flashy flows following precipitation events. Photo 4-34 is Hendricks Creek (Ia4) in Edgecombe County, a reach armored with rip-rap that has been destabilized by flashy flows resulting from impervious surfaces in the watershed. Photo 4-35 is Marsh Creek (Pa3) in Wake County with banks stabilized by rip-rap, excess sedimentation in the stream bed, and a parallel, maintained utility line corridor. Photo 4-36 is upper Pigeon House Creek (Pa2) in Wake County with a bank stabilized by both gabions and a wing wall.

Photo 4-35

Photo 4-36

Photo 4-37

Photo 4-38

Photo 4-37 is Upper Skewakee Gut (Ia2) in Martin County, which is characterized by down-cutting and a slumping left bank supported by a bulkhead. Photo 4-38 is Crooked Run (Ia4) in Jones County. The wing walls fortify banks and contain potentially high-energy flows from the Brock Millpond spillway under N.C. Highway 58 near Trenton. Photo 4-39 is an unnamed tributary to Marsh Creek (Pa1) in Wake County and shows total armoring of a stream bed and banks in an urban setting. Photo 4-40 is a Tidal Marsh Stream (an unnamed tributary to Myrtle Grove Sound in New Hanover County), which is characterized by a left-bank retaining wall, apparently installed to expand a residential yard.

Photo 4-39

Photo 4-40

## 6. Streamside Area Interaction – streamside area metric

**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no evidence of conditions that adversely affect reference interaction |
| ☐B | ☐B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] <u>or</u> too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) <u>or</u> floodplain/intertidal zone unnaturally absent <u>or</u> assessment reach is a man-made feature on an interstream divide |

This metric is used in the determination of the Streamside Area Attenuation component of the Class 1 Hydrology function and the Streamside Habitat component of the Class 1 Habitat function for all streams. This metric is concerned with the interaction of water between the assessment reach and the streamside area (overbank flow) and the interaction of water from upland areas into the streamside area (upland runoff). The assessor should evaluate both the left bank (LB) and right bank (RB) for this metric (this determination is made from the perspective of looking downstream or toward the mouth of a Tidal Marsh Stream). Any change from reference (relatively undisturbed stream and streamside area) is considered to be an adverse effect. For the purposes of this metric, expected streamside area interaction for ditched tributaries in interstream divides (Photo 3-13 and Photo 3-14) is primarily overland flow to the stream, with no overbank flow expected to occur.

Evidence that overbank flows are accessing the streamside area includes wrack lines (Photo 4-41), surface scour, recent sediment deposition (Photo 4-42), water marks on vegetation, and reclining vegetation (Photo 4-43). Conditions that may increase or decrease (adversely affect) a stream's access to the streamside area include, but are not limited to, stream relocation, man-made berms and levees (Photo 4-44), channel down-cutting (Photo 4-6 and Photo 4-37), fill or structures (such as spoil piles [Photo 4-18], logging roads, causeways [Photo 4-6], access roads, and pipelines), man-made channelization (Photo 4-9, Photo 4-17, and Photo 4-18), dredging (Photo 4-30 and Photo 4-31), channel aggradation, bulkheads (Photo 4-37), retaining walls (Photo 4-40 and Photo 4-45), tide gates, perched culverts (Photo 2-4), weirs (Photo 2-37), flashboard risers, and excessive sedimentation (Photo 4-46).

Evidence of upland runoff within the streamside area may be difficult to observe. In this case, a better approach is to determine if conditions that adversely affect streamside area interaction (stressors) exist. Conditions that may adversely affect this interaction include, but are not limited to, alterations increasing runoff into and across the streamside area (such as impervious surfaces [Photo 4-37] and a reduction of vegetation in the streamside area [Photo 4-48]), ditching (Photo 2-6), man-made berms (Photo 4-44), and retaining walls (Photo 4-40 and Photo 4-45). The effect of a stormwater pond in the streamside area may depend upon the setting. In less disturbed settings, a stormwater pond in the streamside area is typically considered to be a stressor because such a feature will modify the frequency of flooding in the downstream floodplain and typically drains directly into the stream rather than allowing sheet flow across the streamside area. However, in more disturbed settings, such as urban areas, stormwater ponds in the streamside area can restore a more “natural” hydrograph, by slowing upland runoff access to the stream following precipitation events. In the absence of stressors, it can be assumed that appropriate streamside area interaction is occurring.

The assessor needs to determine among “little to no,” “moderate,” and “extensive” evidence of conditions that adversely affect reference interaction. Descriptor “A” is appropriate if there is little to no disturbance in the channel or the streamside area, indicating that streamside area interaction is occurring naturally. Examples provided within the metric descriptors are intended to assist with determining between descriptors “B” and “C;” however, it is left to the assessor to judge the intensity of the effect the stressor is having on the assessment area. In general, descriptor “B” is appropriate if there is evidence of conditions that adversely affect streamside area interaction, but there is evidence that overbank flow still occurs on a limited basis and upland runoff can reach the stream. Descriptor “C” is appropriate if there is evidence of conditions that adversely affect streamside area interaction, and there is evidence that overbank flows rarely, if ever, occur and/or upland runoff is severely restricted from reaching the stream.

In addition to visual observation of indicators of interaction, an assessor may consider using in-field measurements when available. For instance, bank height ratio and entrenchment ratio are measurements typically used to determine the degree of channel incision and/or stability, but these measurements can also be used to document a choice between descriptors “B” and “C” for this metric. When this type of information is available, the assessor should check “Yes” for Information 19 (p. vii) and either include results in the “Notes/Sketch” section of the Field Assessment Form or attach documentation to the Field Assessment Form/Stream Rating Sheet.

Descriptor “A” is appropriate for both banks shown in Photo 4-43. Photo 4-44, taken facing upstream, shows a straightened and down-cut tributary. Descriptor “C” is appropriate for the cleared right bank with an adjacent berm, and descriptor “B” is appropriate for the vegetated left bank. The bank visible in Photo 4-45 is evaluated as descriptor “C” due to the retaining wall. Excessive sedimentation in the streambed in Photo 4-46 increases frequency of overbank flows, resulting in evaluation as descriptor “B.” The stream visible in Photo 4-47 is slightly incised, has been straightened in the past, and is characterized by primarily agricultural field and an approximately 50-foot wide abutting mature forest buffer in the streamside area, resulting in evaluation as descriptor “B.” A lack of appropriate vegetation and the presence of pavement in the streamside area shown in Photo 4-48 resulted in an evaluation as descriptor “C” for the bank in view.

Note that descriptor “C” is appropriate for three different conditions: 1) extensive evidence of conditions that adversely affect reference interaction (for instance, the bulkhead in Photo 4-37 degrades both overbank flow and overland flow streamside area interaction, and the streams in Photo 4-49 and Photo 4-50 have down-cut well below the floodplain), 2) the expected floodplain or intertidal zone is unnaturally absent (for instance, the bulkhead supports fill in what used to be Salt/Brackish Marsh in Photo 4-40), and 3) the assessment reach is a man-made feature on an interstream divide (Photo 3-13 and Photo 3-14).

Photo 4-41

Photo 4-42

The first three photos provide evidence of overbank flow into the streamside area. Photo 4-41 is wrack lines in the streamside area of an unnamed tributary to Little Branch (Pa4) in Wake County. Photo 4-42 is recent sediment deposition in the streamside area of Mill Creek (Ia4) in Johnston County. Photo 4-43 is reclining vegetation due to overbank flows reaching the streamside area of Reedy Creek (Ia3) in Craven County. This photo was taken shortly after a large rainfall event. The view in Photo 4-44 faces upstream. This photo shows a man-made berm on the right bank of the straightened and dredged Fork Swamp (Ia3) in Pitt County. This berm is expected to hamper overland runoff and decrease the frequency of overbank flows into the right bank streamside area.

Photo 4-43

Photo 4-44

Photo 4-45

Photo 4-46

Photo 4-45 shows a retaining wall used to extend a residential yard on Brice Creek (Ia4) in Craven County. The lawn increases the rate of overland runoff, and the retaining wall decreases the frequency of overbank flooding. Photo 4-46 is an unnamed tributary to Marsh Creek (Pa2) in an urban area of Wake County subject to flashy flows due to the high coverage of impervious surfaces within the watershed. This stream is characterized by excessive sedimentation expected to embed riffles, fill pools, and increase the frequency of overbank flows. Photo 4-47 is an unnamed tributary to Stonyton Creek (Ia2) in Lenoir County. Just upstream of this site, an agricultural field is abutting the stream. The stream in view is slightly incised and has been straightened at some point in the past. An on-site investigation found evidence of irregular overbank flow (old debris piles but no recent sediment deposits). Runoff from the upslope agricultural fields is buffered by the approximately 50-foot wide mature forest abutting the stream. Descriptor "B" is appropriate for the reach in view. Photo 4-48 is Turkey Creek (Ma4) in Transylvania County, which is characterized by some down-cutting resulting in the reduced frequency of overbank flooding, and an altered streamside area resulting in increased runoff.

Photo 4-47

Photo 4-48

Photo 4-49

Photo 4-50

Photo 4-49 is an unnamed tributary to Second Broad River (Ma2) in McDowell County, which has down-cut well below the natural floodplain. Vegetation removed from the left bank results in degraded shading for this reach of stream. Photo 4-50 is Crabtree Creek (Pa4) adjacent to a greenway trail and commercial development in Wake County. This stream has down-cut well below the natural floodplain, the natural floodplain has received fill, and the streamside area has been modified resulting in accelerated drainage.

## 7. Water Quality Stressors – assessment reach/intertidal zone metric

**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B Excessive sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach and causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in "Notes" section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc.)
☐I Other: ____________________ (explain in "Notes/Sketch" section)
☐J Little to no stressors

For all streams, this metric is used in the determination of the Indicators of Stressors component of the Class 1 Water Quality function.

To check a box for descriptors "A" through "D" and "F" through "H", the assessor must observe evidence of pollutants causing water quality degradation in the assessment reach or intertidal zone (for Tidal Marsh Streams). Please note that "evidence of pollutant discharges" alone is not sufficient to check a box. The pollutant discharge must also be causing observable water quality degradation in the assessment reach or intertidal zone. For instance, just the presence of a stormwater pipe outlet in the assessment reach or intertidal zone is not sufficient to check a box. Evidence of a stressor resulting from stormwater effluent (for instance, sedimentation, oil sheens, or odor) must be observed to check a box.

A brief discussion of metric descriptors follows.

A: Discolored water in stream or intertidal zone (milky white [Photo 4-51], blue, unnatural water discoloration, oil sheen (Photo 4-53), stream foam [Photo 4-52])

In the Inner and Outer Coastal Plain, tannic water should not be considered discolored water.

Assessors should determine if observed oil sheens are the result of natural iron deposits or the result of a water-quality stressor. To this end, the following guidance is provided by the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (USACE 2010b). "Iron sheen on water can be distinguished from an oily film by touching with a stick or finger; iron films are crystalline and will crack into angular pieces." Photo 4-53 shows an oil sheen resulting from a water quality stressor; while Photo 4-54 shows natural iron deposits from iron-oxidizing bacteria (that do not result from a water quality stressor) (note the angular shape of the cracked surface that has just been penetrated with a stick).

Stream foam is generally a bad thing; however, an exception can be in tannic streams in the Coastal Plain. Usually, stream foam results from some sort of anthropogenic discharge, but in blackwater streams natural foam can be produced when decomposed organic compounds lessen the surface tension of water and create bubbles. This

Photo 4-51

Photo 4-52

These photos provide examples of different types of discolored water that are considered water quality stressors. Photo 4-51 is milky white water in Knap of Reeds Creek (Pa4) in Granville County. Photo 4-52 shows foam on the surface of an unnamed tributary to Carvers Creek (Ia2) in Cumberland County. Photo 4-53 shows surface oil sheen (evidence of a water quality stressor) on an urban reach of an unnamed tributary to Smith Mill Creek (Ma3) in Buncombe County. Photo 4-54 shows a surface sheen on Hominy Creek (Ma4) in Buncombe County, resulting from natural-oxidizing bacteria and is not an indicator of a water quality stressor.

Photo 4-53

Photo 4-54

usually happens below head-cuts or riffles, but can also happen if the current is swift enough passing a snag with a lot of branches or another such object in the current.

"Turbidity" refers to the amount of solid particles suspended in water that cause light rays shining through the water to scatter. Thus, turbidity makes the water cloudy or opaque in extreme cases. Low levels of turbidity resulting solely from a rain event should not be considered a water-quality stressor. Turbidity resulting from a disturbance in the watershed (Photo 4-55) is a water-quality stressor.

B: Excessive sedimentation (burying of stream features or the intertidal zone)

The term "excessive" is important when evaluating this metric. For the purposes of this metric, sedimentation is considered to be "excessive" when it results in the burying of stream features, such as riffles and pools (Photo 4-19, Photo 4-22, Photo 4-46, and Photo 4-56), or when the deposition of sediment deposits bury marsh vegetation or aquatic life refugia in the intertidal zone.

Selection of descriptor "B" is not appropriate for sedimentation resulting from natural processes, such as floods, extreme tides, and hurricane/storm impacts.

Photo 4-55

Photo 4-56

These photos show different types of water quality stressors. Photo 4-55 is the confluence of a tributary with the Tuckaseegee River (Ma4) in Jackson County. The tributary (the left fork) is carrying a heavy sediment load, evidence that it drains a watershed characterized by disturbance. Photo 4-56 shows excessive sedimentation (buried stream features) in Bush Creek (Pa2) in Chatham County.

The timing of excessive sedimentation is not as big a factor as the current effect of sedimentation on the stream or intertidal zone. If a past sedimentation event still meets the criterion of "excessive sedimentation," selection of this descriptor is appropriate. Sedimentation from which the stream or intertidal zone has recovered is not considered to be a stressor.

C: Noticeable evidence of pollutant discharges entering the assessment reach and causing a water quality problem

Note that selection of this descriptor requires evidence of water-quality degradation. Typically, stormwater that enters an assessment reach/intertidal zone subsequent to passing through an appropriately-sized treatment feature will not be expected to result in a water-quality problem. Alternately, stormwater that directly enters a channel (for example: by way of a pipe, ditch, or bridge deck drains) can be considered to be a discharge, but <u>evidence of an effect</u> (such as an oil sheen or odor) is needed in order to select this descriptor.

D: Odor (not including natural sulfide odors)

This descriptor is appropriate if the assessor can connect an unexpected odor with a source, such as a broken or overflowing sewer line, a leaky septic field, or other water-quality stressor.

E: Current published or collected data indicating degraded water quality in the assessment reach. Cite source in "Notes/Sketch" section.

This descriptor is appropriate only if the degraded water quality data corresponds to the assessment reach and is recent. "Degraded" refers to any diminished federal, state, or local water quality standard (for example, descriptor "E" is appropriate if the assessment reach is on a 303(d)-listed stream). The SFAT has decided that Nutrient Sensitive Waters (NSW) are not to be considered degraded for the purposes of this metric since the designation can be broad, including entire river basins. Published or collected data can include data collected by federal, state, or local governments, or various educational institutions, or collected during the evaluation. Citations to the data must be noted in the "Notes/Sketch" section of the Field Assessment Form.

F: Livestock with access to stream or intertidal zone

The term "livestock" refers to cattle, horses, poultry, and similar animals kept for domestic use. Livestock with direct access to a stream or intertidal zone may reduce water quality through deposition of manure or urine and hoof shear, which destabilizes banks, degrades buffers, and increases water turbidity (Photo 2-15 through Photo 2-18). Livestock manure or urine is considered a "pollutant" by NC SAM.

For the purposes of this metric, this descriptor is appropriate if a confined animal operation (such as a poultry house or hog operation) occurs in the watershed within 30 feet of the assessment reach.

G: Excessive algae in stream or intertidal zone

The term “excessive” is important when evaluating this metric. For the purposes of this metric, algae are considered to be “excessive” when it is pervasive and readily apparent throughout the reach. Excessive algae interrupt the food chain by smothering habitat and from oxygen depletion resulting from algae death and decomposition. This condition is typically the result of a stressor such as high nutrient inputs. Photo 4-57 and Photo 4-58 show excessive algae in streams.

Assessors should note that non-excessive algae is beneficial to in-stream habitat (see Metric 10: Natural In-stream Habitat Types [p. 76]) since it is an essential part of the aquatic food chain.


Photo 4-57

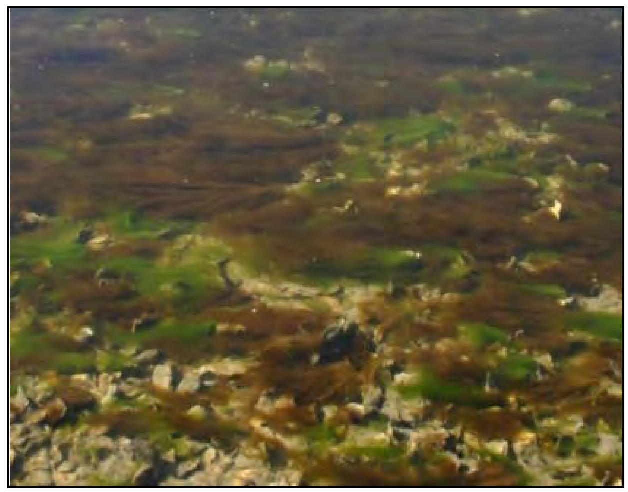


Photo 4-58

Photo 4-57 shows excessive algae over the saprolite bed in an unnamed tributary to Burdens Creek (Pa3) in Durham County. Photo 4-58 shows excessive algae on the oyster bottom of an unnamed tributary draining Harbor Island Marsh (a Tidal Marsh Stream) in New Hanover County.

H: Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc.)

This situation is typically found near residences with maintained lawns (Photo 4-21), livestock grazing in pastures, around boat ramps, within utility line corridors (Photo 4-59), and under bridge crossings.

I: Other

This descriptor is appropriate when an assessor observes evidence of pollutant discharges causing water-quality degradation in the assessment reach or intertidal zone as a result of a stressor not listed in this metric. The assessor should describe the stressor in the blank space provided or in the "Notes/Sketch" section of the Field Assessment Form. Examples of "other" stressors include landfills and streams subject to high levels of human foot traffic (for example: a publically accessible location like a park (Photo 4-60) or an unimproved boat access point).

J: Little or no stressors

This descriptor is appropriate when the assessor observes little or no evidence of pollutant discharges causing water quality degradation in the assessment reach or intertidal zone.

Photo 4-59

Photo 4-60

Photo 4-59 shows degraded marsh vegetation due to a maintained utility line corridor within the intertidal zone of Bradley Creek (a Tidal Marsh Stream) in New Hanover County. Photo 4-60 is a reach of Kitchen Branch (Mb3) that flows through a heavily used playground in Buncombe County. The thinning of vegetation (low stem density) within this playground has resulted in degraded shading for this reach.

## 8. Recent Weather – watershed metric (skip for Tidal Marsh Streams)

For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.

- ☐A Drought conditions and no rainfall or rainfall not exceeding 1 inch within the last 48 hours
- ☐B Drought conditions and rainfall exceeding 1 inch within the last 48 hours
- ☐C No drought conditions

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the Baseflow component of all three Class 1 functions and the Aquatic Life Tolerance component of the Class 1 Water Quality function.

For drought classifications, NC SAM will rely on the U.S. Drought Monitor, which is a synthesis of multiple indices, outlooks, and news accounts that represent a consensus of federal and academic scientists (http://drought.unl.edu/dm/index.html). The Drought Monitor generates maps labeling drought areas in order of intensity (D0 through D4), with D1 being the least intense and D4 being the most intense. D0 represents drought watch areas. Following is a brief description of each drought category. Refer to http://www.ncdrought.org/ for a current map of North Carolina drought areas. It is suggested that the assessor examine the status of the U.S. Drought Monitor before going into the field or immediately upon returning to the office. The date on the Field Assessment Form must correspond to the date when the Drought Monitor was visited.

- D0 Abnormally dry. Going into drought or coming out of drought: characterized by water deficits and fire risk above average.
- D1 Moderate drought: characterized by some damage to crops; high fire risk; and low water levels in streams, reservoirs, or wells.
- D2 Severe drought: characterized by likely crop losses, very high fire risk, and water shortages are common.
- D3 Extreme drought: characterized by major crop losses, extreme fire risk, and widespread water shortages.
- D4 Exceptional drought: characterized by exceptional and widespread crop losses; exceptional fire risk; and shortages of water in reservoirs, streams, and wells creating water emergencies.

## 9. Large or Dangerous Stream – assessment reach metric

☐Yes ☐No Is stream too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

For all streams, this metric is used to notify the Rating Calculator as to whether or not the Field Assessment Form will document assessment reach characteristics such as natural in-stream habitat types, bedform, aquatic life, and substrate composition.

"Yes" should be selected and Metrics 10, 11, and 12 should be skipped if the assessor is not able to observe or safely access the bed of the assessment reach. When "Yes" is selected, the Rating Calculator follows an alternative path for generating the functional rating that assumes a high-quality condition for these metrics. Reasons an assessor might select "Yes" for this metric include large size, inaccessibility to the bed, and extraordinarily high waters. Photo 4-61 and Photo 4-62 are streams for which "Yes" was selected.

"No" is selected when the assessor is able to observe and/or evaluate the assessment reach bed. When "No" is selected, the assessor should continue the evaluation with Metric 10: Natural In-stream Habitat Types.

Photo 4-61

Photo 4-62

These photos provide examples of streams determined to be too large or dangerous for an assessment of habitat types, bedform, and substrate composition. Photo 4-61 is Smith Creek (a Tidal Marsh Stream) near its confluence with the Cape Fear River in New Hanover County. Photo 4-62 is the Northeast Cape Fear River (Ia4) on the New Hanover/Pender County line.

## 10. Natural In-stream Habitat Types – assessment reach metric

10a. ☐Yes ☐No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 11)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**

- ☐A Multiple aquatic macrophytes and aquatic mosses (including liverworts, lichens, and algal mats)
- ☐B Multiple sticks and/or leaf packs and/or emergent vegetation
- ☐C Multiple snags and logs (including lap trees)
- ☐D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
- ☐E Little or no habitat

Check for Tidal Marsh Streams only

- ☐F 5% oysters or other natural hard bottoms
- ☐G Submerged aquatic vegetation
- ☐H Low-tide refugia (pools)
- ☐I Sand bottom
- ☐J 5% vertical bank along the marsh
- ☐K Little or no habitat

<u>Metric 10a</u>

Metric 10a is only used for Size 4 streams in the Coastal Plain (Ia4, Ib4, and Oa4 streams) when determining the In-stream Habitat component of the Class 1 Habitat function. Some examples of degraded in-stream habitat are provided in the descriptor text parentheses. Other examples include riffle-dominated reaches, low depth variability, low bedform complexity, unnatural gravel in the streambed in the Coastal Plain, and unstable banks (Photo 4-24). Sedimentation is considered to be "excessive" when it results in the burying of stream features such as riffles and pools (again, Photo 4-24). "Excavation" is the removal of sediment from the bed of a stream channel. For the purposes of NC SAM, "excavation" and "mining" are considered to be one-time events – as opposed to "dredging," which is considered to be an on-going practice. In-stream hardening refers to the armoring of the stream bed and/or banks altering natural in-stream habitat. "Snagging" is the act of removing a tree or part of a tree held fast in the bottom or banks of a river. Some larger streams in the Coastal Plain are snagged on a regular basis to assist with regional drainage or navigation.

"Yes" should be selected for this metric when in-stream habitat is degraded in more than 50 percent of the assessment reach. An assessment reach that is a man-made feature such as a ditch or canal typically cannot be evaluated as "Yes" if it has naturalized. It is considered to have naturalized if characterized by stable, vegetated banks and appropriate bedform for the slope.

<u>Metric 10b</u>

Metric 10b is used for all streams, except Size 4 Coastal Plain streams (Ia4, Ib4, and Oa4 streams) in the determination of the In-stream Habitat component of the Habitat function.

The assessor is requested to check a box for each descriptor appropriate for the assessment reach. The first set of five descriptors ("A" through "E") is used for all streams except Tidal Marsh Streams. The second set of five descriptors ("F" through "K") is used for Tidal Marsh Streams only. A box should be checked for a descriptor that occurs over greater than 5 percent of the assessment reach. More specifically, the assessor should check a box for any descriptor that occurs within the assessment reach on more than just an incidental basis. More than one box can be selected for each set of descriptors.

The assessor should evaluate habitats within the normal wetted perimeter. Note that during drought conditions, all or a portion of the normal wetted perimeter of an assessment reach may lack water. In Tidal Marsh Streams, the normal wetted perimeter includes the channel below the vegetation line on the stream banks – the sub-tidal portion of the channel. The assessor should not consider rip-rap to be natural habitat. However, rocks placed in the channel for the purpose of ecological restoration are considered to be natural habitat. Substrate (rocks, logs, sticks, etc.) is not considered to be "habitat" when coated with silt to the point where aquatic organisms cannot colonize the substrate.

A brief discussion of metric descriptors follows.

A: Multiple aquatic macrophytes and aquatic mosses (including liverworts, lichens, and algal mats)

"Aquatic macrophytes" are plants attached or rooted beneath the mean water surface, both submerged (Photo 4-63 and Photo 4-64) and floating (Photo 4-65). This term includes aquatic mosses, liverworts, lichens, and various flowering plants and does not include emergent plants.

"Algal mats", in limited coverage (Photo 4-66), provide a benefit to in-stream habitat. The assessor should look for green or blue-green filaments or mats, or golden brown "crusts" on appropriate substrates (rocks, sticks, leaves, or plants) (NCDWQ 2010). However, "excessive" algae may remove or degrade in-stream habitat. Algae is considered "excessive" when it is pervasive and readily apparent throughout the reach (Photo 4-57 and Photo 4-58), thereby interrupting the food chain by smothering habitat and from death and decomposition of algae, resulting in oxygen depletion. This condition is typically the result of a stressor such as high nutrient inputs.

B: Multiple sticks and/or leaf packs and/or emergent vegetation

The size of a "stick" varies among stream categories. A stick is a linear piece of woody debris small enough to be moved by stream flow during a bankfull event. Therefore, a stick will likely be a smaller size on smaller streams and a larger size on larger streams. Conversely, a "log" is a linear piece of woody debris large enough that it is not expected to be moved by stream flow during a bankfull event. Photo 4-68 shows a stream with several sticks and a log.

A "leaf pack" is a cluster of leaves that has been pushed into a pile by flowing water, usually against a stick or rock, and usually off the bottom (not loose leaves lying on the stream bed) (Photo 4-69 and Photo 4-70). Flowing water keeps dissolved oxygen levels high, so good leaf packs in good quality streams support intolerant aquatic life. Note: the presence of leaf packs suggests enough flow that dissolved oxygen is not a problem for aquatic life.

Photo 4-63

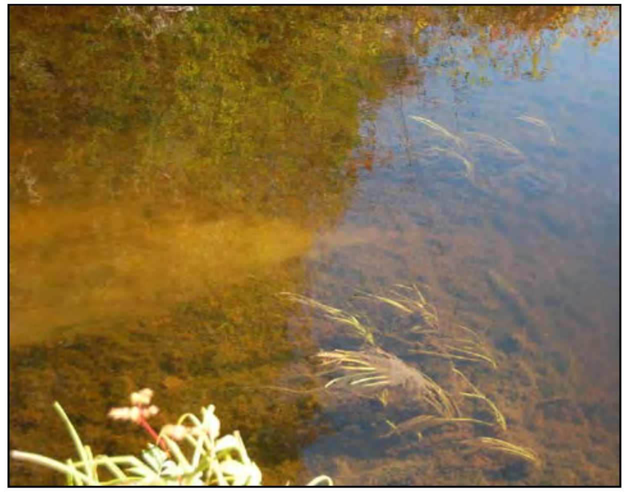


Photo 4-64

These photos provide examples of natural in-stream habitat types. Photo 4-63 is Bear Creek (Ia4) in Lenoir County, which supports dense growth of both submerged and floating aquatic macrophytes. Photo 4-64 is Little Hell Creek (Ia4) in Jones County, the bed of which supports various submerged aquatic macrophytes. Photo 4-65 is the Perquimans River (Oa4) in Perquimans County, which supports a stand of rooted and floating aquatic macrophytes near a moored periauger in a sluggish, wind-tide driven coastal stream. Photo 4-66 is an unnamed tributary to Mine Creek (Pa2) in Wake County with algal mats benefiting aquatic habitat.

Photo 4-65

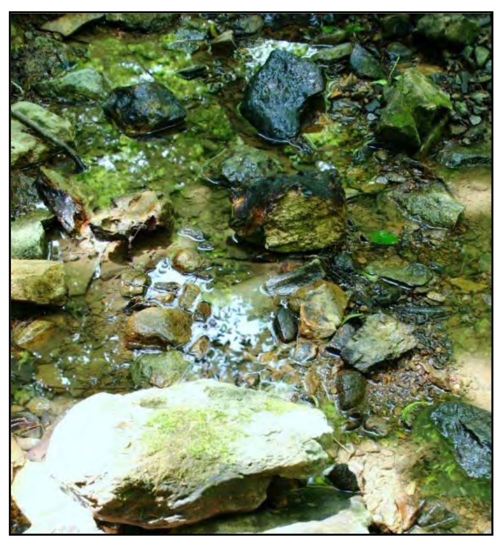


Photo 4-66

Photo 4-67

Photo 4-68

These photos provide examples of natural in-stream habitat types. Photo 4-67 is Flat River (Pa4) in Durham County, which supports a stand of aquatic macrophytes in a bed of cobble and boulders. Photo 4-68 is Little Doe Creek (Oa3) in Brunswick County, which is characterized by multiple sticks and a log. Photo 4-69 shows a leaf pack in a riffle in Kennedy Mill Branch (Ia3) in Johnston County. Photo 4-70 shows a leaf pack in a riffle in an unnamed tributary to Carvers Creek (Ia1) in Cumberland County.

Photo 4-69

Photo 4-70

"Emergent vegetation" includes rooted herbaceous plants with parts extending above a water surface (Environmental Laboratory 1987).

C: Multiple snags and logs (including lap trees)

A "snag" is a dead tree or part of a dead tree held fast in the bed or bank of a stream that provides aquatic habitat (Photo 4-71 and Photo 4-72).

The size of a "log" varies among stream categories. A log is a linear piece of woody debris large enough that it is not expected to move during a bankfull event (Photo 3-2 and Photo 4-68). Therefore, a log will likely be a smaller size on smaller streams and a larger size on larger streams. Conversely, a "stick" is a linear piece of woody debris that is small enough to be moved by stream flow during a bankfull event.

A "lap tree" is a tree (living or dead) that extends laterally from the stream bank into the stream (Photo 4-71 and Photo 4-72). Lap trees provide wildlife access between the stream and the streamside area as well as providing habitat for aquatic life if the lap tree is at least partially underwater.

D: 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter

An "undercut bank" is an area of bank adjacent to the mean water level of a stream where energy from moving water has scoured a shelf in the bank. Undercut banks are typically considered to be stable fixtures that provide aquatic habitat (Photo 4-29, Photo 4-30, and Photo 4-73), as opposed to eroding banks, which are unstable and degrade aquatic habitats due to their instability and threat of imminent mass wasting (Photo 4-25 through Photo 4-28 and Photo 4-31 and Photo 4-32).

A "root mat" is a mass of plant roots extending from a stream bank into the water column or along the stream bed (Photo 4-74 and Photo 4-75). Root mats and roots extending from the bank provide stability to stream beds and banks, as well as provide for aquatic habitat.

E: Little or no habitat

Select this descriptor if habitats included as descriptors "A" through "D" are present only incidentally or are absent within the assessment reach.

F: 5% oysters or other natural hard bottoms

With the exception of a sand or sandy mud fringe along the shoreline, most of the sub-tidal bottom of most Tidal Marsh Streams is composed of mud – ranging from sandy mud to a "puddin' bottom." This results from the death of marsh grass every winter; some portion floats out into the sound to decompose, while the remainder sinks and rots in the sub-tidal channel. There is rarely enough tidal energy to transport the detritus and silt out to the sound leading to a soft bottom of high-organic, low-oxygen mud. Tidal Marsh Streams with mud bottoms are considered primary nursery areas because they support a large abundance of worms and clams that become food for shrimp, crabs and

Photo 4-71

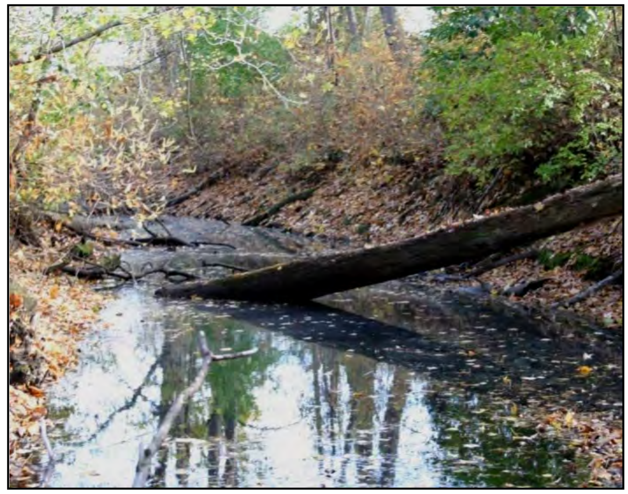


Photo 4-72

These photos provide examples of natural in-stream habitat types. Both top photographs show snags that are also acting as lap trees. Photo 4-71 is a natural channel in Honey Island Swamp (Oa3) in Brunswick County, and Photo 4-72 is the Vann Swamp Canal (Oa4) in Beaufort County. Photo 4-73 is an unnamed tributary to Crabtree Creek (Pa2) in Wake County with undercut banks benefiting aquatic habitat. Photo 4-74 is roots and root mats in banks that extend into the normal wetted perimeter on an unnamed tributary to Carvers Creek (Ia1) in Cumberland County.

Photo 4-73

Photo 4-74

Photo 4-75

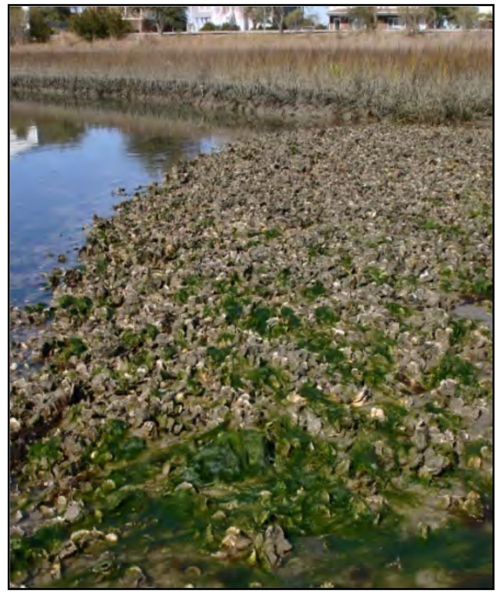


Photo 4-76

These photos provide examples of natural in-stream habitat types. Photo 4-75 shows roots and root mats in banks that extend into the normal wetted perimeter on an unnamed tributary to Belews Lake (Pa3) in Rockingham County. Photo 4-76 is an oyster bottom of an unnamed Tidal Marsh Stream within Harbor Island Marsh in New Hanover County.

fish. Hard substrates, like oysters, rip rap, dock pilings, and boat hulls provide habitat for a wide variety of species, sanctuary for larval fish, and feeding grounds for primary predators. Photo 4-76 shows an oyster bottom within a Tidal Marsh Stream in Harbor Island Marsh near Wrightsville Beach, New Hanover County.

G: Submerged aquatic vegetation

For the purposes of NC SAM, Metric 10, the term “submerged aquatic vegetation” follows the definition used by the North Carolina Coastal Resources Commission (NCCRC): “Beds of submerged aquatic vegetation (SAV) are those habitats in public trust and estuarine waters vegetated with one or more species of submergent vegetation. These vegetation beds occur in both sub-tidal and intertidal zones and may occur in isolated patches or cover extensive areas” (15A NCAC 07H .0208 [6]). Typical species of submerged vegetation include eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*), and widgeon grass (*Ruppia maritima*). SAV beds are defined by the presence of above-ground/bed leaves (Photo 4-77) or the below-ground rhizomes and propagules.

H: Low-tide refugia (pools)

“Low-tide refugia” are depressions offering deeper water and therefore habitat for aquatic species during low tide in the intertidal zone (Photo 4-78).

I: Sand bottom

With the exception of a sand or sandy mud fringe along the shoreline, the sub-tidal bottom of most Tidal Marsh Streams is composed of mud, from sandy mud to a "pudding bottom." This results from the death of marsh grass every winter; some portion floats out into the sound to decompose, while the remainder sinks and rots in the sub-tidal channel. There is rarely enough tidal energy to transport the detritus and silt out to the sound. However, where there is enough tidal or wind energy to flush out the silt and detritus, sand bottoms occur in these streams, resulting in higher oxygen levels both at the surface and deeper into the sediments. Sand bed reaches support a much higher diversity of fauna than reaches with mud beds due to a harder bottom, greater flows, and higher oxygen levels.

J: 5% vertical bank along the marsh

For the purposes of NC SAM, "vertical banks" are the area of bank along the channel margin of marshes where energy from moving water has scoured a shelf in the bank. Vertical banks are typically considered to be stable fixtures that provide aquatic habitat (Photo 4-79 and Photo 4-80), as opposed to eroding and undercut banks that are an imminent mass-wasting threat (Photo 4-21).

K: Little or no habitat

Select this descriptor if habitats included as descriptors "E" through "J" are present only incidentally or are absent within the assessment reach.

Photo 4-77

Photo 4-78

These photos provide examples of natural in-stream habitat types. The tricolor heron in Photo 4-77 is hunting for prey within a bed of submerged aquatic vegetation (SAV) on the fringe of Bogue Sound in Carteret County. Photo 4-78 is an unnamed tributary to Middle Sound (Tidal Marsh Stream) in New Hanover County, which is characterized by a natural sand bed with low-tide refugia. The bottom two photographs show vertical banks along Tidal Marsh Streams that provide natural habitat. Photo 4-79 is Hewlett's Creek in New Hanover County, and Photo 4-80 is an unnamed tributary to the North River in Carteret County.

Photo 4-79

Photo 4-80

## 11. Bedform and Substrate – assessment reach metric

11a. ☐Yes ☐No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check appropriate box(es). (skip for Tidal Marsh Streams)**
☐A Riffle-run section
☐B Pool-glide section
☐C Natural bedform absent (skip to Metric 12, Aquatic Life)

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☐ | ☐ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Silt (< 0.062 mm) |
| ☐ | ☐ | ☐ | ☐ | ☐ | Detritus |
| ☐ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☐No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

Metric 11a

Metric 11a is used for streams in the Piedmont and Mountains only (skip for all Coastal Plain streams). Metric 11a is used in the Sediment Transport component of the Class 1 Hydrology function and the Substrate component of the Class 1 Habitat function for these stream types.

Coastal Plain streams are expected to be characterized by sand beds. Natural sand-bed streams occur only in certain areas of the Piedmont and Mountains. See Appendix G for the potential location of sand-bed stream watersheds in the Piedmont and Mountains. For Piedmont and Mountain streams located in areas known to potentially support natural sand-bed streams, the presence of abundant or predominant sand in the substrate will not be considered degraded habitat. For Piedmont and Mountain streams located outside of areas known to support natural sand-bed streams or any stream determined to be subject to anthropogenic disturbance, the assessor should select descriptor "No," and the presence of abundant or predominant sand in the substrate will be considered degraded habitat.

In Piedmont and/or Mountain streams, assessors should carefully consider ways to distinguish between a natural sand-bed stream and a non-natural sand-bed stream that has been degraded by fine sediment deposition. The following guidance may be helpful.

Natural Sand-Bed Streams

Natural sand-bed streams will be characterized by predominantly sand-sized particles (fragments with a median axis length of between 0.062 and 2 millimeters) in the streambed. However, riffle sections and natural bars may contain up to 30 percent fine and very fine gravel-sized particles (fragments with a median axis length of larger than 2 millimeters [0.08 inch] but less than 4 millimeters [0.16 inch]). Parent material with a similar grain size distribution should be evident in the banks, streamside areas, and/or the floodplain valley wall. For some natural sand-bed streams, stream banks and floodplain valley walls may contain saprolite. Saprolites associated with natural sand-bed streams will be highly weathered, friable, and break down easily into sand and finer gravel-sized particles. Outside the Coastal Plain, natural sand-bed streams will usually be associated with "a" valley shapes and lower stream and stream valley gradients.

Non-Natural Sand-Bed Stream Degraded by Fine Sediment Deposition

Natural gravel, cobbles, even bedrock in the streambed can be buried, resulting in the appearance of a natural sand-bed stream. This phenomenon can be readily determined with use of a soil auger (or a stick). If there is doubt, it may be advisable to look in the streamside area or farther upstream for predominately sandy substrate (in this case, the assessor should look beyond any natural berm, which might be expected to be comprised of sandy substrate). An assessor should be able to confirm a suspicion of sedimentation/aggradation as the source of sand by investigating the assessment reach watershed while on site or through remote mapping, which may reveal possible sediment sources such as construction sites or other recent ground-surface disturbance activities.

Appendix G provides mapping of high probability sand-bed stream areas in the Piedmont and Mountains. It should be noted that due to the map scale and level of detailed geologic mapping available, this map is a general indication of where sand-bed streams might occur, but there will be locations within the areas highlighted that do not have natural sand-bed streams.

Metric 11b

Metric 11b is used for all streams except Tidal Marsh Streams. Metric 11b is used in the Sediment Transport component of the Hydrology function and the Substrate component of the Habitat function. An assessment reach should include at least one riffle-run section and one pool-glide section whenever practicable. The availability of these features for evaluation should result in the selection of Metric 11b, descriptor "A" and/or "B," as appropriate. Examples of these features are provided in Photo 4-81 through Photo 4-96).

A riffle-run section is characterized by a reach of shallower, faster-moving water with coarser bed materials, relative to the remainder of the stream, followed by less turbulent water as it deepens and slows in the transition to a pool. Riffle-run sections typically occur on straight reaches and are relatively steep in comparison with pool-glide sections (Figure 4, p. 39). A step-pool section is characterized by an alternating succession of step and pool stream features with fast, high-energy water moving over a steep bed of bedrock or boulders. Step-pools typically occur on steeper reaches than riffles. NC SAM considers "ripple" to be a Coastal Plain subset of "riffle." For the purposes of NC SAM, availability of a riffle-run section, step-pool section, or riffle for evaluation will allow the assessor to check Metric 11b, descriptor "A."

A pool-glide section is characterized by a reach with deeper, slower-moving water, relative to the remainder of the stream, with fine bed materials followed by a reach over a rising bed causing the water to gain velocity as it approaches a riffle. Pool-glide sections typically occur on stream bends and are relatively flat in comparison with riffle-run sections (Figure 4, p. 39).

If both of these bedforms are present in the assessment reach, the assessor should select both descriptors “A” and “B.” When not practicable to include both a riffle-run section and a pool-glide section in the assessment reach, and when a portion of at least one of these bedforms occurs within the assessment reach, a riffle-run section or a pool-glide section outside of, but still within sight of the assessment reach may be used in the evaluation. This may be necessary if the assessment reach is too short to include both of these bedforms. However, it is recommended that the assessor only utilize bedforms when in-stream and stream-side conditions are similar to those of the assessment area. Also, an assessor should not use extra-assessment reach bedforms if natural bedform is absent from the assessment reach. Selecting descriptor “A” leads the assessor to evaluate Metric 11c, and selecting descriptor “B” leads the assessor to evaluate Metric 11d.

Descriptor “C” is selected in the situation of an assessment reach that lacks natural bedform due to some type of degradation. Selection of this descriptor indicates either that the assessment reach has been subject to disturbance sufficient to remove natural bedform, such as sediment filling pools and-or embedding riffles (Photo 4-6, Photo 4-19, and Photo 4-23), or the assessment reach is part of an excavated and/or maintained channel (ditch, canal, etc.) that has no natural bedform (Photo 4-12, Photo 4-13, Photo 4-17, Photo 4-18, and Photo 4-39). Selecting descriptor “C” leads the assessor to skip Metric 11c and 11d and go to Metric 12.

Photo 4-81

Photo 4-82

These photos provide examples of bedform types. Photo 4-81 shows a step-pool section on Three Tops Creek (Mb3) in Ashe County. Photo 4-82 shows a step-pool section in the background transitioning to a riffle section nearer the viewer on Stony Fork Creek (Pb3) in Wilkes County. Photo 4-83 shows a large step on Carvers Creek (Ib4) in Cumberland County. Photo 4-84 shows a pool-riffle sequence on Mill Creek (Mb4) in McDowell County.

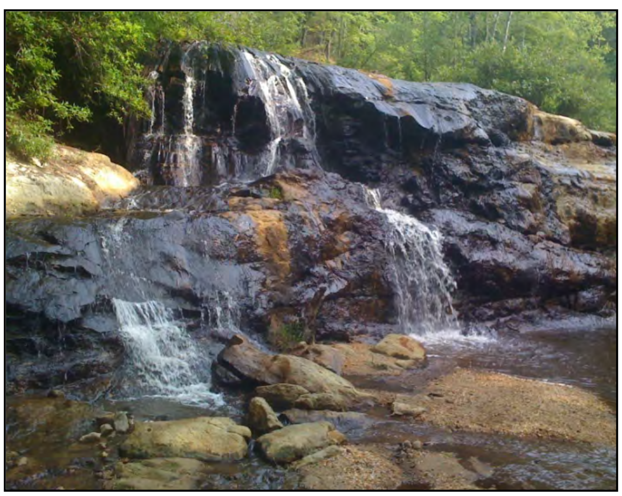


Photo 4-83

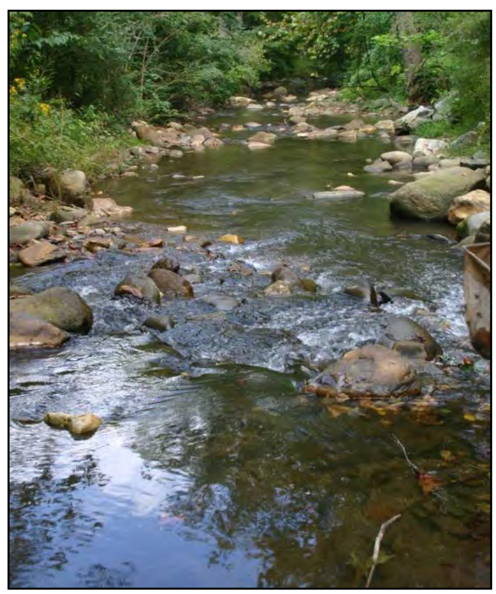


Photo 4-84

Photo 4-85

Photo 4-86

These photos provide examples of bedform types. Photo 4-85 shows a riffle section on the North Toe River (Mb4) on the Mitchell/Yancey County line. Photo 4-86 shows bedrock forming a step-pool section on an unnamed tributary to Stinking Creek (Pa2) in Chatham County. Photo 4-87 shows a riffle flowing into a pool on the Flat River (Pa4) in Durham County. Photo 4-88 shows a glide flowing into a riffle-run section on an unnamed tributary to North Deep Creek (Pa3) in Yadkin County.

Photo 4-87

Photo 4-88

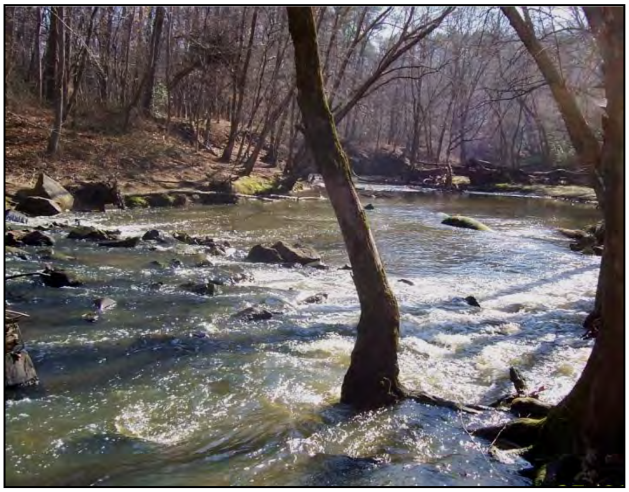


Photo 4-89

Photo 4-90

These photos provide examples of bedform types. Photo 4-89 shows a riffle-run section flowing to a pool at the bend on Crabtree Creek (Pb4) in Wake County. Photo 4-90 shows a riffle flowing into a pool on an unnamed tributary to Sycamore Creek (Pa2) in Wake County. Photo 4-91 shows a riffle-run section flowing into a pool on Sal's Branch (Pa2) in Wake County. Photo 4-92 shows a pool in a bend of Sal's Branch.

Photo 4-91

Photo 4-92

Photo 4-93

Photo 4-94

These photos provide examples of bedform types. Photo 4-93 shows a riffle-pool-riffle sequence in an unnamed tributary to Crabtree Creek (Pa1) in Wake County. Photo 4-94 shows a pool-glide section flowing into a riffle in Holly Creek (Ia3) in Edgecombe County. Photo 4-95 shows a ripple section in Batarora Branch (Ia4) in Brunswick County (note the multiple leaf packs). Photo 4-96 shows a pool-ripple-pool sequence in an interstream flat ditch that is an unnamed tributary to Pages Creek (Ia2) in New Hanover County.

Photo 4-95

Photo 4-96

Metric 11c

Metric 11c is used for all streams, except Size 4 Coastal Plain streams (Ia4, Ib4, and Oa4 streams) and Tidal Marsh Streams. Metric 11c is used in the Sediment Transport component of the Hydrology function and the Substrate component of the Habitat function. This metric should only be evaluated if the assessor selected descriptor "A" for Metric 11b.

The assessor should make substrate observations in riffle sections below the normal wetted perimeter of the assessment reach, whether submerged or not. Documentation should reflect an average of all riffles within the assessment reach. For each designation of substrate (bedrock/saprolite, boulder, cobble, gravel, sand, silt, detritus, man-made), the assessor should select the appropriate descriptor (one only for each substrate) indicating extent of occurrence within the assessment reach. Following are Metric 11c descriptors.

Not Present (NP) = absent

Rare (R) = present but less than or equal to 10 percent coverage

Common (C) = greater than 10 percent to 40 percent coverage

Abundant (A) = greater than 40 percent to 70 percent coverage

Predominant (P) = greater than 70 percent coverage

The cumulative percentages describing extent of occurrence should not exceed 100 percent for each assessment reach; therefore, only one substrate type can be identified as predominant, and no more than two substrate types can be identified as abundant. Stone placed as part of natural channel design should be regarded as natural stone in the appropriate size designation of substrate, not as man-made material (such as rip-rap).

The following guidance is provided for consideration of each size designation of substrate. The Udden-Wentworth scale (http://en.wikipedia.org/wiki/Particle_size_(grain_size)) defines size ranges of particle (grain) size.

Bedrock

"Bedrock" refers to rocks partially or wholly within a stream with a diameter greater than 4096 millimeters (13.4 feet) (Photo 4-97, Photo 4-98, Photo 4-99, and Photo 4-101).

Saprolite

"Saprolite" refers to underlying rock that has weathered in place to the degree that it is loose enough to be dug with a spade (Photo 4-100).

Boulder

"Boulder" refers to rock fragments within a stream with a diameter between 246 and 4096 millimeters (10 inches and 13.4 feet) (Photo 4-99, Photo 4-101, and Photo 4-102).

Cobble

"Cobble" refers to rock fragments within a stream with a diameter between 64 and 246 millimeters (2.5 and 10 inches) (Photo 4-101 and Photo 4-102).

Gravel

"Gravel" refers to rock fragments within a stream with a diameter between 2 and 64 millimeters (0.01 and 2.5 inches) (Photo 4-102, Photo 4-104, and Photo 4-105).

Sand

"Sand" refers to rock fragments within a stream with a diameter between 0.062 and 2 millimeters.

Photo 3-5, Photo 3-7, Photo 4-6, and Photo 4-105 through Photo 4-108 show streams with sand mixed in the bed substrate. Photo 4-105 through Photo 4-107 show Coastal Plain streams that have sand as a primary substrate – as expected. Photo 4-108 and Photo 4-19 show a Piedmont stream and a Mountain stream, respectively, both of which are located outside of areas known to support natural sand-bed streams, and are characterized by abundant or predominant sand in the bed. The natural bed substrate of these streams is expected to be common cobble, gravel, and sand, but disturbance in the watershed has resulted in embedding of the natural substrate by excessive sand deposition, thereby degrading aquatic habitat.

Silt

"Silt" refers to mineral particles within a stream with a diameter less than 0.062 millimeters (Photo 4-109).

The presence of a layer of silt is considered to inhibit the substrate from providing aquatic habitat.

Detritus

"Detritus" is organic material of various sizes (including silt-size up to leaves, twigs, or bark) lying on the stream bed, including collecting in pools (Photo 4-106, Photo 4-107, and Photo 4-110). Detritus, including loose leaves, filling a pool is usually a sign that dissolved oxygen is low because of microbial activity. A coating of silt-sized detritus on the bottom of a very small stream is doing the same thing – reducing dissolved oxygen available to aquatic life. Note: the presence of common or more detritus may suggest that dissolved oxygen is a problem for aquatic life.

Assessors should not mistake detritus for silt in the Coastal Plain. A careful examination of the material in your hand will help make certain that this mistake does not occur.

Artificial (rip-rap, concrete, etc.)

"Artificial" substrate/debris refers to structures placed in streams that are not part of an ecological restoration project. Examples of artificial debris include rip-rap, bricks, concrete blocks, treated lumber, etc. (Photo 4-12, Photo 4-17, Photo 4-23, Photo 4-34, Photo 4-35, and Photo 4-39). NC SAM does not consider artificial debris to provide aquatic habitat.

Stone placed as part of an ecological restoration project such as those using natural channel design (Photo 4-111 and Photo 4-112) should be recorded as natural stone in the appropriate size designation of substrate, not as artificial material (such as rip-rap).

Metric 11d

Metric 11d is used for all streams, except Size 4 Coastal Plain streams (Ia4, Ib4, and Oa4 streams) and Tidal Marsh Streams. Metric 11d is used in the Sediment Transport component of the Hydrology function and the Substrate component of the Habitat function. This metric should only be evaluated if the assessor selected "B" for Metric 11b.

The assessor should check "Yes" if assessment reach pools are filled to the point of degrading habitat and affecting sediment transport. A simple field test to confirm that this is the case is to use a stick or soil auger to probe for accumulations of fine sediment in the appropriate locations for pools. The lack of a depression in the channel profile and presence of relatively deep, unconsolidated, fine sediment in bends indicates that pools have filled. Concentrated organic debris in bends does not necessarily indicate that pools have filled.

Photo 4-97

Photo 4-98

These photos provide examples of various stream substrate types. Both Photo 4-97 and Photo 4-98 show beds consisting predominantly of bedrock. Photo 4-97 is Toxaway Falls (Mb4) in Transylvania County, and Photo 4-98 is an unnamed tributary to Stinking Creek (Pa2) in Chatham County. Photo 4-99 is a reach of Crabtree Creek (Pb4) in Wake County, which is characterized by a bed of abundant bedrock and boulders. Photo 4-100 shows a bed and bank comprised predominantly of saprolite in an unnamed tributary to Burdens Creek (Pa3) in Durham County.

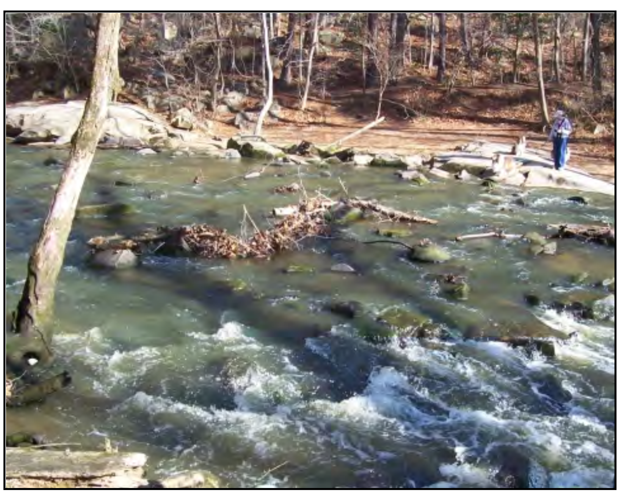


Photo 4-99

Photo 4-100

Photo 4-101

Photo 4-102

These photographs provide examples of various stream substrate types. Photo 4-101 is an unnamed tributary to Knap of Reeds Creek (Pa3) in Granville County with a bed characterized by abundant bedrock and common boulder and cobble. Photo 4-102 is an unnamed tributary to Richlands Creek (Pb1) in Wake County characterized by a bed of common boulder, cobble, and gravel. Photo 4-103 shows a northern water snake swimming among a predominance of cobble in an unnamed tributary to Stinking Creek (Pa2) in Chatham County. Photo 4-104 is an unnamed tributary to Sycamore Creek (Pa2) in Wake County with a bed of common gravel and abundant sand.

Photo 4-103

Photo 4-104

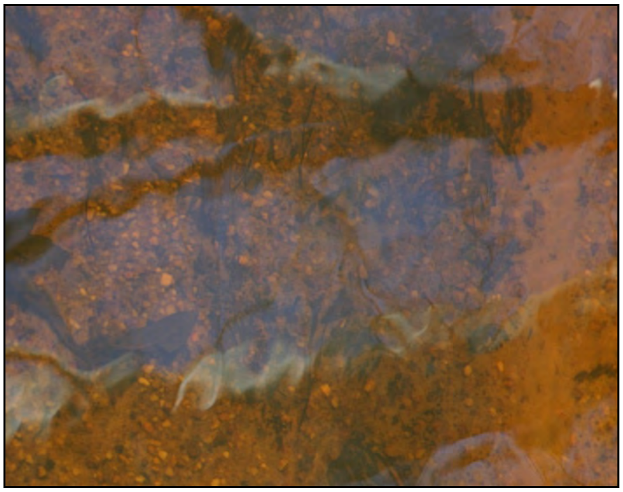


Photo 4-105

Photo 4-106

These photos provide examples of various stream substrate types. Photo 4-105 is a reach of Little Doe Creek (Oa3) in Brunswick County, a larger stream in the Outer Coastal Plain, with a bed characterized by common gravel and abundant sand. Photo 4-106 is an unnamed tributary to Town Creek (Oa1) in Brunswick County, and Photo 4-107 is an unnamed tributary to the Pasquotank River (Oa1) in Camden County, both characterized by a bed of abundant sand and detritus. Photo 4-108 is an unnamed tributary to Marsh Creek (Pa2) in Wake County, which is characterized by excessive sand deposition. The natural bed substrate of this stream is likely to be common cobble, gravel, and sand, but disturbance in the watershed has resulted in embedding of the natural substrate by excessive sand deposition – degrading aquatic habitat.

Photo 4-107

Photo 4-108

Photo 4-109

Photo 4-110

Photo 4-109 and Photo 4-110 provide examples of two stream substrate types. Photo 4-109 is an unnamed tributary to Joyce Creek (Oa3) in Camden County. This low-energy feature is a man-made ditch in an interstream divide supporting large tracts of agriculture and scattered residential development. The bed is predominantly silt. Photo 4-110 is an unnamed tributary to Little River (Ia1) in Moore County, a low-energy stream in a forested setting with a bed comprised predominantly of detritus. Photo 4-111 and Photo 4-112 show streams with stone cross vanes (in both cases, boulder) constructed as part of natural channel designs. Photo 4-111 is Holly Creek (Ia3) flowing through a golf course in Edgecombe County. Photo 4-112 is Little Sandy Creek (Pa3) in Wilkes County at Stone Mountain State Park.

Photo 4-111

Photo 4-112

## 12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)

12a. ☐Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________

12b. ☐Yes ☐No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

| 1 | >1 | Numbers over columns refer to "individuals" for Size 1 and 2 streams and "taxa" for Size 3 and 4 streams. |
|---|---|---|
| ☐ | ☐ | Adult frogs |
| ☐ | ☐ | Aquatic reptiles |
| ☐ | ☐ | Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats) |
| ☐ | ☐ | Beetles (including water pennies) |
| ☐ | ☐ | Caddisfly larvae (Trichoptera [T]) |
| ☐ | ☐ | Asian clam (*Corbicula*) |
| ☐ | ☐ | Crustacean (isopod/amphipod/crayfish/shrimp) |
| ☐ | ☐ | Damselfly and dragonfly larvae |
| ☐ | ☐ | Dipterans (true flies) |
| ☐ | ☐ | Mayfly larvae (Ephemeroptera [E]) |
| ☐ | ☐ | Megaloptera (alderfly, fishfly, dobsonfly larvae) |
| ☐ | ☐ | Midges/mosquito larvae |
| ☐ | ☐ | Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*) |
| ☐ | ☐ | Mussels/Clams (not *Corbicula*) |
| ☐ | ☐ | Other fish |
| ☐ | ☐ | Salamanders/tadpoles |
| ☐ | ☐ | Snails |
| ☐ | ☐ | Stonefly larvae (Plecoptera [P]) |
| ☐ | ☐ | Tipulid larvae |
| ☐ | ☐ | Worms/leeches |

Metric 12 is used for all streams except Tidal Marsh Streams. This metric is used in the determination of the Baseflow component of the three Class 1 functions in Size 2, 3, and 4 streams and the Aquatic Life Tolerance component of the Class 1 Water Quality function of all streams.

Metric 12a

If the assessment reach is "too large or dangerous" to sample, the assessor should have selected "Yes" for Metric 9 (p. 75) and will then skip Metric 12. In this case, the Rating Calculator will default to giving this metric a rating of "High." Circumstances aside from prohibitive size and danger may prevent an aquatic life assessment from being performed. In such cases, the assessor should select "No" for Metric 12a and provide a reason, either select "No Water" or select "Other" and write the reason in the blank provided. In this case, the Rating Calculator follows an alternative path for generating the function rating that excludes this information.

The aquatic life assessment is anticipated to be part of the 15-minute NC SAM assessment. Guidance for conducting an in-stream aquatic life assessment sufficient for the purposes of NC SAM is provided as follows.

NC SAM Guidance for Conducting an In-stream Aquatic Life Assessment

The aquatic life assessment need not be lengthy, but should be thorough (sample all available habitats). The assessment should begin in riffles, if present, and proceed to other habitats (in the order of pools, snags and logs, leaf packs, macrophytes, root mats, hard substrate, and banks) as time allows if not finding aquatic life in riffles.

Ideally, a search for macroinvertebrates will be conducted with a net (Photo 4-113). The size of the net itself is not terribly important; however, the mesh size should be between 0.5 and 0.8 millimeters. The net should be placed in a riffle downstream of the largest movable habitat in the deepest part of the riffle. The area upstream of the net should be agitated, usually by hand, to knock invertebrates loose and allow them to wash into the net. Detritus caught in the net can be examined in the net; however, it is easier and more efficient to put the net's contents into a white pan with a small amount of water in the bottom. The water allows invertebrates to swim (or walk), making them easier to find. The pan (or net) contents should be carefully examined for invertebrates. Observance of mussels/snail shells and larval cases/exuviae within the assessment reach indicate presence of these animals.

If a net is not available, rocks or sticks located in the deeper parts of riffles should be visually examined. Macroinvertebrates are usually located on the underside of the habitat; however, the top and sides should be examined as well (Photo 4-114).

Photo 4-113

Photo 4-114

These photos depict in-stream aquatic life assessments. Guidance for conducting an assessment sufficient for the purposes of NC SAM is provided in the Metric 12 (Aquatic Life) discussion. Photo 4-113 portrays the sampling of an unnamed tributary to Beaverdam Creek (Ia1) in Martin County, and Photo 4-114 portrays the sampling of an unnamed tributary to Carvers Creek (Ia2) in Cumberland County.

Metric 12b

If an appropriate aquatic life assessment is conducted and no aquatic organisms are present in the assessment reach, the assessor should select "No" for Metric 12b and skip to Metric 13.

If an appropriate aquatic life assessment is conducted and aquatic organisms are present in the assessment reach, the assessor should select "Yes" for Metric 12b and record the results in this section. All boxes that apply to the results for the assessment reach should be checked. Note that the column headings ("1" and ">1") refer to individuals for Size 1 and 2 streams and taxa for Size 3 and 4 streams. "Taxa" is the plural form of taxon, a taxonomic category or group, such as a phylum, order, family, genus, or species. Invertebrates, once found, should be identified to the lowest practical taxonomic level (Order or lower). See Appendix H for a pictorial guide to common aquatic fauna.

Assessors that conduct or have access to a more detailed aquatic life survey for the assessment reach than is proposed by NC SAM should consider appending the results of the more detailed survey to the NC SAM product for the assessment area.

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no alteration to water storage capacity over a majority of the streamside area |
| ☐B | ☐B | Moderate alteration to water storage capacity over a majority of the streamside area |
| ☐C | ☐C | Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) |

This metric is used for all streams found in "a" valley types (this excludes "b" valley types and Tidal Marsh Streams). This metric is used in the determination of the Microtopography component of the Class 1 Hydrology function.

The Assessor should evaluate both the left bank (LB) and right bank (RB) for this metric (this determination is made from the perspective of looking downstream). The term "alteration" means a change in water storage capacity resulting from human activity. Evaluation of this metric requires the assessor to make a determination as to whether <u>a majority</u> of the streamside area has been altered from reference (a relatively undisturbed state) water storage capacity. For the purposes of this metric, "water storage capacity" refers to both the ground surface microtopography and the interstitial soil capacity to store water from overbank events, precipitation, and upland runoff. This metric does not require the assessor to make or estimate any measurements concerning ground surface microtopography or soil interstitial capacity; rather, the assessor is requested to make a judgment as to whether the water storage capacity has been altered from reference. The timing of an alteration is not as important as whether an alteration is apparent and currently affecting streamside area water storage capacity.

If a majority of the streamside area appears to have "little or no" alteration in water storage capacity from reference, the assessor should select descriptor "A." If the assessor determines that more than a little alteration has occurred, a further determination of the intensity of alteration (moderate ["B"] or severe ["C"]) is required. If a portion of the streamside area is disturbed and a portion is relatively undisturbed, the assessor should consider whether the disturbed area is abutting the stream or is buffered from the stream by a relatively undisturbed area. A disturbed area that is buffered from the stream by a relatively undisturbed area is considered to have less of a detrimental effect on stream function than a disturbed area abutting the stream. Therefore, the existence of good buffer abutting the stream can possibly raise the rating of a site from descriptor "C" to descriptor "B," even if the majority of the streamside area fits the description of descriptor "C."

Examples provided within descriptor "C" (ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) are not considered to be all inclusive, but are intended to assist with this determination; however, it is left to the assessor to judge the intensity of the stressor affecting the streamside area when deciding between a moderate and a severe alteration. Assessors should consider both stressors that increase surface and sub-surface storage capacity and stressors that decrease surface and sub-surface storage capacity. Stressors that potentially reduce surface and sub-surface storage capacity may include ditches connected to a tributary or other receiving water, fill, soil compaction (foot traffic in parks, maintenance of utility line corridors causing an alteration of infiltration rates), livestock disturbance (soil compaction, vegetation removal), buildings, and drainage pipes. Stressors that potentially increase surface and sub-surface capacity may include ditches not connected to a tributary or other receiving water, livestock disturbance (increased surface roughness), and man-made levees/berms. The cause of an alteration to water storage capacity does not necessarily have to be located within the streamside area.

Samples of sites evaluated by the SFAT are provided in Photo 4-115 through Photo 4-118). Photo 4-115 shows a streamside area with no alteration in water storage capacity – descriptor "A." Photo 4-116 (the view is downstream) shows a streamside area that is unaltered on the left bank – descriptor "A," and is moderately altered on the right bank as a result of vegetation strata removal and compaction from regular mowing – descriptor "B." Photo 4-117 shows a man-made ditch in an interstream flat, and Photo 4-118 shows a channelized stream in an urban setting. In both of these photos the streamside area on both banks is characterized by severe alteration to water storage capacity – descriptor "C."

Photo 4-115

Photo 4-116

These photos provide examples of streamside area ground surface condition. Photo 4-115 is an unnamed tributary to Town Creek (Oa1) in Brunswick County, which flows through a mature forest with no alteration to streamside water storage capacity. Photo 4-116 is a downstream view of an unnamed tributary to Knap of Reeds Creek (Pa3) in Granville County. The streamside area is unaltered on the left bank and moderately altered on the right bank (vegetation strata removal, compaction from regular mowing, and a curb-and-gutter street located 200 feet from the stream). Photo 4-117 is an unnamed tributary to Joyce Creek (Oa3) in Camden County, a man-made ditch in an interstream flat with abutting active row crops on one bank and abutting maintained turf on the other. Photo 4-118 is an unnamed tributary to the Neuse River (Ia2) in Lenoir County. In both Photo 4-117 and Photo 4-118, the streamside area on both banks is characterized by severe alterations that have degraded water storage capacity and now accelerate surface runoff to the stream.

Photo 4-117

Photo 4-118

## 14. Streamside Area Water Storage – streamside area metric (skip for Tidal Marsh Streams and B valley types)

**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Unaltered or majority of streamside area with depressions able to pond water ≥ 6 inches deep |
| ☐B | ☐B | Majority of streamside area with depressions able to pond water 3 to 6 inches deep |
| ☐C | ☐C | Majority of streamside area with depressions able to pond water < 3 inches deep |

This metric is used only for Size 2 and 3 streams found in "a" valley types. This metric is used in the determination of the Microtopography component of the Class 1 Hydrology function. The assessor should consider the streamside area when evaluating this metric and should evaluate both the left bank (LB) and right bank (RB) for this metric (this determination is made from the perspective of looking downstream).

Initially, evaluation of this metric requires the assessor make a determination as to whether a majority of the streamside area is characterized by a surface water storage capacity that has been altered from reference (a relatively undisturbed state) (similar to Metric 13). "Unaltered" means the natural water-storage capacity has not been changed by human activity. For the purposes of this metric, "surface water storage capacity" refers to the ground surface microtopography only and its ability to store water from overbank events, precipitation, and upland runoff. This is not an evaluation of the depth of the streamside area "bowl," but an evaluation of the surface microtopography. The timing of an alteration is not as important as whether an alteration is currently affecting streamside area water storage capacity. The cause of an alteration to surface water storage capacity does not necessarily have to be located within the streamside area.

If there is no alteration from reference surface water storage capacity, descriptor "A" is appropriate. If there is an alteration from reference, the assessor should estimate the depth of ground surface microtopography. A simple method for doing this is to lay a stick (auger, shovel, or branch) across depressions (Photo 4-119) and estimate the average distance between the stick and the ground surface. The assessor is cautioned that overestimation of depression depth is common, and use of a tool is highly recommended. The assessor should consider all depressions in the streamside area regardless of origin (include man-made microtopography). The optimum descriptor for this metric varies with stream category. A smaller stream requires less microtopography to rate "High" than a larger stream.

Photo 4-119

Photo 4-119 shows a soil auger (with a 3-foot shaft) being used to determine average streamside area water storage depth in Tyrrell County. This site is characterized by depressions able to pond water 1 to 2 feet deep.

## 15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)

**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

| LB | RB | |
|---|---|---|
| ☐Y | ☐Y | Are wetlands present in the streamside area? |
| ☐N | ☐N | |

For all Size 1 and 2 streams, and Size 3 streams in the Inner and Outer Coastal Plain, this metric is used in determination of the Baseflow component of all three Class 1 functions. This metric is used for all streams in the determination of the "streamside area pollutant filtration" sub-class of the Water Quality function. The assessor should consider both the left bank (LB) and right bank (RB) of the streamside area (this determination is made from the perspective of looking downstream) when evaluating this metric and should not consider wetlands located within the stream banks.

"Wetlands" are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (Environmental Laboratory 1987). Wetlands generally include swamps, marshes, bogs, and similar areas (33 CFR 328.3(b)). The term "wetlands," as used by NC SAM, refer to areas that meet the criteria set forth by the USACE in the *Corps of Engineers Wetlands Determination Manual* (Environmental Laboratory 1987) and the Regional Supplements (USACE 2010a and USACE 2010b). Examples of streamside area wetlands are provided in Photo 4-120 and Photo 4-121.

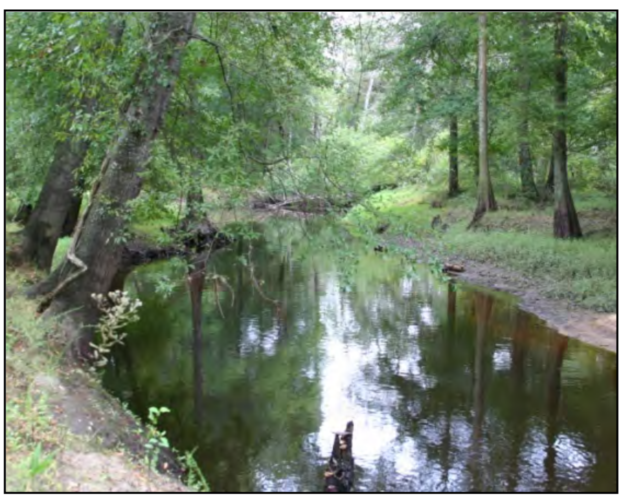


Photo 4-120

Photo 4-121

These photos provide examples of wetlands within the streamside area. Photo 4-120 is Mill Creek (Ia4) in Johnston County, and Photo 4-121 is Portohonk Creek (Oa3) in Camden County. In both examples, streamside area wetlands are the NC WAM general type Riverine Swamp Forest. The plant community visible in the latter photo is a mature forest.

## 16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)

**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☐A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction that passes some flow during low-flow periods affecting assessment reach (ex: beaver dam, bottom-release dam)
☐D Evidence of bank seepage or sweating (iron oxidizing bacteria in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☐F None of the above

For all Size 1 and 2 streams, and Size 3 streams in the Inner and Outer Coastal Plain, this metric is used in determination of the Baseflow component of all three Class 1 functions. This metric is not used in the evaluation of Size 3 streams in the Piedmont and Mountains, all Size 4 streams, and Tidal Marsh Streams.

Assessors should note the instructions to "check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach." Contributors may occur outside of the assessment area, but must be draining to the assessment reach. The term "in view of" is intentional so as to avoid obligating the assessor to travel outside of the assessment area. The conjunction "<u>and</u>" is underlined to indicate that both stated conditions must be met for the descriptor to be appropriately checked. More than one contributor can be checked.

A brief discussion of metric descriptors follows.

A: Streams and/or springs

A stream is a body of concentrated flowing water in a natural low area or natural channel on the land surface (15A NCAC 2B .0259 (2) (k)) or a ditch or canal. A stream may be either a natural or man-modified or man-made water course containing water at least part of the year. For the purposes of NC SAM, the terms stream and tributary are synonymous and used interchangeably, and both imply federal and/or state jurisdictional status. An example of the confluence of a small stream with a larger one is provided in Photo 4-122.

A spring is a place where a concentrated discharge of ground water flows at the ground surface (http://water.usgs.gov/water-basics_glossary.html) (Photo 4-123). Springs may be a source of hydrology to a wetland abutting a stream, or result in the formation of a channel immediately, or contribute to an adjacent stream.

B: Ponds (include wet detention basins; do not include sediment basins or dry detention basins)

Ponds are open, still bodies of water, smaller than lakes (less than 20 acres). Ponds are usually impoundments and may be man-made (farm ponds, small impoundments) or natural (beaver ponds, vernal pools). It is anticipated that wet detention basins (Photo 2-27) will provide baseflow through slow runoff following precipitation events and groundwater infiltration thereafter, while sediment basins (Photo 4-124 ) and dry detention basins (Photo 4-125) will be dry between precipitation events, resulting in negligible inputs to stream baseflow.

C: Obstruction that passes some flow during low-flow periods affecting the assessment reach (examples: beaver dam, leaky dam, bottom-release dam, weir)

Obstructions are structures that impede stream flow. For the purposes of this metric, the assessor should look for obstructions that allow for the passage of water within the assessment reach during low-flow periods such as during late summer and in drought conditions. This includes (but is not limited to) man-made structures such as leaky dams, bottom-release dams, and weirs and natural structures such as fallen trees, debris piles, and beaver dams (Photo 2-7, Photo 2-8, Photo 4-7, and Photo 4-126).

The obstruction does not have to be within the assessment reach, but the obstruction must be within view of the assessment reach and affecting the assessment reach.

D: Evidence of bank seepage or sweating (iron oxidizing bacteria in water indicates seepage)

Bank seepage refers to groundwater discharging from the surface of a stream bank. Physical evidence may include moving water, oxidized iron (orange), and algae growth (Photo 4-127, Photo 4-128, and Photo 4-129).

Bank sweating refers to refers to groundwater discharging from the surface of a stream bank. Physical evidence may include soil surface glistening, oxidized iron (orange) (Photo 4-130), and algae growth (Photo 4-130).

E: Stream bed or bank soil reduced (dig through deposited sediment if present)

Reduced soils are soils in an oxygen-depleted, environment. In the absence of oxygen, certain mineral ions (mainly iron and manganese) within the soil become chemically reduced and leach from the parent material. Reduced soils may be identified by their low chroma. A “reducing environment” is one conducive to the removal of oxygen and chemical reduction of ions in the soils (Environmental Laboratory 1987).

The assessor should check for reduced soils within the assessment reach (Photo 4-131). This descriptor is given credit as a baseflow contributor in intermittent streams (in which it occurs some of the time) but not in perennial streams (in which it occurs almost all of the time).

F: None of the above

This descriptor is appropriate if none of descriptors “A” through “E” applies to the assessment area.

Photo 4-122

Photo 4-123

The first two photos provide examples of baseflow contributors. Photo 4-122 is an unnamed tributary (Pb1) flowing into South Prong Little River (Pb3) in Montgomery County. The unnamed tributary is a baseflow contributor to the South Prong Little River. The standing pipe in Photo 4-123 is located at a spring that forms an unnamed tributary to the Haw River (Pa1) in Alamance County. The spring itself is considered a baseflow contributor to the unnamed tributary it forms. Photo 4-124 shows a sediment basin protecting water quality in an unnamed tributary to Crabtree Creek (Pa2) in Wake County. Sediment basins are expected to provide short-term water storage only and are therefore not considered to be baseflow contributors. Photo 4-125 shows a dry detention basin at the end of its construction on the I-440 beltline in Raleigh, Wake County. This stormwater BMP is designed to treat initial runoff from precipitation events and dry out shortly thereafter; therefore, it is not considered a baseflow contributor.

Photo 4-124

Photo 4-125

Photo 4-126

Photo 4-127

These photos provide examples of baseflow contributors.  The beaver dam in Photo 4-126 is acting as an obstruction allowing the passage of flow during low-flow periods on Smith Mill Creek (Ma3) in Buncombe County, and is therefore considered to be a baseflow contributor.  Photo 4-127 shows both bank seepage and algae growth on an unnamed tributary to Coinjock Bay (Oa4) in Currituck County.  Photo 4-128 shows evidence of bank seepage (oxidized iron in the water column) in Knap of Reeds Creek (Pa4) in Granville County.  Photo 4-129 shows both bank seepage and iron-oxidizing bacteria along the shoreline of a Riverine Swamp Forest abutting the Neuse River (Ia4) in Craven County.

Photo 4-128

Photo 4-129

Photo 4-130

Photo 4-131

These photos provide evidence of baseflow contributors. Photo 4-130 shows evidence of bank sweating (iron-oxidizing bacteria and algae growth along the bank) in an unnamed tributary to Ledge Creek (Pa1) in Granville County. Photo 4-131 shows a reduced soil sample taken from a stream bank with a Dutch auger.

## 17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)

**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (examples: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☐F None of the above

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the Baseflow component of all three Class 1 functions. Assessors should note that more than one detractor can be checked. Descriptors refer to various evaluation areas: assessment reach, streamside area, and watershed). In general, assessors should consider the effect of the detractor in terms of the stream size (example: a small detractor may not substantially affect a large stream).

A brief discussion of metric descriptors follows.

A: Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)

Reason for water withdrawal is not important. However, the assessor must determine that the withdrawal is “substantial” (has an effect on stream baseflow). For instance, removal of water for irrigating crops is expected to substantially affect baseflow for even a large stream. Photo 4-132 shows the inlet end of a withdrawal pipe located in an excavated pool within an Ia3 stream; the withdrawn water is used to irrigate agricultural fields. During development of this manual, SFAT members observed water withdrawal from a Size 3 stream for aquaria at a small environmental center adjacent to the stream (Photo 4-133). This withdrawal was not likely to substantially affect baseflow of the Size 3 stream and would therefore not merit the selection of this descriptor. Photo 4-134 shows a weir and transfer pipe combination used to withdraw water from a Size 2 stream to fill a pond within a public park. The source stream is small enough for this activity to be considered a baseflow detractor.

B: Obstruction not passing flow during low-flow periods affecting the assessment reach (examples: water-tight dam, sediment deposit)

For the purposes of NC SAM, an obstruction is a structure that impedes stream flow. Obstructions that do not allow the passage of flow within the assessment reach during low-flow periods include man-made structures such as water-tight dams and weirs (Photo 4-134) and natural structures such as bedrock sills and sediment deposits. However, the latter features will have to be watertight at low flow, which will not normally be the case.

Note the term “during low-flow periods.” Low-flow periods include the dry season and drought conditions.

The obstruction does not have to be within the assessment reach, but the obstruction must be within view of the assessment reach and affecting the assessment reach.

C: Urban stream (≥ 24% impervious surface for watershed)

Impervious surfaces impede surface water infiltration (examples: concrete, asphalt, roof tops, gravel), thereby increasing the rate of surface runoff. This decreases the ability of the streamside area to contribute to baseflow and increases surface runoff leading to flashy flows.

The U.S. Geological Survey has a web utility called StreamStats that may prove useful for delineating watershed areas and watershed land uses (including percent impervious surfaces) for specific points on their stream network. This utility is available at the following website: [http://streamstats.usgs.gov/north_carolina.html.](http://streamstats.usgs.gov/north_carolina.html)

As a rule of thumb, this descriptor is appropriate if the watershed draining to the lowest point of the assessment reach is characterized by 24 percent or more impervious surfaces. This threshold is based on the NCDWQ's stormwater, water supply and buffer rules (contained throughout 15A NCAC 02B and 02H), which include various levels of percent imperviousness as regulatory triggers for various intensities of stormwater treatment. In general, the 24 percent imperviousness threshold is used for this purpose for the most common types of waters across the state. However, in watersheds characterized by more sensitive waters (such as High Quality Waters or Outstanding Resource Waters), a threshold of 12 percent imperviousness is used in the NCDWQ's rules (15A NCAC 02H .1006 (2)(b) and 15A NCAC 02H .1006 (1) (i)), respectively. In these watersheds, the assessor may use the 12 percent threshold to indicate an urban stream for the purposes of this metric instead of the 24 percent threshold (with documentation), especially if in-stream effects of higher/flashy flows are apparent. In the absence of 24 percent or more impervious surface, this descriptor is appropriate if the assessor observes that the assessment area is subject to flashy flows that, among other things, may destabilize banks, scour the channel and/or streamside area, and damage streamside vegetation (Photo 2-33 and Photo 4-135 through Photo 4-137).

D: Evidence of streamside area modification resulting in accelerated drainage into the assessment reach

Evidence that makes this descriptor appropriate includes pipes, drain tiles, ditches (shallow or few ditches are not likely to affect baseflow or accelerate drainage), and thinning or removal of vegetation (Photo 2-5, Photo 4-28, Photo 4-32, Photo 4-50, Photo 4-117, Photo 4-118, Photo 4-138, and Photo 4-139). If a portion of the streamside area is modified to have accelerated drainage into the assessment reach and a portion is relatively undisturbed, the assessor should consider whether the modified area is abutting or directly affecting the stream (is a point source) or is successfully buffered from the stream by a relatively undisturbed area. A modified area that is buffered from the stream by a relatively undisturbed area is considered to have less of a detrimental effect on stream function than a modified area abutting the stream (a point source). Therefore, the existence of good buffer abutting the stream may obviate the reason to select descriptor "D" for this metric when other portions of the streamside area have been modified.

Presence of a stormwater basin in the streamside area decelerates drainage by temporarily storing water, thereby reducing the storm hydrograph. Therefore, this descriptor is not appropriate for features such as stormwater basins.

E: Assessment reach relocated to valley edge

The term "relocated" means "relocated by humans."

Although a meandering stream may naturally approach the valley wall from time to time, a stream that has been relocated away from the center/fall of the valley to the valley edge (Photo 4-15 and Photo 4-138) is expected to capture a reduced amount of ground water for baseflow relative to a stream located near or in the center of the valley.

F: None of the above

This descriptor is appropriate if none of descriptors "A" through "E" applies to the assessment area.

Photo 4-132

Photo 4-133

These photos provide examples of baseflow detractors. Photo 4-132 shows a pipe extending to a float in Turkey Creek (Ia3) in Pender County. Photo 4-133 shows pipes used to withdraw water from Church Creek (Pa3) in Rowan County for the purpose of maintaining small aquaria associated with a nature center. Photo 4-134 shows a weir and transfer pipe combination used to collect water from an unnamed tributary to Grant's Creek (Pa2) in Rowan County for transfer to a pond in a public park. Photo 4-135 shows a stream in an urban setting, the East Prong of Slocumb Creek (Ia3) in Craven County. This stream is characterized by parking lots and maintained lawn in the streamside area, unstable banks, and surface scour in the channel and streamside area.

Photo 4-134

Photo 4-135

Photo 4-136

Photo 4-137

These photos provide additional examples of baseflow detractors. Photo 4-136 is Hendrick's Creek (Ia4) in Edgecombe County. Photo 4-137 is an unnamed tributary to Gum Branch (Pa3) in Mecklenburg County. Photo 4-138 is an unnamed tributary to Little River (Pa3) in Randolph County that has been relocated to the edge of the floodplain to make room for a shopping center. Photo 4-139 is the streamside area of the Linville River (Ma4) in Burke County. The first three photos show streams in urban settings subject to flashy flows that result in unstable banks and scoured channels and streamside areas. The stream in Photo 4-138 is characterized by degraded shading, and in Photo 4-139, stream shading is gone or largely absent. The last two photos provide examples of streamside area modifications that result in accelerated drainage into the stream.

Photo 4-138

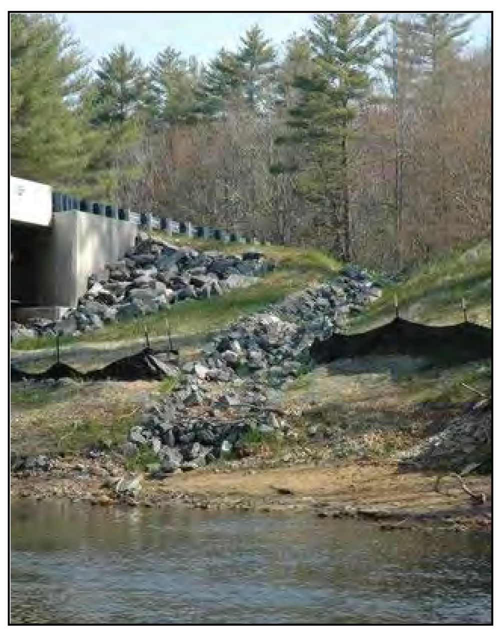


Photo 4-139

### 18. Shading – assessment reach metric (skip for Tidal Marsh Streams)

Consider aspect. Consider "leaf-on" condition.

☐A Stream shading is appropriate for the stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the "thermoregulation" sub-class of the Water Quality function and the Streamside Area Habitat component of the Habitat function.

The option of right and left banks for this metric is waived in favor of the consideration of aspect. The statement "consider aspect" means the following: if a portion of the streamside vegetation is absent, but the absent portion is located on the north side of the stream, appropriate vegetation on the south bank may still allow descriptor "A" to be an appropriate selection since this vegetation will tend to cast a shadow across the stream during the hottest part of the year. Shading can be provided by vegetation not immediately adjacent to the stream. Tall vegetation a little distance away may still provide appropriate shading due to sunlight angle of incidence.

"Appropriate" shading is a relative term and varies among stream categories. "Appropriate" shading includes "natural gaps," which refers to gaps that may form in a forest canopy when trees fall as a result of "natural processes" such as lightning strikes, disease, and storms. Large, widespread canopy gaps, even to the point of canopy loss, due to fire or hurricane damage are considered natural gaps. Processes not considered to be natural include man-maintained gaps, such as utility line and road corridors and maintained residential/commercial yards lacking appropriate shading.

Larger streams with trees along each bank are considered to have appropriate shading, even though the middle of the streams are exposed to sunlight much of the time (Photo 4-62 and Photo 4-140). In Photo 4-140, even though the floodplain on each side of this stream supports pasture, a wooded buffer on both banks results in "appropriate" shading (descriptor "A").

"Degraded" shading refers to situations where natural vegetation has been thinned or reduced by humans such as park, suburban, and urban settings (Photo 2-9, Photo 2-19, Photo 2-39, Photo 4-49, Photo 4-60, and Photo 4-141); agricultural and pastoral settings (Photo 2-17); near infrastructure such as roads and utility lines (Photo 2-13); in areas recovering from disturbances such as timber removal (Photo 2-23, Photo 4-24, Photo 4-27, Photo 4-138, Photo 4-142, and Photo 4-143); or areas dominated by non-native, invasive species (Photo 2-24).

"Gone or largely absent" refers to situations where natural vegetation that provides shade has been removed entirely or nearly so by humans. Again, examples are provided for park, suburban, and urban settings (Photo 2-5, Photo 2-20, Photo 2-21, Photo 2-33, and Photo 3-14); agricultural and pastoral settings (Photo 2-38, Photo 4-9, and Photo 4-28); near infrastructure such as roads and utility lines (Photo 2-14 and Photo 4-139); and areas recovering from disturbances such as timber removal (Photo 4-112).

Photo 4-140

Photo 4-141

These photos provide examples of various shading scenarios. Photo 4-140 shows appropriate shading provided by a narrow stand of medium-density vegetation on Hunting Creek (Ma4) in Wilkes County. This stand of woody vegetation acts as a buffer between the stream and an active livestock pasture. Photo 4-141 is Burnt Mill Creek (Ia3) through Wallace Park in Wilmington, New Hanover County. This portion of the park retains canopy cypress trees, while the saplings, shrubs, and natural herbs have been replaced by a maintained lawn, resulting in low stem density and degraded shading. Photo 4-142 shows a dense thicket within a young secondary growth forest over an unnamed tributary to Turkey Creek (Ia1) in Pender County, which is evaluated as “degraded” shading. Photo 4-143 shows a man-made structure (Jerry’s Kitchen) providing shade for an unnamed tributary to the Atlantic Intracoastal Waterway (Oa1) near Holden Beach in Brunswick County. Although aspect results in stream shading, this case is evaluated as “degraded” shading.

Photo 4-142

Photo 4-143

## 19. Buffer Width – assessment area metric (skip for Tidal Marsh Streams)

**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated LB | Vegetated RB | Wooded LB | Wooded RB | |
|---|---|---|---|---|
| ☐A | ☐A | ☐A | ☐A | ≥ 100 feet wide or extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide or no trees |

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the Streamside Area Attenuation component of the Hydrology function, the Upland Pollutant Filtration component of the Water Quality function, and the Streamside Habitat component of the Habitat function. The assessor should consider the streamside area when evaluating this metric and should evaluate both the left bank (LB) and right bank (RB) for this metric (this determination is made from the perspective of looking downstream).

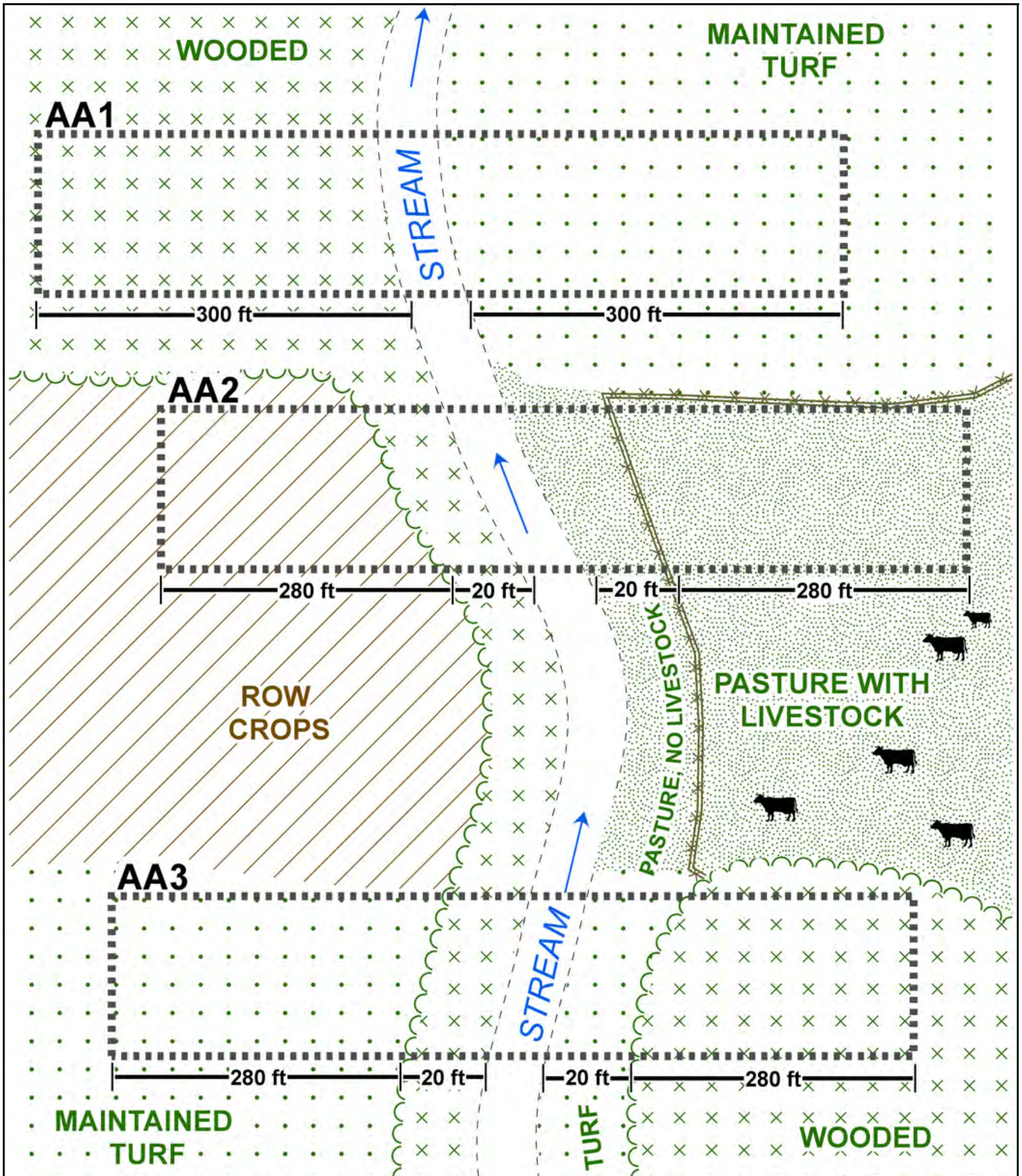
"Vegetated buffer" is an area dominated by vegetation and abutting a stream. In this case, "vegetation" refers to both herbaceous and woody vegetation, regardless of height. An area dominated by vegetation has greater than 50 percent coverage of vegetation. Vegetated buffer breaks are areas lacking vegetation and greater than 10 feet wide. Vegetated buffer width is measured perpendicular to the stream from the top of bank to the first break. Vegetated buffer provides the Water Quality functions of promotion of infiltration, erosion deterrent, and temperature moderation (thermoregulation).

"Wooded buffer" is an area of vegetation dominated by woody species and abutting a stream. The height of the woody species is not important. Wooded buffer breaks are areas not dominated by woody vegetation and greater than 10 feet wide. Wooded buffer width is measured perpendicular to the stream from the top of bank to the far side of woody stems along the first break. Wooded buffer provides the Hydrology functions of energy dissipation of overbank flows and upland runoff and interception of precipitation, as well as the Habitat functions of temperature moderation and habitat diversity enhancement.

Buffer widths are measured horizontally, as opposed to along the ground surface. If the distance from the top of bank to a buffer break varies within the streamside area, estimate the average buffer width for each bank. If the streamside area contains a gap in the buffer, make a note on the Field Assessment Form and evaluate this metric based on perceived buffer function or consider re-evaluating the original assessment reach termini. Only living vegetation should be considered when evaluating this metric.

Note that descriptor "A" includes the clause "or extends to the edge of the watershed." Descriptor "A" is appropriate if the watershed is less than 100 feet wide and the buffer extends from the top of bank to the edge of the watershed.

See Figure 5 and Photo 4-138, Photo 4-140, Photo 4-141, and Photo 4-144 through Photo 4-149 for examples of the evaluation of this metric. Note that this metric focuses on buffer width




| | | |
|---|---|---|
| NC SAM USER MANUAL | **EXPLANATION OF BUFFER WIDTH AND BUFFER STRESSOR METRICS** | FIGURE **5** |

and not buffer structure (Metric 20, p. 125), stem density (Metric 22, p. 136), or vegetative composition (Metric 24, p. 140).

Figure 5 provides three assessment reach examples for the evaluation of buffer width: assessment area 1 (AA1), assessment area 2 (AA2), and assessment area 3 (AA3). AA1 is characterized by a left bank streamside area dominated by wooded vegetation and a right bank streamside area dominated by maintained turf. For the vegetated buffer portion of this metric, both banks (LB and RB) are evaluated as descriptor "A" – "≥ 100 feet wide or extends to the edge of the watershed." For the wooded buffer portion of this metric, the left bank (LB) is evaluated as descriptor "A" – "≥ 100 feet wide or extends to the edge of the watershed," and the right bank (RB) is evaluated as descriptor "E" – "< 10 feet wide or no trees."

AA2 is characterized by a left bank streamside area dominated by wooded vegetation for the first 20 feet from the top of bank and then active row crops from 20 to beyond 300 feet from the top of bank, and a right bank streamside area dominated by pasture with active livestock use. For the vegetated buffer portion of this metric, the result of the left bank evaluation is dependent on whether or not the row crop area is dominated by vegetation. If the row crop area is dominated by vegetation, both banks (LB and RB) are evaluated as descriptor "A" – "≥ 100 feet wide or extends to the edge of the watershed." If the row crop area is not dominated by vegetation, the left bank (LB) is evaluated as descriptor "D" – "from 10 to 30 feet wide," and the right bank (RB) is evaluated as descriptor "A." For the wooded buffer portion of this metric, the left bank (LB) is evaluated as descriptor "D," and the right bank (RB) is evaluated as descriptor "E" – "< 10 feet wide or no trees."

AA3 is characterized by a left bank streamside area dominated by wooded vegetation for the first 20 feet from the top of bank and then maintained turf from 20 to beyond 300 feet from the top of bank, and a right bank streamside area dominated by maintained turf for the first 20 feet from the top of bank and then wooded vegetation from 20 to beyond 300 feet from the top of bank. For the vegetated buffer portion of this metric, both banks (LB and RB) are evaluated as descriptor "A" – "≥ 100 feet wide or extends to the edge of the watershed." For the wooded buffer portion of this metric, the left bank (LB) is evaluated as descriptor "D" – "from 10 to 30 feet wide," and the right bank (RB) is evaluated as descriptor "E" – "< 10 feet wide or no trees." The right bank is appropriately evaluated as descriptor "E" even though the outer 280 feet of the streamside area is wooded vegetation. Wooded buffer is measured from the top of bank outward to the first wooded buffer break, which is an area not dominated by woody vegetation and greater than 10 feet wide. Since the first 20 feet from the top of bank is not dominated by wooded vegetation, this area constitutes a wooded buffer break.

The stream in Photo 4-138 has recently been moved to the edge of the floodplain to make room for a shopping center and parking lot. The left bank (the far bank in the photo) is currently dominated by shrubs from the stream bank out to about 30 feet. An additional 10 feet (from 30 to 40 feet from the top of bank) is comprised of maintained lawn that extends to the parking lot. The left bank supports a vegetated buffer that extends for 40 feet from the top of bank; therefore, the appropriate descriptor for vegetated buffer is "C." The left bank supports a wooded buffer that extends 30 feet from the top of bank; therefore, the appropriate descriptor for wooded buffer is also “C.”

Photo 4-140 shows a wooded buffer that extends 15 feet from the top of bank and active cow pasture that extends from 15 to beyond 300 feet. The appropriate descriptor for vegetated buffer for this reach is “A,” and the appropriate descriptor for wooded buffer for this reach is “D.” Trees are growing on the bank slope; however, the bank slope is part of the stream channel and is not considered part of the wooded buffer width, which starts at the top of bank.

Photo 4-141, taken looking downstream, shows Wallace Park in Wilmington. Shrubs and saplings have been removed, leaving maintained lawn and scattered cypress trees. Both banks support vegetation for a width of over 100 feet from the top of bank and are evaluated as descriptor “A” for vegetated buffer. Both banks support wooded buffer for an average of 50 to 60 feet, so the appropriate descriptor for wooded buffer for both banks is “B.”

The view in Photo 4-144 is looking upstream. On the right bank, both the vegetated and wooded buffer exceeds 100 feet in width (descriptor “A”). On the left bank, the width of the vegetated buffer extends 10 feet from the top of bank to the edge of paved road. The road represents a vegetated buffer break. Since the edge of road is less than 10 feet from the top of bank the appropriate vegetated buffer descriptor is “E.” The left bank supports no wooded buffer, so the appropriate wooded buffer descriptor is “E.”

The view in Photo 4-145 is looking downstream. Both banks support vegetation that extends greater than 100 feet from the top of bank and are evaluated as descriptor “A” for vegetated buffer. The fence on the left bank demarcates the closest extent of wooded vegetation, which is approximately 20 feet from the visible reach. Since the wooded buffer is measured from the top of bank to the first break, and the distance to the closest wooded buffer is greater than 10 feet from the top of bank, the appropriate wooded buffer descriptor is “E.” The right bank lacks wooded vegetation; therefore, the appropriate wooded buffer descriptor is “E” again.

Essentially all wooded vegetation has been removed from the bank shown in Photo 4-146. A vegetated buffer extends approximately 10 feet from the top of bank. Therefore, the appropriate descriptor for both vegetated buffer and wooded buffer for this reach is “E.”

The view in Photo 4-147 is looking upstream. Both banks of the visible reach support vegetation for more than 100 feet from the top of bank and are evaluated as descriptor “A” for vegetated buffer. The average distance to wooded buffer on the right bank is between 10 and 15 feet, and the average distance to wooded buffer on the left bank is over 40 feet. Wooded buffer is measured from the top of bank to the first break, and since the first 10 feet from the top of bank is lacking wooded vegetation, the appropriate wooded buffer descriptor is “E” for both banks.

Photo 4-144

Photo 4-145

These photos provide examples of various vegetated buffer and wooded buffer widths, which are discussed in detail in the text. Photo 4-144 is an unnamed tributary to the Albemarle Sound (Oa2) in Tyrrell County. Photo 4-145 is an unnamed tributary to Bogue Sound (Oa2) in Carteret County. Photo 4-146 is an unnamed tributary to Charles Creek (Oa3) in Pasquotank County. Photo 4-147 is Raynor Mill Branch (Ia2) in Wayne County.

Photo 4-146

Photo 4-147

The view in Photo 4-148 is looking upstream. The right bank streamside area is maintained as an agricultural field with an approximately 10 foot wide maintained herbaceous strip abutting the stream. Since this area is dominated by vegetation, the appropriate descriptor is "A" for vegetated buffer. If the agricultural field had recently been plowed, removing the vegetation within the field and leaving only the 10 foot wide herbaceous strip, the appropriate descriptor would be "E." The left bank streamside area supports vegetation for more than 100 feet and is evaluated as descriptor "A" for vegetated buffer. The left bank streamside area supports scattered woody vegetation, but woody vegetation is not dominant, so the appropriate descriptor is "E."

The view in Photo 4-149 is looking upstream. Both banks support narrow strips (less than 10 feet wide) of irregularly maintained shrubs and then agricultural fields dominated by herbaceous vegetation. Therefore, the appropriate descriptor for vegetated buffer is "A," and the appropriate descriptors would be "E" for both vegetated and wooded buffer.

Photo 4-148

Photo 4-149

These photos provide examples of various vegetated buffer and wooded buffer widths, which are discussed in detail in the text. Photo 4-148 is an unnamed tributary to Briery Run (Ia3), and Photo 4-149 is an unnamed tributary to Falling Creek (Ia2), both in Lenoir County. The unnamed tributary to Falling Creek has been excavated in an interstream divide.

## 20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)

**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation <u>or</u> modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the Upland Pollutant Filtration component of the Water Quality function. The assessor should consider the streamside area when evaluating this metric and should evaluate both the left bank (LB) and right bank (RB) for this metric (this determination is made looking downstream).

<u>This metric should be evaluated for the "vegetated buffer" considered in Metric 19 (Buffer Width).</u> If the streamside area contains more than one characteristic buffer structure, make a note on the Field Assessment Form and evaluate this metric based on perceived buffer function provided or consider re-locating the original assessment reach termini. If a portion of the streamside area supports a modified buffer structure and a portion supports mature forest, the assessor should consider whether the area supporting a modified buffer structure is abutting the stream or is successfully buffered from the stream by mature forest. A modified buffer structure that is buffered from the stream by a mature forest is considered to have less of a detrimental effect on stream function than a modified buffer structure abutting the stream. Therefore, the existence and width of good buffer (mature forest) abutting the stream may obviate the reason to select any of descriptors "B" through "E" for this metric, depending on the characteristics of the site.

A brief discussion of metric descriptors follows.

A: Mature forest

"Mature forest" has an appropriately stratified vegetative structure comprised of large canopy trees, a sub-canopy of smaller trees, and an understory.

"Trees" are woody plants approximately 20 feet or more in height and 3 inches or more in diameter at breast height (DBH) (modified from USACE 2010a and/or b).

B: Non-mature woody vegetation or modified vegetation structure

"Non-mature woody" vegetation is a forest assemblage that does not meet the criteria of mature forest stated above.

"Scattered trees" is considered to be equivalent to "modified vegetation structure" and is included in this descriptor.

This descriptor may be appropriate if the assessor finds pronounced evidence of hemlock wooly adelgid damage resulting in the death of a portion of the canopy.

C: Herbaceous vegetation with or without a strip of trees < 10 feet wide

An “herb” is a non-woody plant, regardless of size (modified from USACE 2010a and/or b). Maintained lawn, pasture, and agricultural field (row crops) are included in this descriptor.

“A strip of trees < 10 feet wide” includes a line of trees along the top of a stream bank and a narrow band or strip of trees that may or may not vary in width, but does not average 10 feet in width or greater as measured from the outer diameter of the stem.

D: Maintained shrubs

“Shrubs” are woody plants approximately less than 20 feet in height (modified from USACE 2010).

“Maintained shrubs” refers to a plant community that is regularly maintained and is dominated by woody vegetation (such as a utility line corridor).

E: Little or no vegetation

Select this descriptor if vegetation assemblages included as descriptors “A” through “D” are present only incidentally or vegetation is absent within the streamside area.

Visual examples of “mature forest” are provided by Photo 3-1, Photo 4-30, Photo 4-115, and Photo 4-121.

Photo 4-150 provides an example of “non-mature woody vegetation or modified vegetation structure” on both banks. This site is a park within a residential subdivision in Cary, NC. The plant community is characterized by scattered trees over a maintained lawn (shrubs and saplings have been removed), resulting in an appropriate buffer structure descriptor of “B” for both banks. Other visual examples of descriptor “B” are provided by Photo 2-19, Photo 4-24, Photo 4-31, Photo 4-138, and Photo 4-141.

Photo 4-151 provides an example of “herbaceous vegetation with or without a strip of trees < 10 feet wide” on both banks. This photo shows a stream with pasture on both banks characterized by herbaceous vegetation with a strip of trees; the appropriate buffer structure descriptor for both banks is “C.” Other visual examples of descriptor “C” are provided by Photo 2-17, Photo 2-21, Photo 2-38, and Photo 4-48.

Photo 4-152 provides an example of “maintained shrubs.” This photo shows a streamside area under a regularly maintained utility line corridor that is dominated by shrubs; therefore, the appropriate buffer structure descriptor is “D.” Another visual example of descriptor “D” is provided by Photo 4-111, which shows a stream crossing a golf course fairway. The wooded buffer is maintained in a low, shrub state to ease the passage of golf balls.

The view in Photo 4-153 is looking downstream and shows a stream extending parallel to a road. The left bank is a mature forest (descriptor “A”). The right bank is a maintained road shoulder dominated by herbaceous vegetation (descriptor “C”).

Visual examples of “little or no vegetation” are provided by Photo 4-118 and Photo 4-146. The former is located in an urbanized area of Kinston and is characterized by a less than 10-foot wide strip of maintained lawn. The latter is located in a rural, residential area and is again characterized by a less than 10-foot wide strip of vegetation.

Photo 4-150

Photo 4-151

These photos provide examples of disturbed buffer structure as discussed in the text. Photo 4-150 is an unnamed tributary to Swift Creek (Pa1) in a residential development in Wake County. The streamside area wooded vegetation is maintained at a low stem density. Photo 4-151 and Photo 4-152 show streamside areas of two reaches of Chappel's Creek (Pa3) in Person County. The streamside area of the former is characterized by active livestock pasture with a single line of trees on stream banks; the streamside area of the latter is within a maintained utility line corridor dominated by shrubs. Photo 4-153 shows a reach of Rocky Creek (Pa2) along a road shoulder in Wake County bounded to one side by mature forest and to the other by maintained herbaceous vegetation.

Photo 4-152

Photo 4-153

## 21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)

**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).

**If no stressors, check here and skip to Metric 22:** ☐No Stressors

| Abuts LB | Abuts RB | < 30 feet LB | < 30 feet RB | 30-50 feet LB | 30-50 feet RB | |
|---|---|---|---|---|---|---|
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the Upland Pollutant Filtration component of the Water Quality function. A box is provided for the assessor to check if none of the listed stressors occurs within 50 feet of the assessment reach. The assessor should consider the streamside area when evaluating this metric and should evaluate both the left bank (LB) and right bank (RB) (this determination is made from the perspective of looking downstream) for each of the conditions (Abuts, <30 feet, and 30-50 feet) evaluated by this metric. If a stressor occurs on one bank only, the appropriate box should be checked for that bank, and no box should be checked for the other bank.

These stressors are land uses considered to degrade water quality through runoff of nutrients and chemicals associated with fertilizers, animal wastes, herbicides, pesticides, and sedimentation from hoof shear.

Following are brief discussions of each listed stressor.

A: Row crops

"Row crops" refers to a land use wherein the ground surface is maintained for the planting of crops (examples: tobacco, corn, soy beans, cotton, tomatoes) and the land is subject to fertilizers, herbicides, and pesticides. This land use includes areas regularly plowed as well as areas subject to no-till practices. Although no-till fields typically receive lower levels of fertilizers and pesticides and are characterized by less runoff and export to streams than regularly plowed fields, no-till fields typically receive more herbicides than regularly plowed fields and are irregularly plowed. The determination of whether or not a field is used for row crops is based on evidence at the site on the day of the evaluation (some examples include stubble in fields from the previous growing season and recently plowed fields).

B: Maintained turf

"Maintained turf" refers to lawn and other herbaceous assemblages characterized by intensive management, assuming regular application of fertilizers, herbicides, and/or pesticides, as would be expected in a residential or commercial yard, a golf course, or sod farm. This term does not include roadside shoulders, fallow fields, regularly burned areas, or regularly mowed areas without application of fertilizers, herbicides, and/or pesticides.

C: Pasture (no livestock)/commercial horticulture

"Pasture (no livestock)" primarily refers to areas maintained in grasses and herbs. Hay fields that typically are not plowed and do not support livestock are included in this category. Also in this category are commercial horticultural operations, the cultivation of an orchard or nursery, including Christmas tree farms. The primary reason for including horticultural operations is the incidental soil compaction within the streamside area that results from maintenance of these areas. The NCDWQ has found that herbicides and pesticides used in association with horticultural operations are typically not a water quality problem for nearby streams.

D: Pasture (active livestock use)

"Pasture (active livestock use)" is maintained in grasses and herbs to provide forage for livestock. In this case, there is evidence (grazed vegetation, hoof shear/ground disturbance, animal waste) of the presence of livestock in the pasture.

The first pair of columns is appropriate if a listed stressor abuts the assessment reach. A stressor is considered to be abutting an assessment reach if it extends to the top of bank. If a stressor extends to near the top of bank, and there is either little or no vegetation between the stressor and the assessment reach or the vegetation present is somehow diminished in terms of providing buffer (examples may include: regularly maintained by mowing, burning, or chemicals), then "abuts" is the appropriate descriptor. The second pair of columns is appropriate if a listed stressor occurs within 30 feet of the assessment reach but is not abutting the assessment reach. If a stressor extends to near the top of bank, and the vegetation between the stressor and the assessment reach provides a functioning buffer (examples may include: mature forest or medium to high density non-mature woody vegetation), then "< 30 feet" is the appropriate descriptor. The third pair of columns is appropriate if a listed stressor occurs between 30 and 50 feet of the assessment reach. NC SAM utilizes the 30-foot threshold to maintain consistency with USACE and NCDWQ riparian buffer widths utilized in the Mountains.

Photo 4-117 was taken facing upstream. A crop of soy beans has been planted to the top of the left bank of a stream excavated in an interstream divide in the Outer Coastal Plain. The appropriate descriptor for this example is "A" in the "LB" column under "Abuts." Maintained turf abuts the stream on the right bank; therefore, the appropriate descriptor for this example is "B" in the "RB" column under "Abuts."

Photo 4-154 shows a downstream view of an excavated stream within an agricultural field at the upper end of the drainage basin. The reach in the foreground is characterized by an approximately 10 foot wide strip of maintained herbaceous vegetation abutting the stream and no-till row crops beyond that on both sides of the stream. A literal reading of the metric leads to an evaluation of row crops within 30 feet of, but not abutting, the stream (descriptor "A" in both the "LB" and "RB" columns under "< 30 feet"). However, if the assessor observes evidence that the narrow strip of maintained herbaceous vegetation abutting the stream is providing diminished buffer function resulting in water quality degradation, this reach may more appropriately be evaluated as row crops abutting the stream on both banks (descriptor "A" in both the “LB” and “RB” columns under “Abuts”). The reach in the background is characterized by row crops within 30 feet of the stream, resulting in evaluation as descriptor “A in both the “LB” and “RB” columns under “< 30 feet.”

Photo 4-155 shows an excavated and straightened stream in an agricultural field at the upper end of the drainage basin. This agricultural field has lain fallow for a year and currently supports herbaceous vegetation interspersed with stubble from a recent crop. In this case, both banks can be rated as “row crops, abuts” (descriptor “A” in both the “LB” and “RB” columns under “Abuts”).

Photo 4-156 shows a stream flowing across a golf course fairway. The reach in the foreground is characterized by maintained turf extending to the top of bank, resulting in evaluation as descriptor “B” in both the “LB” and “RB” columns under “Abuts.” The reach in the background is characterized by a narrow (less than 30 feet wide) shrub thicket between the maintained turf and the stream, resulting in evaluation as descriptor “B” in both the “LB” and “RB” columns under “< 30 feet.” Other examples of maintained turf abutting streams are provided by Photo 2-20, Photo 2-22, Photo 2-39, Photo 4-12, Photo 4-23, and Photo 4-145.

Photo 4-157 through Photo 4-159 show streams characterized by abutting active pasture. The appropriate descriptor for these examples is “D” in both the “LB” and “RB” columns under “Abuts.” Function degradation is apparent in both of the latter two photos (a dead cow on the bank in the first and bank and streamside area erosion and aquatic vegetation choking the channel in the second).

Other visual examples of pasture with active livestock use include Photo 2-15, Photo 2-18, and Photo 4-151. Photo 4-160 shows pasture with evidence of active livestock use that extends to within 30 feet of the left stream bank but is not abutting the stream. The appropriate descriptor for this example is “D” in the “LB” column under “< 30 feet.” Photo 4-9 provides another visual example of this circumstance. Photo 4-140 shows pasture with evidence of active livestock use located between 30 and 50 feet from the right stream bank. The appropriate descriptor for this example is “D” in the “RB” column under “30-50 feet.”

An example of horticultural uses is a Christmas tree farm. Photo 4-161 shows a Christmas tree farm within 30 feet of but not abutting the stream. The appropriate descriptor for this example is “C” in the “LB” column under “30-50 feet.” The maintained grass abutting each side of the stream would only be considered maintained turf if evidence of the use of fertilizer, pesticides, and/or herbicides is observed on site or learned of from a knowledgeable source.

Photo 4-162 and Photo 4-163 provide an example of a stressor abutting a stream that does not meet the criteria to be evaluated for this metric. Photo 4-162 shows a parallel, maintained utility line abutting a stream, and Photo 4-163 shows a perpendicular crossing of a maintained utility line over a stream. Although these utility lines appear to be regularly disturbed and both support vegetation dominated by a non-native, invasive species, Japanese grass (*Microstegium vimineum*), the circumstances do not meet the criteria of this metric (land uses considered to degrade water quality through runoff of nutrients and chemicals associated with fertilizers, animal wastes, herbicides, pesticides, and sedimentation from hoof shear). In the case of both of these streams, an evaluator should check the “No Stressors” box and skip to the next metric.

Figure 5 (p. 120) provides three assessment reach examples for the evaluation of Metric 19 (Buffer Width, p. 119): assessment area 1 (AA1), assessment area 2 (AA2), and assessment area 3 (AA3). These examples are evaluated for Metric 21: Buffer Stressors (p. 129) in the following three paragraphs.

AA1 has a left bank streamside area dominated by wooded vegetation and a right bank streamside area dominated by maintained turf abutting the assessment reach. Evaluation of AA1 results in selection of descriptor “B” in the “RB” column under “Abuts.” No listed stressor occurs on the left bank, so no “LB” boxes are checked.

AA2 has a left bank streamside area dominated by wooded vegetation for the first 20 feet from the top of bank and then row crops beginning 20 feet from the top of bank and extending out beyond 300 feet from the top of bank, and a right bank streamside area dominated by pasture with active livestock use. Within the pasture, a fence is located an average of 20 feet from the assessment reach blocking access to the stream by livestock. In summary, the left bank has a buffer stressor (row crops) within 30 feet of the stream but not abutting the stream, and the right bank has pasture with no livestock abutting the stream and pasture with active livestock within 30 feet of the stream but not abutting the stream. Evaluation of AA2 results in selection of descriptor “A” in the “LB” column under “< 30 feet,” selection of descriptor “C” in the “RB” column under “Abuts,” and selection of descriptor “D” in the “RB” column under “< 30 feet.” In this case, only part of the left bank streamside area supports a listed buffer stressor (row crops), and although the right bank fully supports pasture, only part of the right bank supports pasture with active livestock use. Notes describing these streamside area features should be written on the Field Assessment Form, and the evaluation of this metric should be based on the perceived/evidenced buffer function provided.

AA3 has a left bank streamside area dominated by wooded vegetation for the first 20 feet from the top of bank and maintained turf from 20 to beyond 300 feet from the top of bank, and a right bank streamside area dominated by maintained turf for the first 20 feet from the top of bank and wooded vegetation from 20 to beyond 300 feet from the top of bank. Evaluation of AA3 results in selection of descriptor “B” in the “LB” column under “< 30 feet” and selection of descriptor “B” in the “RB” column under “Abuts.” In this case, only part of each bank streamside area supports a listed buffer stressor (maintained turf). Notes describing these streamside area features should be written on the Field Assessment Form, and the evaluation of this metric should be based on the perceived/evidenced buffer function provided.

Photo 4-154

Photo 4-155

The top two photos provide examples of row crops in the streamside area. Photo 4-154 is a downstream view of an excavated unnamed tributary to Stonyton Creek (Ia2) in Lenoir County. The reach in the foreground is characterized by row crops within 30 feet of the stream and a narrow, maintained herbaceous assemblage abutting both banks, while the reach in the background is characterized by row crops within 30 feet of the stream on both banks but separated from the stream by "non-mature woody vegetation" on the left bank and "mature forest" on the right bank. Photo 4-155 is an excavated unnamed tributary to New River (Ia3) in Onslow County. This reach is situated in an agricultural field that has lain fallow for a year. Photo 4-156 is Holly Creek (Ia3) in Edgecombe County where the stream traverses a golf fairway. The reach in the foreground is characterized by maintained turf abutting both banks, while the reach in the background is characterized by maintained turf within 30 feet of the stream but separated from the stream by "non-mature woody vegetation." Photo 4-157 is Elk Creek (Ma3) in Ashe County. This stream is characterized by abutting pasture with active livestock use.

Photo 4-156

Photo 4-157

Photo 4-158

Photo 4-159

These photos provide examples of various buffer stressors. Photo 4-158 is an unnamed tributary to Back Creek (Pa2) in Mecklenburg County. This stream is characterized by abutting pasture with active livestock use and refuse dumping. Photo 4-159 is an unnamed tributary to the New River (Ia2) in Onslow County where the stream has been excavated within an active cow pasture on an interstream divide. Photo 4-160 is the Little River (Pa4) in Randolph County where an active cow pasture extends to within 30 feet of the stream, but access to the stream is denied by a fence. Photo 4-161 is a downstream view of an unnamed tributary to Squirrel Creek (Ma2) in Avery County. The left bank supports a Christmas-tree plantation (horticulture) within 30 feet of but not abutting the stream.

Photo 4-160

Photo 4-161

Photo 4-162

Photo 4-163

Photo 4-162 is an unnamed tributary to Wildcat Branch (Pa2) in Wake County and is characterized by a parallel, abutting, maintained utility corridor. Photo 4-163 is an unnamed tributary to Crabtree Creek (Pa1) in Wake County and is characterized by a perpendicular crossing of a maintained utility corridor. However, as described above, neither of these streams qualifies for use of this metric.

## 22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)

**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer <u>or</u> predominantly herbaceous species <u>or</u> bare ground |

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the Streamside Area Attenuation component of the Hydrology function. The assessor should consider the streamside area when evaluating this metric and should evaluate both the left bank (LB) and right bank (RB) for this metric (this determination is made from the perspective of looking downstream).

<u>This metric should be evaluated for the "wooded buffer" considered in Metric 19 (Buffer Width).</u> This metric is focused on energy dissipation of both flowing water across the ground surface and precipitation falling through the streamside area airspace. The assessor should consider both living and dead vegetation when evaluating this metric.

"Medium to high stem density" is appropriate if the streamside area wooded buffer is in reference condition or is relatively undisturbed. Examples of medium to high stem density (descriptor "A") are provided by Photo 3-1, Photo 3-3, Photo 4-71, Photo 4-115, Photo 4-121, Photo 4-140, Photo 4-164, and Photo 4-165.

"Low stem density" is appropriate when wooded buffer has been degraded (such as a vegetative community lacking expected strata or one that has been thinned) relative to expectations for the streamside area vegetation. Examples of low stem density (descriptor "B") are provided by Photo 2-39, Photo 3-8, Photo 4-60, Photo 4-141, Photo 4-150, Photo 4-152, Photo 4-166, and Photo 4-167.

Examples of "no wooded riparian buffer <u>or</u> predominantly herbaceous species <u>or</u> bare ground" (descriptor "C") are provided by Photo 4-9, Photo 4-18, Photo 4-23, Photo 4-39, Photo 4-117, Photo 4-118, and Photo 4-145.

Photo 4-164

Photo 4-165

These photos provide examples of stem density. The upper two photos provide examples of “medium to high stem density”, and the lower two photos provide examples of “low stem density.” Photo 4-164 is an unnamed tributary to Beaverdam Creek (Ia2) in Martin County. Photo 4-165 is an unnamed tributary to Crabtree Creek (Pa2) in Wake County. Photo 4-166 is a floodplain park adjacent to an unnamed tributary to Knap of Reeds Creek (Pa3) in Granville County. Photo 4-167 is an unnamed tributary to Burnt Coat Swamp (Ia2) flowing through Randolph Park in Enfield, Halifax County.

Photo 4-166

Photo 4-167

## 23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)

Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the Upland Pollutant Filtration component of the Water Quality function and the Thermoregulation component of the Habitat function. The assessor should consider vegetated buffer within the streamside area and should evaluate both the left bank (LB) and right bank (RB) (this determination is made from the perspective of looking downstream).

This metric requests the assessor to make a determination as to whether the vegetated buffer is continuous along the length of each bank of the assessment reach. "Vegetated buffer" is an area dominated by vegetation (herbaceous and/or woody) starting at the top of the bank. Vegetated buffer width is measured perpendicular to the stream from the top of bank to the first break. Vegetated buffer breaks are areas lacking vegetation greater than 10 feet wide. If the vegetated area is less than 10 feet wide starting at the top of bank (measured perpendicular to the bank), there is a break in buffer continuity; and if there is a break in vegetation 10 feet wide or more measured parallel to the bank (a boat ramp, for example), there is a break in continuity. Thus, buffer breaks can be caused by activities that are parallel to or perpendicular to the stream.

For the purposes of this metric, the assessor should consider the total length of each bank within the assessment area to be 100 percent. If there is more than one break on a bank, the cumulative length of breaks should be used to determine the percentage of breaks on that bank.

Photo 4-168 through Photo 4-170 show breaks in vegetation buffer continuity. In Photo 4-168, the bare ground on the right side of the photo constitutes a break in buffer continuity. In Photo 4-169 and Photo 4-170, the boat ramps and associated parking lots, respectively, constitute breaks in buffer continuity. The parking lot in Photo 4-169 extends to within 10 feet of the top of bank; therefore, the length of bank beside the parking lot is considered to be a break in buffer continuity. Other photos in the User Manual that display breaks in vegetation buffer continuity include Photo 4-118 (the vegetated area does not equal or exceed 10 feet in width on either side of the stream), Photo 4-143 (the vegetated area does not equal or exceed 10 feet in width beside the building), and Photo 4-144 (the vegetated area does not equal or exceed 10 feet in width between the canal and the road).

Photo 4-168

Photo 4-169

These photos provide examples of breaks in continuity of vegetated buffers. Photo 4-168 is Atkins Branch (Ia3) in Lenoir County, and the non-vegetated, sandy area is considered a buffer break. Photo 4-169 is the Roanoke River (Ia4) on the Martin/Bertie County line, where the boat ramps and associated parking lot constitute a buffer break. Photo 4-170 is an unnamed tributary to Bear Swamp (Ia2) in Robeson County, where the parking lot less than 10 feet from the stream constitutes a buffer break.

Photo 4-170

**24. Vegetative Composition – First 100 feet of streamside area metric (skip for Tidal Marsh Streams)**

Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing or communities with non-native invasive species present, but not dominant, over a large portion of the expected strata or communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities composed of planted stands of non-characteristic species or communities inappropriately composed of a single species or no vegetation. |

For all streams, except Tidal Marsh Streams, this metric is used in the determination of the Stream-side Habitat component of the Habitat function. The assessor should consider vegetation within 100 feet of each bank (both the left bank [LB] and right bank [RB]; this determination is made from the perspective of looking downstream) or to the edge of the watershed, whichever comes first, when evaluating this metric. This metric should be evaluated based on current condition, not a past condition or anticipated future condition.

NC SAM considers streamside area vegetative composition and structure with regard to its ability to provide appropriate habitat (logs, sticks, leaves, detritus) to the assessment reach and its ability to provide habitat for wildlife living in the riparian area or using the riparian area as a travel corridor. Note that the assessor should "evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first)." NC SAM considers the first 100 feet of vegetation from the top of bank to be the primary source of vegetative matter providing in-stream habitat. "Dominant vegetation" is the community with 50 percent or greater coverage, regardless of location within the streamside area. The designation "non-native invasive" species includes species that are not indigenous to a region, have been intentionally or accidentally introduced, and are often persistent. See Appendix I for a list of species considered to be non-native invasive species in North Carolina for the purposes of NC SAM. While numerous non-native invasive species occur in North Carolina, the emphasis is on those with the ability to become abundant in natural or disturbed streamside areas and displace or prevent recovery of native species. Communities subject to insect damage (pine beetle, hemlock wooly adelgid, etc.) should be evaluated based on the effects of the infestation on the day of the evaluation.

Photo 4-171 through Photo 4-174 show various examples of vegetative composition. In Photo 4-171 (the view is downstream), the left bank meets the criteria of descriptor "A." The right bank supports dense stands of Chinese privet (*Ligustrum sinense*) intermixed with wisteria (*Wisteria* sp., blooming), both non-native invasive species dominating the first 100 feet measured perpendicular from the top of bank, which matches descriptor "C" (communities with non-native invasive species dominant over a large portion of expected strata). Photo 4-172 shows a streamside area characterized by saplings and a few trees of species typical of recently disturbed areas, vegetation composition that "…indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing," matching descriptor "B." Photo 4-173 shows streamside area vegetation recovering from a clear-cut that is currently characterized by the term "Mature canopy is absent," resulting in a rating of "C." Photo 4-174 shows a reach with the streamside area dominated by kudzu (*Pueraria lobata*) and little to no other vegetation. This streamside area is characterized as "Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities inappropriately composed of a single species," which matches descriptor "C."

Photo 4-171

Photo 4-172

These photos provide examples of vegetative composition. Photo 4-171 is a view facing downstream on Conaby Creek (Oa4) in Washington County. The left bank vegetation is relatively undisturbed, while the right bank supports non-native, invasive species (wisteria [*Wisteria floribunda*]) over a large portion of the expected strata. Photo 4-172 is the streamside area of an unnamed tributary to McPherson Creek (Pa2) in Cumberland County. This community is composed of woody native species that developed after clear-cutting. Photo 4-173 is a reach of the Vann Swamp Canal (Oa4) in Beaufort County. In this example, streamside area timber has recently been harvested. Photo 4-174 is an unnamed tributary to the South Fork Catawba River (Pb1) in Gaston County. In this example, vegetation is severely disturbed and is dominated by non-native, invasive species (kudzu).

Photo 4-173

Photo 4-174

## 25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)

25a. ☐Yes ☐No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ______________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

Metric 25 is used in Mountain and Piedmont streams only, and only when specific conditions occur (see list below). This metric is used for the determination of the Aquatic Life Tolerance component of the Water Quality function.

Conductivity is a measure of a solution's (i.e. water) ability to carry an electrical current. The measurement is used in fresh water analyses to obtain a rapid estimate of dissolved solids or salt content of a water sample. A pristine mountain stream in North Carolina may have a conductivity measurement as low as 15 microsiemens per centimeter (µS/cm), and natural levels statewide are generally less than 100 µS/cm. Conductivity should be measured in water deep enough to cover the probe and without agitating sediment and/or detritus into the water column.

The thresholds for Metric 25b descriptor options are based on a document entitled "Explorations of Specific Conductance Values and Benthic Macroinvertebrate Community Bioclassifications" generated by the N.C. Division of Water Quality in October 2011 (Appendix J). This document provides the results of an analysis of specific conductance readings, chemical water quality monitoring data, and benthic macroinvertebrate community sampling data collected at the same sites for over 25 years. These data determined the relationship between bioclassification and specific conductance and identified conductance ranges that suggest better or worse water quality. The results of this analysis suggest that in the Mountains and Piedmont NC SAM Zones "there are sufficient data available showing strong correlations between annual median specific conductance and the bioclassification based on benthic macroinvertebrate community sampling."

A conductivity reading will be used in generating the NC SAM rating only in specific circumstances. All of the following conditions need to be met for conductivity to be used in generating an NC SAM rating.

- The assessment reach is located in either the Mountains or Piedmont NC SAM Zone
- The assessment reach contains water in either pools or throughout the reach
- The assessment reach contains no habitat (Metric 10b [75] is evaluated as descriptor "E" (Little or no habitat), and Metric 11c [84] is evaluated as "NP" (Not Present for bedrock, boulder, cobble, and gravel)
- An appropriate benthic macroinvertebrate survey has been conducted (see description associated with Metric 12: Aquatic Life, p. 99) and no macroinvertebrates were found

This suite of conditions may regularly be met in intermittent and small perennial streams in the Mountains or Piedmont. Conductivity readings should be recorded in these streams whenever possible. Note that there is a practical limitation when the depth of the stream becomes less than the width of the conductivity probe. The probe should be suspended in the water column when taking a reading. Disturbing the bottom will increase suspended particles in the water column, increasing ions, and subsequently conductivity, rendering the reading meaningless. Be aware that obtaining a meaningful conductivity measurement may not always be possible.

A breakdown of the possible outcomes concerning Metric 25 follows.

If all of these conditions are met <u>and</u> conductivity has been recorded (Metric 25a is “Yes”), the Rating Calculator will use the conductivity measurement in the generation of a rating for the “aquatic life tolerance” sub-class of the Water Quality function. A further possibility in this scenario occurs in the case of an intermittent stream, in which low Conductivity (a “High” rating) can raise a “Low” or “Medium” rating of “aquatic life tolerance” one rating level.

If all of these conditions are met <u>and</u> no conductivity measurement is recorded (Metric 25a is “No”), the Rating Calculator will default to a rating of “High” for the “aquatic life tolerance” sub-class of the Water Quality function.

If all of these conditions are not met <u>and</u> conductivity has been recorded (Metric 25a is “Yes”), the Rating Calculator will ignore the conductivity measurement and use other data documented on the Field Assessment Form in the generation of a rating for the “aquatic life tolerance” sub-class of the Water Quality function.

If all of these conditions are not met <u>and</u> conductivity has not been recorded (Metric 25a is “No”), the Rating Calculator will use other data documented on the Field Assessment Form in the generation of a rating for the “aquatic life tolerance” sub-class of the Water Quality function.

# 5.0 STREAM ASSESSMENT PROCESS

It is crucial that the assessor become familiar with the NC SAM stream categories and Field Assessment Form in order to conduct a proper stream assessment. Assessors will need to be familiar with watershed physiography and appropriate stream geomorphology and function within the project area. Assessors will also need to develop a clear understanding of the intention of each metric, how the intention of each metric may change with different stream categories, and how stream characteristics within categories may change among different ecoregions.

An on-going objective during development of NC SAM was that on-site completion of the Field Assessment Form should take no more than 15 minutes. However, it is assumed that this 15-minute, on-site stream assessment will be performed following a federal and/or state jurisdictional area delineation or determination, and that during the course of the delineation/determination, the assessor will have become familiar with the environmental features important to this stream assessment method. This being the case, the assessor should be familiar with site and regional physiography, soils, hydrology, vegetation, and watershed activities affecting the site. The assessor should also be familiar with the proposed project in order to determine potential impact areas and identify appropriate individual assessment areas.

Completion of a stream functional assessment will typically be a five-step process. The first three steps will likely be completed as part of a jurisdictional area delineation/determination but are outlined here to maintain continuity in the discussion of information sources and methods. The terms “tributary” and “stream” are synonymous since both are features subject to federal and/or state jurisdiction.

1. Background information – become familiar with regional features through off-site research (mostly map analysis); conduct an in-office map/GIS evaluation if needed (see Section 5.1 [p. 146])
2. On-site investigation – conduct an on-site investigation sufficient to identify the presence and extent of tributaries (see Section 5.2 [p. 146])
3. Determination of evaluation areas – identify assessment reaches and make a determination of assessment area boundaries (see Section 5.3 [p. 147])
4. NC SAM documentation – Completion of the Field Assessment Forms through a rapid, on-site evaluation of each assessment area, collect and organize supporting information (see Sections 4.0 through 4.2.2 [pp. 35-144] and 5.4 [p. 169])
5. Generation of functional assessment ratings – use the Rating Calculator to generate assessment reach ratings (see Section 5.5 [p. 170])

## 5.1 Background Information

Tools available for the assessor to become familiar with regional features may include the following.

- NC SAM Zone map (Figure 2, p. 25)
- Topographic mapping (USGS quadrangles, LiDAR, etc.)
- Aerial photography
- NC SAM watershed map
- Web soil survey (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm)
- Land-use mapping
- U.S. Drought Monitor drought classification of project area of the date of assessment, (http://drought.unl.edu/dm/index.html

Stream assessors should examine available natural resource data prior to making the field visit, including (but are not limited to) the NC SAM Zone map, topographic mapping (USGS 7.5-minute quadrangles or more accurate mapping if available) for the determination of geomorphic valley shape and watershed size, aerial photography for a determination of activities within watersheds, web soil survey, local municipal web-based Information Mapping System (IMS) or GIS data sets (photography, contours [such as LiDAR], zoning, parcel data, etc.), current drought classification, and (if available) previously conducted jurisdictional area delineations/determinations from the project vicinity. These resources should initially be viewed with an eye toward landscape/watershed scale features. Next, the assessor should consider how potential stream characteristics are affected by the local landscape. The assessor should evaluate features of interest such as natural physiography and anthropogenic disturbances (such as roadways, impoundments, deforestation, impermeable surfaces, and storm-water sources).

## 5.2 Site Feature Investigation

This step involves a determination that a site contains tributaries and the extent of the tributaries present. This may involve conducting an on-site federal and/or state jurisdictional area delineation or determination or obtaining a pre-existing delineation or determination for the site.

Tools needed to conduct an on-site investigation include (but are not limited to) the following.

- Soil auger or sharp-shooter shovel
- Pocket rod, or other measurement device
- Global Positioning System (GPS) or other method for determining location
- Camera for recording site conditions and characteristics
- Familiarity with the guidance for determining NC SAM stream categories
- Previous federal and/or state jurisdictional area delineations/determinations

## 5.3 Determination of Evaluation Areas

### 5.3.1 Stream Category Determination

Tools needed to assist with stream category identification include (but are not limited to) the following.

- Site and watershed mapping
- Familiarity with the guidance for determining NC SAM stream categories
- Familiarity with the guidance for determining NC WAM general wetland types (when in the Coastal Plain NC SAM Zones so that identification of a Tidal Marsh Stream can be appropriately made)

The assessor should identify each discrete stream category that occurs within the project area using guidance provided in Section 3.0. <u>It is important that the assessor walk the entire project area prior to making an evaluation area determination.</u> The appropriate NC SAM zone is determined by locating the project area on the NC SAM zone map (Section 3.1.1, Figure 2 [p. 25]). Geomorphic valley shape may be determined through on-site observation or referencing a topographic map focused on the specific project area (Section 3.1.2, p. 26). Watershed size is determined using topographic mapping focused on the watershed(s) draining to the project area (Section 3.1.3, p. 32).

### 5.3.2 Assessment Reach Determination

An assessment reach is a defined reach of stream that is subject to functional assessment using the North Carolina Stream Assessment Method (NC SAM); more specifically, this term refers to the area within the normal wetted perimeter (whether submerged or not) of the defined reach of stream subject to the functional assessment. Typically, the length of the assessment reach is determined by the extent of a proposed activity or project, an NC SAM category boundary, confluences, or a change in stream or riparian area character. When practicable, the assessment reach should include at least a portion of a riffle-run section and/or a pool-glide section to completely evaluate a full suite of in-stream bed features. Section 4.1.1 (p. 35) provides detailed guidance for determining assessment reach termini.

### 5.3.3 Streamside Area Determination

The streamside area is the area of land contiguous with the assessment reach, extending perpendicular to elevation contour lines to a distance of 300 feet or to the edge of the natural topographic high point, whichever is reached first. For multi-thread channels, the streamside area is the area of land contiguous with the outermost channels, extending perpendicular to elevation contour lines to a distance of 300 feet or to the edge of the natural topographic high point, whichever is reached first. The assessor should also include alterations in the streamside area that artificially drain away from the assessment reach. Examples of such alterations include curb-and-gutter roads and parking lots, ditches, berms, stormwater diversion, and grading. Therefore, in order to capture deviations from reference, the streamside area may extend outside of the current watershed of the assessment reach. For Tidal Marsh Streams, streamside area is equivalent to the marsh intertidal zone (consisting of either of two NC WAM wetland types: Salt/Brackish Marsh or Tidal Freshwater Marsh) extending from the normal wetted perimeter of the channel, perpendicular to the tidal stream to the edge of marsh or to a distance of 300 feet, whichever is reached first. Section 4.1.2 (p. 40) provides detailed guidance for determining streamside area boundaries.

### 5.3.4 Assessment Area Identification

An assessment area is a defined area of stream (assessment reach) and land abutting the stream (streamside area) that is subject to functional evaluation using NC SAM. A project may contain multiple assessment areas that will be evaluated separately.

### 5.3.5 Example Evaluation Area Determination Exercises

Following are five examples that outline how stream categories and evaluation areas are determined: 1) a road crossing of a single stream (Figures 6A through 6D), 2) the confluence of co-dominant streams in a shared floodplain (Figures 7A through 7D), 3) multiple subordinate stream confluences with a dominant stream in shared floodplains (Figures 8A through 8D), 4) a stream system within a large, non-linear project area (Figures 9A through 9F), and 5) a Tidal Marsh Stream (Figures 10A and 10B). Each example includes a discussion of the steps taken in this process.

#### 5.3.5.1 Example 1: A Road Crossing of a Single Stream

**Step 1: Stream Delineation/Determination**

An existing stream delineation/determination is obtained prior to NC SAM evaluation. Figures 6A through 6D depict a portion of a project that encompasses a road crossing of Marsh Creek in Wake County. Figure 6A depicts the stream in the project area vicinity on a topographic base map generated from LiDAR data.

**Step 2: Stream Category Determination**

Guidance provided in Section 3.0 is used for the determination of project stream categories. The project is located in the Piedmont NC SAM Zone (“P,” Figure 2 [p. 25]). The stream reach is situated in an “a” valley shape. Figure 6B depicts the watershed of upper Marsh Creek (using the southern project area boundary as the downstream terminus). The downstream terminus has a watershed of 0.4 square mile (NC SAM Size 2). This information is used to determine that the project area stream category is Pa2 (<u>P</u>iedmont NC SAM Zone, “<u>a</u>” valley shape, Size <u>2</u> watershed).

**Step 3: Assessment Reach Determination**

In this example there is one stream within the project area; therefore, there will be at least one assessment reach. Section 4.1.1 (p. 35) suggests five features that may be used in the identification of assessment reach termini. The application of each feature to this example project is considered below.

1. Project area boundary – Consider only reaches within the project area.
2. NC SAM stream category boundary – The entire reach of Marsh Creek within the project area is designated as a Pa2 stream, so this reach will not be subdivided due to a change in NC SAM stream category.

3. Confluence of equal NC SAM watershed size – No confluences occur within the project area, so this reach will not be subdivided due to a confluence.
4. A substantial change in in-stream and/or streamside conditions – The in-stream and streamside area conditions are similar throughout the reach in the project area, so this reach will not be subdivided due to a substantial change in in-stream or streamside area characteristics.

Based on this information, there is no reason to subdivide the reach within the project area, and assessment reach (AR) termini will be based on the project area boundaries (Figure 6C).

**Step 4: Streamside Area Determination**
Guidance provided in Section 4.1.2 (p. 40) is used to delineate streamside area boundaries. The streamside area is the area of land contiguous with the assessment reach, extending perpendicular to elevation contour lines for a distance of 300 feet or to the natural topographic high point, whichever is reached first. The streamside area for AR is depicted by cross-hatching in Figure 6D.

**Step 5: Assessment Area Identification**
Guidance provided in Section 4.1.3 (p. 40) is used in delineating assessment area boundaries. The assessment area is the combined assessment reach and streamside area subject to functional assessment using NC SAM. Figure 6D depicts the assessment area (AA) associated with the assessment reach (AR).

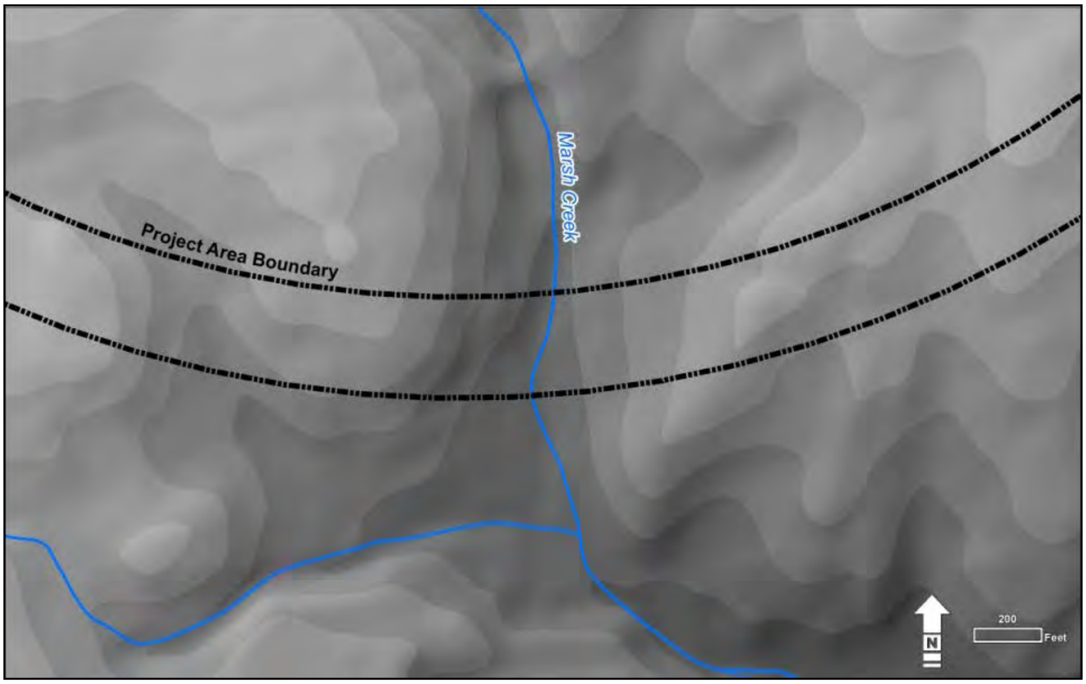



Figure 6A

These figures are associated with evaluation area determination Example 1. Figure 6A depicts a portion of a project that encompasses a road crossing of Marsh Creek in Wake County. Figure 6B depicts the watershed of the reach of Marsh Creek that occurs within the project area.


Figure 6B

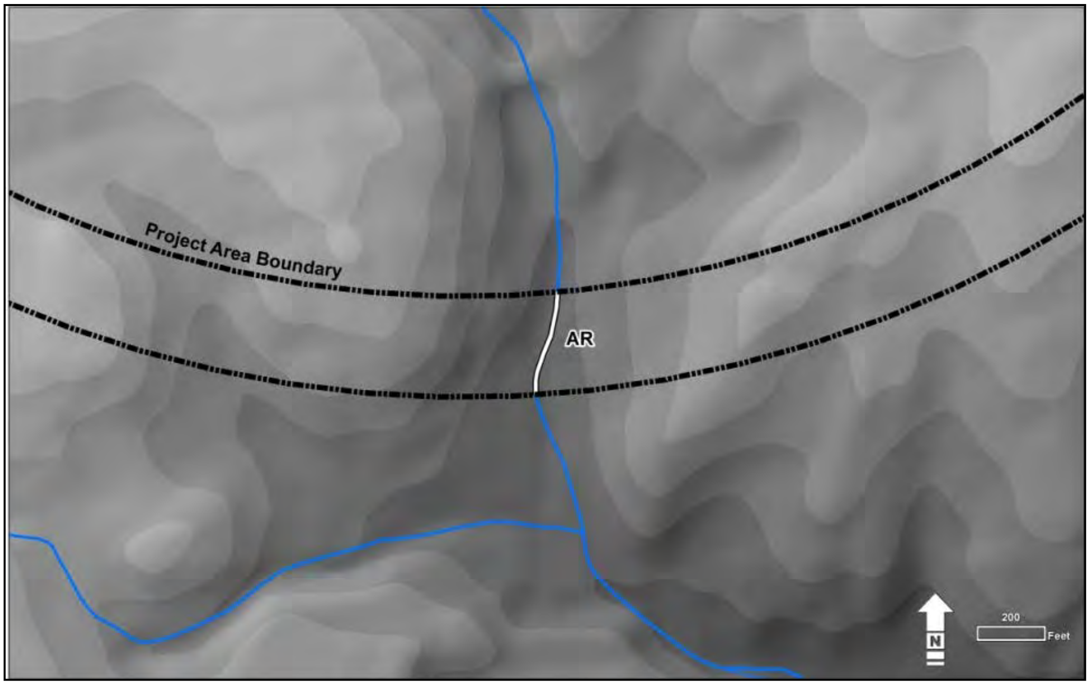



Figure 6C

These figures are associated with evaluation area determination Example 1. Figure 6C depicts the single assessment reach (AR) within the project area. Figure 6D depicts the single assessment area (AA) within the project area.

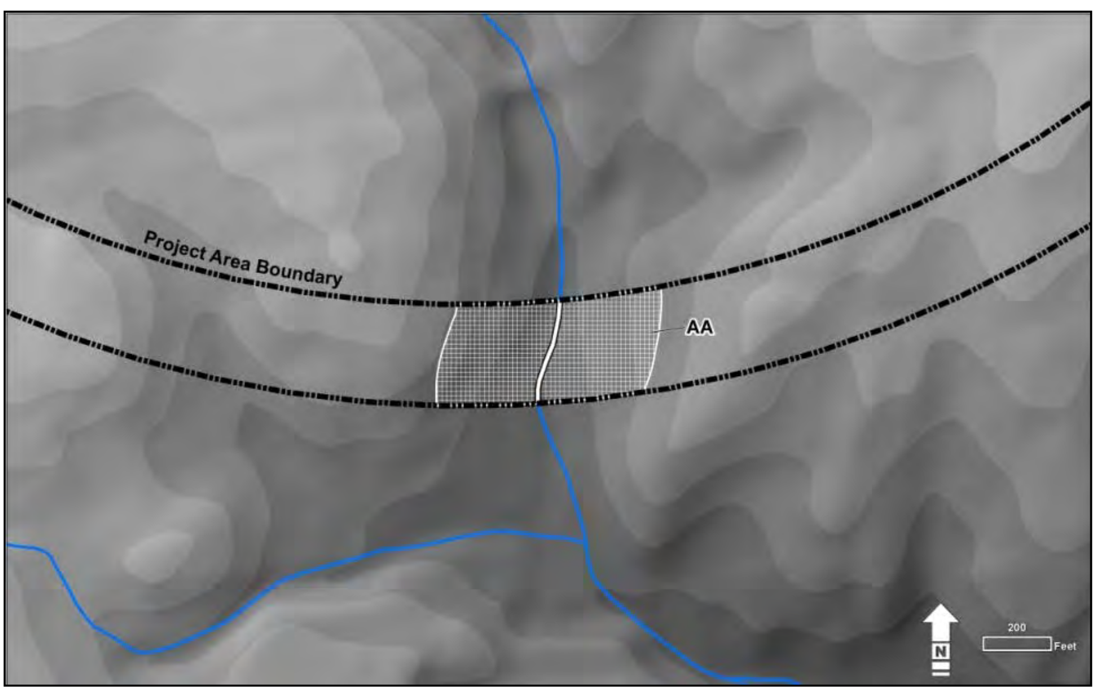



Figure 6D

#### 5.3.5.2 Example 2: Confluence of Two Co-dominant Streams in a Shared Floodplain

**Step 1: Stream Delineation/Determination**

An existing stream delineation/determination is obtained prior to NC SAM evaluation. Figures 7A through 7D depict a portion of a project that encompasses the confluence of Marsh Creek and an unnamed tributary (UT) to Marsh Creek in Wake County. Figure 7A depicts tributaries within the project area on a topographic base map generated from LiDAR data.

**Step 2: Stream Category Determination**

Guidance provided in Section 3.0 is used for the determination of project stream categories. The project is located in the Piedmont NC SAM Zone ("P," Figure 2 [p. 25]). All stream reaches within the project area are situated in "a" valley shapes. Figure 7B depicts the watersheds of reaches located within the project area. The watershed (area that drains to the lowest point of Marsh Creek at the southern project area boundary) is approximately 1.25 square miles (NC SAM Size 3). The watershed size of each reach at the confluence within the project area was determined. Upper Marsh Creek (above the confluence, W1) is approximately 0.97 square mile (NC SAM Size 3) and the UT to Marsh Creek (W2) is approximately 0.25 square mile (NC SAM Size 2). This information is used to determine the project area stream categories listed below.

Upper Marsh Creek – Pa3

UT to Marsh Creek – Pa2

Lower Marsh Creek – Pa3

**Step 3: Assessment Reach Determination**

Section 4.1.1 (p. 35) suggests five features that may be used in the identification of assessment reach termini. The application of features to this example project is considered below.

1. Project area boundary – In this example, there are two distinct tributaries (Marsh Creek and the UT to Marsh Creek) within the project boundary, so there will be at least two assessment reaches for this project.
2. NC SAM stream category boundary – Project reaches will be subdivided at the stream category boundaries. In this example, a stream category boundary occurs at the confluence. Marsh Creek, both above and below the confluence, is a Pa3 stream, and the UT to Marsh Creek is a Pa2 stream.
3. Confluence of equal NC SAM watershed size – One confluence is located in the project area. This is a confluence of a stream of larger NC SAM watershed size (Pa3) with a stream of smaller NC SAM watershed size (Pa2). In this case, there is little change observed in the condition of the larger stream above the confluence compared to below the confluence, therefore the larger stream is not subdivided into two assessment reaches.
4. A substantial change in in-stream and/or streamside conditions – In-stream and streamside conditions are similar throughout their lengths; therefore, these reaches do not need to be subdivided based on in-stream and/or streamside conditions.

The result of this analysis is that streams in this example will be separated into two assessment reaches, with project boundaries constituting the Marsh Creek termini (AR1) and the northern project boundary and the confluence constituting the UT to Marsh Creek termini (AR2) (Figure 7C).

**Step 4: Streamside Area Determination**

Guidance provided in Section 4.1.2 (p. 40) is used to delineate streamside area boundaries. The streamside area is the area of land contiguous with the assessment reach, extending perpendicular to elevation contour lines to a distance of 300 feet or to the natural topographic high point, whichever is reached first.

When two or more tributaries share a floodplain, and neither tributary is dominant over the other, the streamside area of each tributary extends to the top of the near bank of the other tributary or, if present, to a natural high point within the floodplain that separates the tributaries. In the case of this example, neither stream exerts a visible dominance at the confluence, even though one watershed is approximately four times the size of the other. There is no natural high point in the floodplain topography that separates upper Marsh Creek (AR1) and the UT to Marsh Creek (AR2). Therefore, the streamside areas of each assessment reach extends 300 feet outward from the stream bank and inward to the top of the near bank of the stream that shares the floodplain. The streamside area of lower Marsh Creek extends 300 feet outward from both stream banks.

**Step 5: Assessment Area Identification**

Guidance provided in Section 4.1.3 (p. 40) is used in delineating assessment area boundaries. The assessment area is the combined assessment reach and streamside area subject to functional assessment using NC SAM. Figure 7D depicts the two assessment areas associated with AR1 and AR2 (AA1 and AA2, respectively).

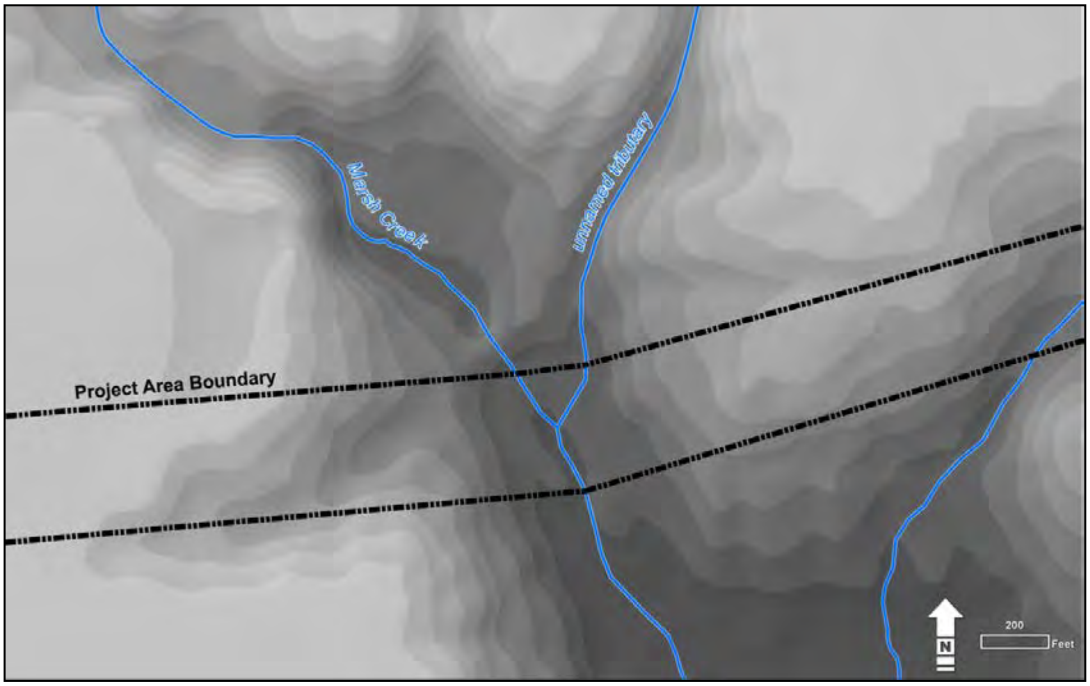



Figure 7A

These figures are associated with evaluation area determination Example 2. Figure 7A depicts a portion of a project that encompasses a road crossing of Marsh Creek and an unnamed tributary. Figure 7B depicts the watershed of each reach that occurs within the project area.

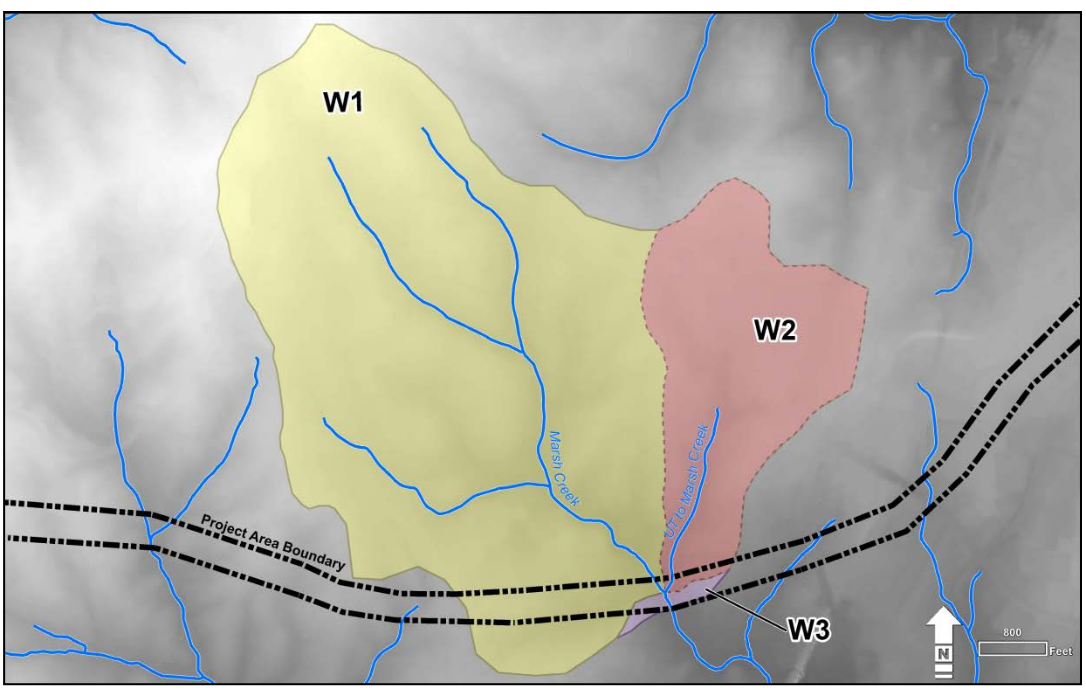



Figure 7B

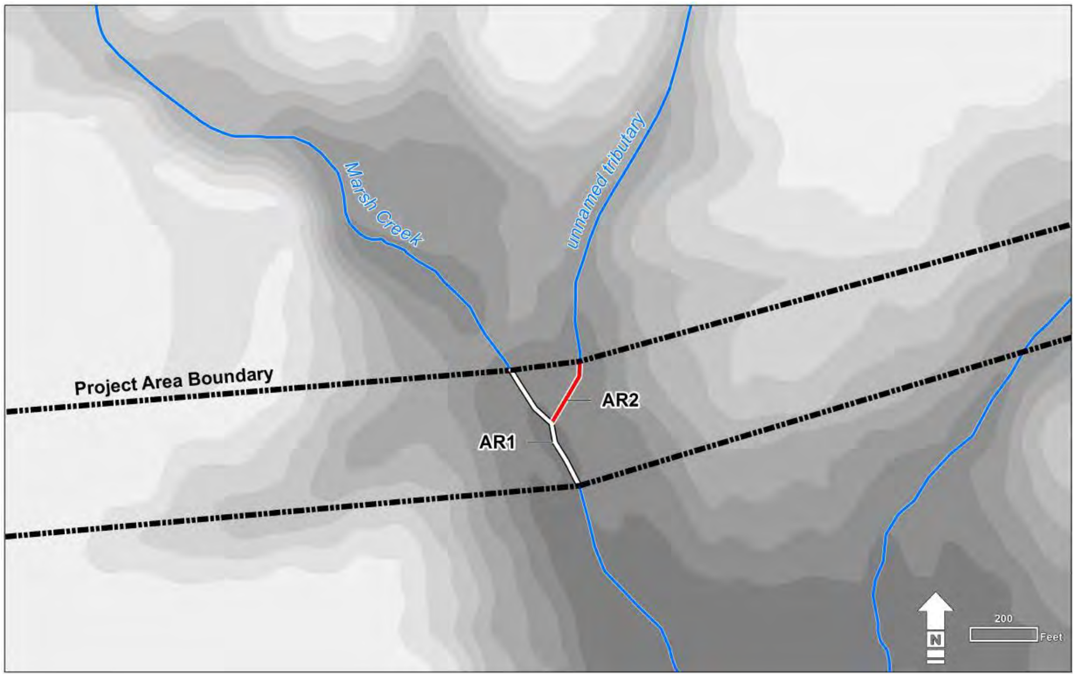



Figure 7C

These figures are associated with evaluation area determination Example 2. Figure 7C depicts the two assessment reaches (AR1 and AR2) within the project area. Figure 7D depicts the two assessment areas (AA1 and AA2) within the project area. When two or more tributaries share a floodplain, and neither tributary is dominant over the other, the streamside area of each tributary extends to the top of the near bank of the other tributary or, if present, to a natural high point within the floodplain that separates the tributaries.

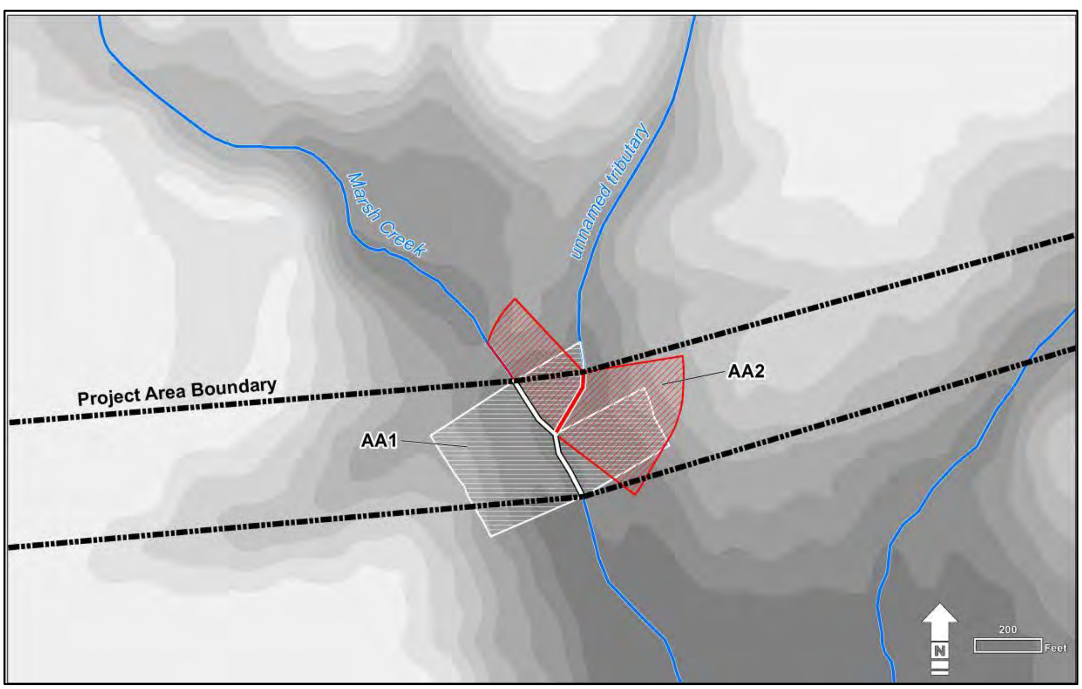



Figure 7D

#### 5.3.5.3 Example 3: Two Confluences with a Larger Stream Where the Larger Stream is Dominant

**Step 1: Stream Delineation/Determination**

An existing stream delineation/determination is obtained prior to NC SAM evaluation. Figures 8A through 8D depict a portion of a project that encompasses the confluences of Crabtree Creek with an unnamed tributary (UT) to Crabtree Creek and Crabtree Creek with Big Branch in Wake County. Figure 8A depicts tributaries on a topographic base map generated from LiDAR data.

**Step 2: Stream Category Determination**

Guidance provided in Section 3.0 is used for the determination of project stream categories. The project is located in the Piedmont NC SAM Zone ("P," Figure 2 [p. 25]). All stream reaches within the project area are situated in "a" valley shapes. Figure 8B depicts the watersheds of Crabtree Creek (W1) (using the southern project area boundary as the downstream terminus), Big Branch (W2), and the UT to Crabtree Creek (W3). Crabtree Creek has a watershed of 119.98 square miles (NC SAM Size 4), Big Branch has a watershed of 3.99 square miles (NC SAM Size 3), and the UT to Crabtree Creek has a watershed of 0.68 square mile (NC SAM Size 3). This information is used to determine the project area stream categories as listed below.

Crabtree Creek – Pa4

Big Branch – Pa3

UT to Crabtree Creek – Pa3

**Step 3: Assessment Reach Determination**

Section 4.1.1 (p. 35) suggests five features that may be used in the identification of assessment reach termini. The application of each feature to this example is considered below.

1. Project area boundary – In this example, there are three distinct tributaries (Crabtree Creek, Big Branch, and the UT to Crabtree Creek) within this portion of the project boundary, so there will be at least three assessment reaches for this project.
2. NC SAM stream category boundary – Project reaches will be subdivided at stream category boundaries. In this example, a stream category boundary occurs at each of the confluences; therefore, the confluences will denote downstream termini of the Big Branch and UT to Crabtree Creek assessment reaches.
3. Confluence of equal NC SAM watershed size – At both project area confluences, Crabtree Creek is the substantially larger and dominant stream, and little change is observed in the Crabtree Creek channel due to its passing through either confluence; therefore, the presence of a confluence will not serve to subdivide Crabtree Creek within the project area, but will serve as the lower terminus of both Big Branch and the UT to Crabtree Creek.
4. A substantial change in in-stream and/or streamside conditions – Onsite evidence indicates the in-stream and streamside conditions of these streams are dominated by

Crabtree Creek below each of the confluences, and there is no change in characteristics sufficient to warrant subdividing assessment reaches.

The result of this analysis is that streams in this example will be separated into three assessment reaches, with project boundaries and the confluences constituting the termini. The entire reach of Crabtree Creek within the project area is designated as assessment reach 1 (AR1), the UT to Crabtree Creek is designated as assessment reach 2 (AR2), and Big Branch is designated as assessment reach 3 (AR3) (Figure 8C).

**Step 4: Streamside Area Determination**

Guidance provided in Section 4.1.2 (p. 40) is used to delineate streamside area boundaries. The streamside area is the area of land contiguous with the assessment reach, extending perpendicular to elevation contour lines to a distance of 300 feet or to the natural topographic high point, whichever is reached first.

When two or more tributaries share a floodplain, and one tributary is dominant over the other, the streamside area of the dominant tributary should not be interrupted by the subordinate tributary. The dominant tributary is the tributary that clearly exerts the most influence over the in-stream character at the confluence. In this example, Crabtree Creek is the dominant tributary at both confluences; therefore, the streamside area of the Crabtree Creek assessment reach (AR1) is not interrupted by the two subordinate tributaries (the UT to Crabtree Creek and Big Branch) and will extend outward for 300 feet from both banks. Within the shared floodplain, the streamside area of each subordinate tributary extends to the top of the near bank of Crabtree Creek, or, if present, to the natural high point that separates the subordinate tributary from Crabtree Creek. An on-site investigation of the UT to Crabtree Creek (AR3) found a topographic high point on the left bank between the UT and Crabtree Creek and a topographic high point on the right bank between the UT and a topographic crenulation without a stream. An on-site investigation of Big Branch (AR2) found a topographic high point on both the right bank between Big Branch and Crabtree Creek and the left bank between Big Branch and Crabtree Creek.

**Step 5: Assessment Area Identification**

Guidance provided in Section 4.1.3 (p. 40) is used in delineating assessment area boundaries. The assessment area is the combined assessment reach and streamside area subject to functional assessment using NC SAM. Figure 8D depicts the assessment areas associated with AR1, AR2, and AR3 (AA1, AA2, and AA3, respectively).

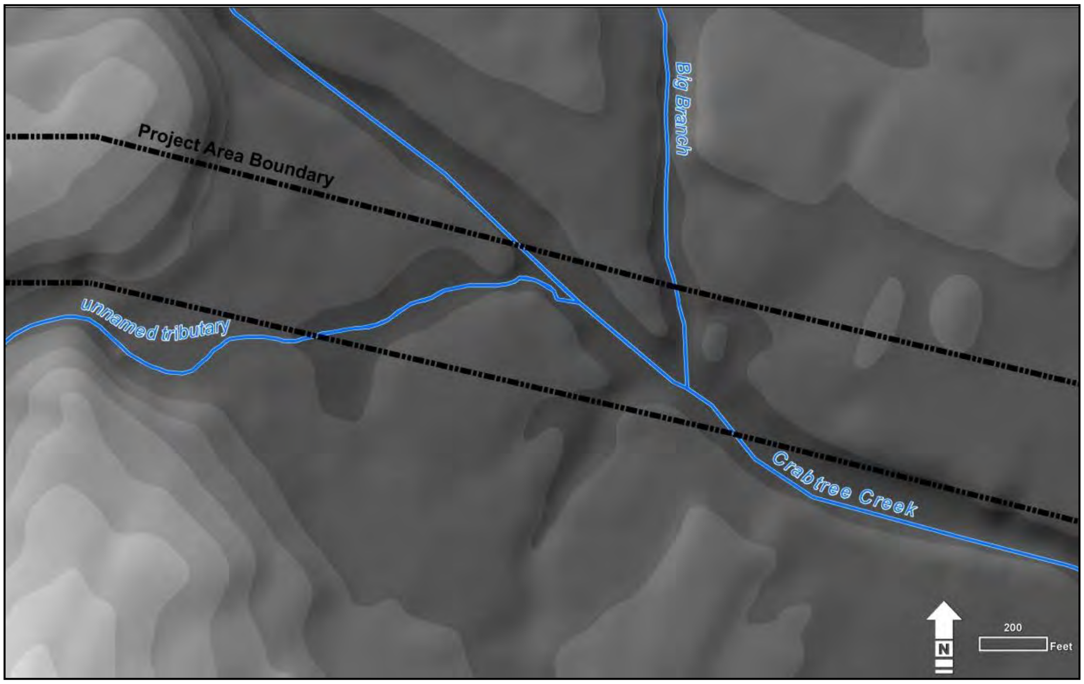



Figure 8A

These figures are associated with evaluation area determination Example 3. Figure 8A depicts a portion of a project that encompasses a road crossing of Crabtree Creek and two unnamed tributaries. Figure 8B depicts the watershed of each reach that occurs within the project area.

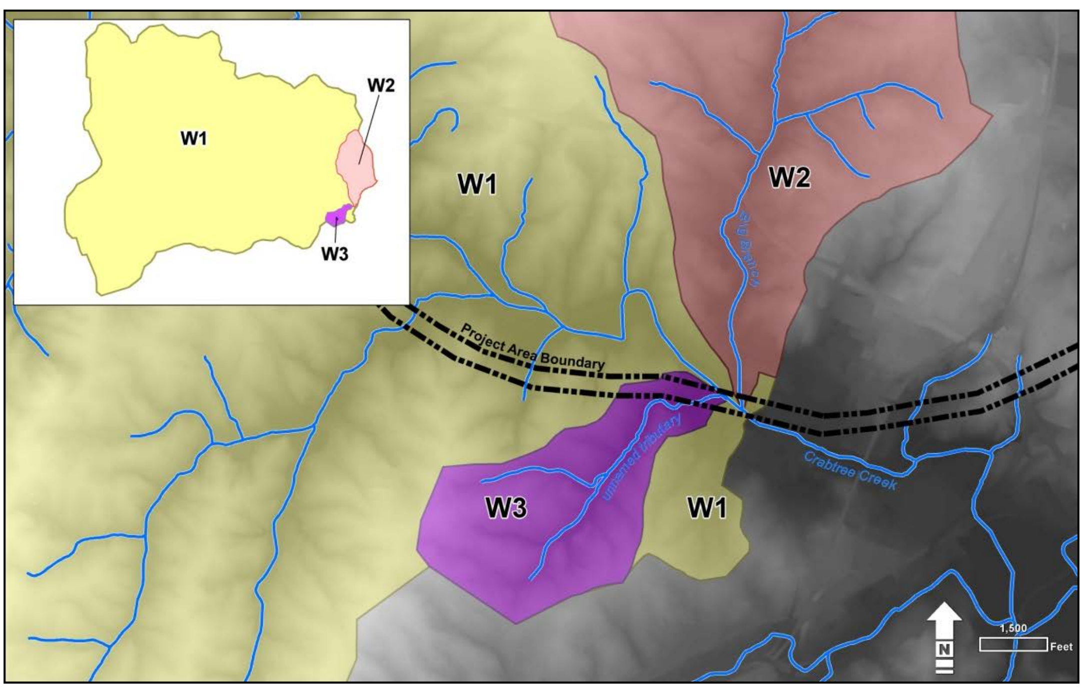



Figure 8B

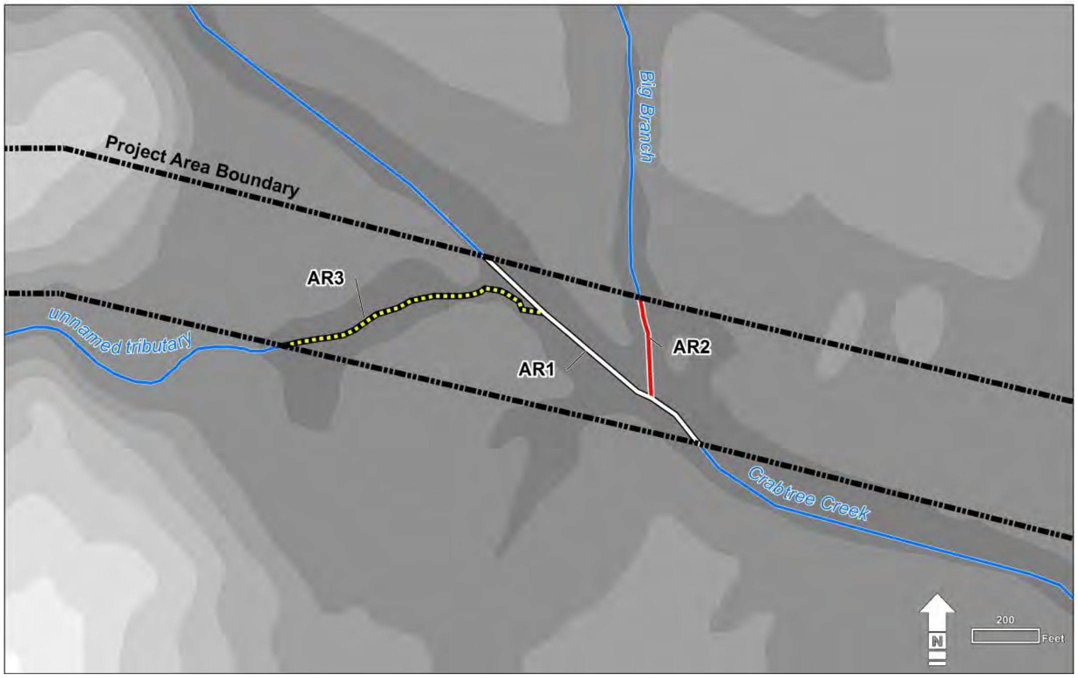



Figure 8C

These figures are associated with evaluation area determination Example 3. Figure 8C depicts the three assessment reaches (AR1, AR2, and AR3) within the project area. Figure 8D depicts the three assessment areas (AA1, AA2, and AA3) within the project area. Note that the northeast and south boundaries of AA3 and the southwest and southeast boundaries of AA2 are defined by the natural high point that separates the streamside areas of these subordinate tributaries from that of Crabtree Creek.

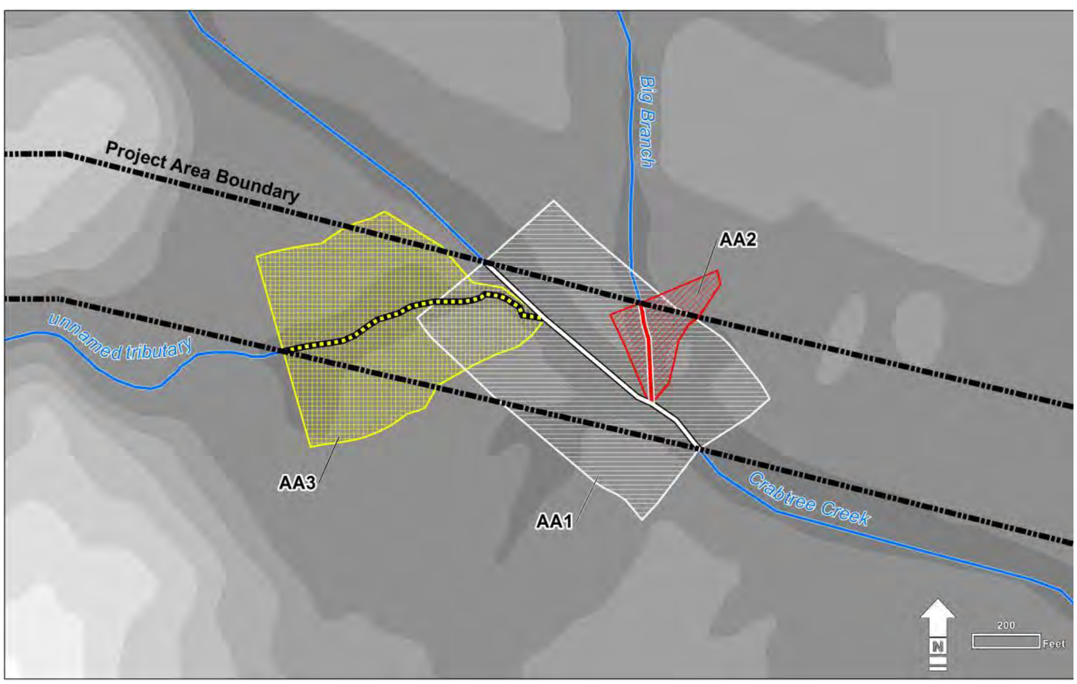



Figure 8D

#### 5.3.5.4 Example 4: A Stream System within a Large, Non-linear Project Area

**Step 1: Stream Delineation/Determination**

Figures 9A through 9F focus on a project area that encompasses a reach of Little Hell Creek and four of its tributaries: UT1, UT2, UT3, and UT4. Figure 9A depicts tributaries within the project area on a topographic base map generated from LiDAR data. Note that UT1 has a confluence with Little Hell Creek downstream (north) of the project area, and UT4 is discontinuous due to an in-line pond just upstream of its confluence with Little Hell Creek. All of the UTs appear to have been dredged or excavated.

**Step 2: Stream Category Determination**

Guidance provided in Section 3.0 is used for the determination of project stream categories. Findings resulting from this guidance is combined to determine the project area stream categories as listed in Table 2. The project is located in the Inner Coastal Plain NC SAM Zone ("I," see Figure 2 [p. 25]). All stream reaches within the project area are situated in "a" valley shapes. Figure 9B depicts the NC SAM watershed sizes characteristic of project area tributaries. Watershed 1 (W1) includes the Little Hell Creek main stem, with a downstream terminus at the project boundary. The confluence of Little Hell Creek and UT4 is a boundary between two NC SAM watershed sizes; the reach above this point has a Size 3 watershed (4.67 square miles, Ia3; depicted as W1(3) in Figure 9B), and the reach below this point has a Size 4 watershed (5.52 square miles, Ia4; depicted as W1(4) in Figure 9B). Watershed 2 (W2) includes UT1, with a downstream terminus at the project boundary. Upper UT1 has the maximum Size 1 watershed (0.09 square mile, Ia1; depicted as W2(1) in Figure 9B), and lower UT1 has a Size 2 watershed (0.49 square mile, Ia2; depicted as W2(2) in Figure 9B). Watershed 3 (W3) includes UT2, with a downstream terminus at the confluence with Little Hell Creek. UT2 has a Size 2 watershed (0.38 square mile, Ia2). UT2 is also a swamp stream. Within the project area, it is characterized by multiple channels with no apparent main channel. This swamp stream has a downstream terminus where its channels converge at the confluence with Little Hell Creek. Watershed 4 (W4) includes UT3, with a downstream terminus at the confluence with Little Hell Creek. UT3 has a Size 3 watershed (0.75 square mile, Ia3). Watershed 5 (W5) includes UT4, with a downstream terminus at the confluence of Little Hell Creek. Upper UT4 has a Size 2 watershed (0.49 square mile, Ia2; depicted as W5 (2) in Figure 9B). The remainder of UT 4 is within a Size 3 watershed (0.67 square mile, Ia3; depicted as W5(3) in Figure 9B) but is divided into two reaches (a middle reach and a lower reach) by a pond.

Table 2. This table lists NC SAM stream categories present in the Example 4 project area. Watershed codes (example: W1) refer to Figure 9B designations. See Section 3 for an explanation of stream category designations. The location of tributaries is depicted in Figure 9A (unnamed tributary = UT).

| Watershed | Stream Category | Tributary |
|---|---|---|
| W1(4) | Ia4 | Little Hell Creek below the confluence with UT4 |
| W1(3) | Ia3 | Little Hell Creek above the confluence with UT4 |
| W2(3) | Ia3 | Lower UT1 |
| W2(2) | Ia2 | Upper UT1 |
| W3 | Ia2 | UT2 |
| W4 | Ia3 | UT3 |
| W5(3) | Ia3 | Lower UT4, below the pond |
| W5(3) | Ia3 | Middle UT4, above the pond and within the Size 3 watershed |
| W5(2) | Ia2 | Upper UT4 |

**Step 3: Assessment Reach Determination**

Section 4.1.1 (p. 35) suggests four features used in the identification of assessment reach termini. The application of each feature to this example project is considered below.

1. Project area boundary – In this example, there are six distinct tributaries within the project area (Little Hell Creek, UT1, UT2, UT3, UT4 above the in-line pond, and UT4 below the pond), so there will be at least six assessment reaches.
2. NC SAM stream category boundary – Confluences with Little Hell Creek are stream category boundaries and therefore mark the lower termini for UT2, UT3, and UT4. A stream category boundary occurs on Little Hell Creek at its confluence with UT4, marking an assessment reach division of Little Hell Creek. A stream category boundary occurs on both UT1 and upper UT4. Consideration of stream category boundaries raises the number of assessment reaches to at least nine.
3. Confluences – All project area confluences are assessment reach termini. The confluence of Little Hell Creek and UT2 is a lower terminus for UT2, while the Little Hell Creek assessment reach continues past this confluence with a tributary of a smaller NC SAM size. The confluence of Little Hell Creek and UT3 is an assessment reach terminus for both tributaries because they are same-NC SAM sized tributaries and neither is dominant over the other. The confluence of Little Hell Creek and UT4 was previously determined to be a lower terminus for both streams due to a change in NC SAM category boundary for both streams. Consideration of confluences raises the number of assessment reaches to at least ten.
4. A substantial change in in-stream and/or streamside conditions – For the purposes of this example, streamside condition changes visible on available aerial photography (Figure 9C) are used. Only two streams are affected by this feature. Lower UT1 (an Ia2 stream) and middle UT4 (an Ia3 stream) are each divided into two assessment reaches based on the presence of contiguous forested vegetation versus agricultural row crops.

Also, the length of UT2 in the project area is a swamp stream, providing additional evidence for designating this stream a separate assessment reach.

As a result of this analysis, streams in this example will be separated into 12 assessment reaches (see AR1 through AR12 on different base maps in Figures 9C and 9D), with project boundaries, confluences, changes in streamside characteristics, and limits of federal/state jurisdiction constituting the termini (Table 2).

A list of assessment reaches and associated stream categories and tributary designations is provided in Table 3. Also included are descriptions of features used to identify the upstream and downstream termini of each assessment reach.

Table 3. This table refers to the 12 assessment reaches (AR) resulting from Example 4 and depicted in Figures 9C and 9D. See Section 3 for an explanation of stream category designations. The location of tributaries is depicted in Figure 9A (unnamed tributary = UT).

| Assess. Reach | Stream Category | Tributary | Upstream Terminus | Downstream Terminus |
|---|---|---|---|---|
| AR1 | Ia4 | Little Hell Creek | NC SAM stream category boundary | Project area boundary |
| AR2 | Ia3 | Little Hell Creek | Confluence of two Ia3 streams | NC SAM stream category boundary |
| AR3 | Ia3 | Little Hell Creek | Project area boundary | Confluence of two Ia3 streams |
| AR4 | Ia2 | UT2 | Limit of federal/state jurisdiction | NC SAM stream category boundary |
| AR5 | Ia3 | UT3 | Limit of federal/state jurisdiction | NC SAM stream category boundary and swamp stream terminus |
| AR6 | Ia3 | Lower UT4 | Pond | NC SAM stream category boundary |
| AR7 | Ia3 | Middle UT4 | Streamside area condition change | Pond |
| AR8 | Ia3 | Middle UT4 | NC SAM stream category boundary | Streamside area condition change |
| AR9 | Ia2 | Upper UT4 | Limit of federal/state jurisdiction | NC SAM stream category boundary |
| AR10 | Ia2 | Lower UT1 | Streamside area condition change | Project area boundary |
| AR11 | Ia2 | Middle UT1 | NC SAM stream category boundary | Streamside area condition change |
| AR12 | Ia1 | Upper UT1 | Limit of federal/state jurisdiction | NC SAM stream category boundary |

**Step 4: Streamside Area Determination**

Guidance provided in Section 4.1.2 (p. 40) is used in delineating streamside area boundaries. The streamside area is the area of land contiguous with the assessment reach, extending perpendicular to elevation contour lines to a distance of 300 feet or to the natural topographic high point, whichever is reached first.

When two or more co-dominant tributaries share a floodplain, the streamside area of each tributary extends to the top of the near bank of the other tributary or, if present, to a natural high point within the floodplain that separates the tributaries. At the confluences of AR2/AR6 and AR3/AR5, the streamside area extends to a natural high point within the floodplain that separates the tributaries.

When two or more tributaries share a floodplain, and one tributary is dominant over the other, the streamside area of the dominant tributary should not be interrupted by the subordinate tributary.  The dominant tributary is the tributary that clearly exerts the most influence over the in-stream character at the confluence.  In this example, AR3 (Little Hell Creek) is dominant over AR4; therefore, the streamside area of AR3 is not interrupted by the subordinate tributary (AR4) and will extend outward for 300 feet from both banks.

The streamside areas of subordinate tributaries will extend outward perpendicular to elevation contour lines to a distance of 300 feet or to the natural topographic high point, whichever is reached first.  Where the streamside area of subordinate tributary AR4 extends to the dominant tributary (AR3), the streamside area boundaries end at the natural high point within the floodplain that separates the tributaries.

**Step 5:  Assessment Area Identification**

Guidance provided in Section 4.1.3 (p. 40) is used in delineating assessment area boundaries. The assessment area is the combined assessment reach and streamside area subject to functional assessment using NC SAM.  Figures 9E and 9F depict the 12 assessment areas associated with AR1 through AR12 (AA1 through AA12, respectively) on topographic and aerial photograph bases, respectively.

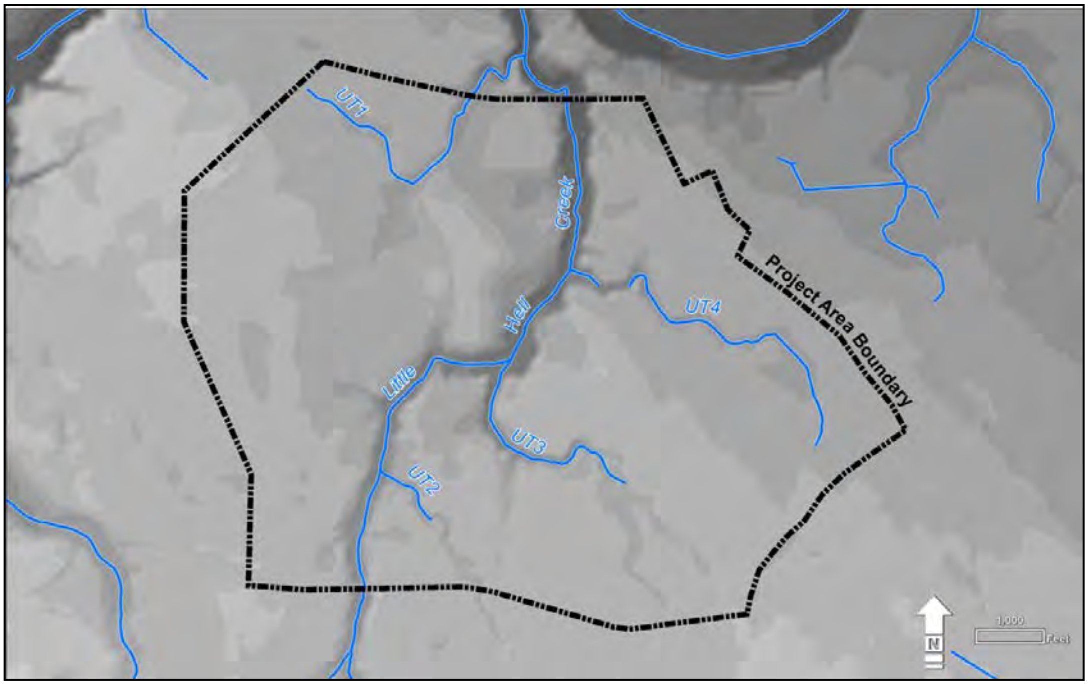



Figure 9A

These figures represent evaluation area determination Example 4. Figure 9A depicts a large project area that encompasses a reach of Little Hell Creek and four unnamed tributaries (UTs; UT1-UT4). Figure 9B depicts NC SAM watersheds (W1-W5) for project area tributaries. Parentheticals indicate size category if a tributary watershed is divided into more than one watershed size. For instance, the Little Hell Creek watershed is divided into NC SAM Size 3 and 4 watersheds at the confluence of UT4.

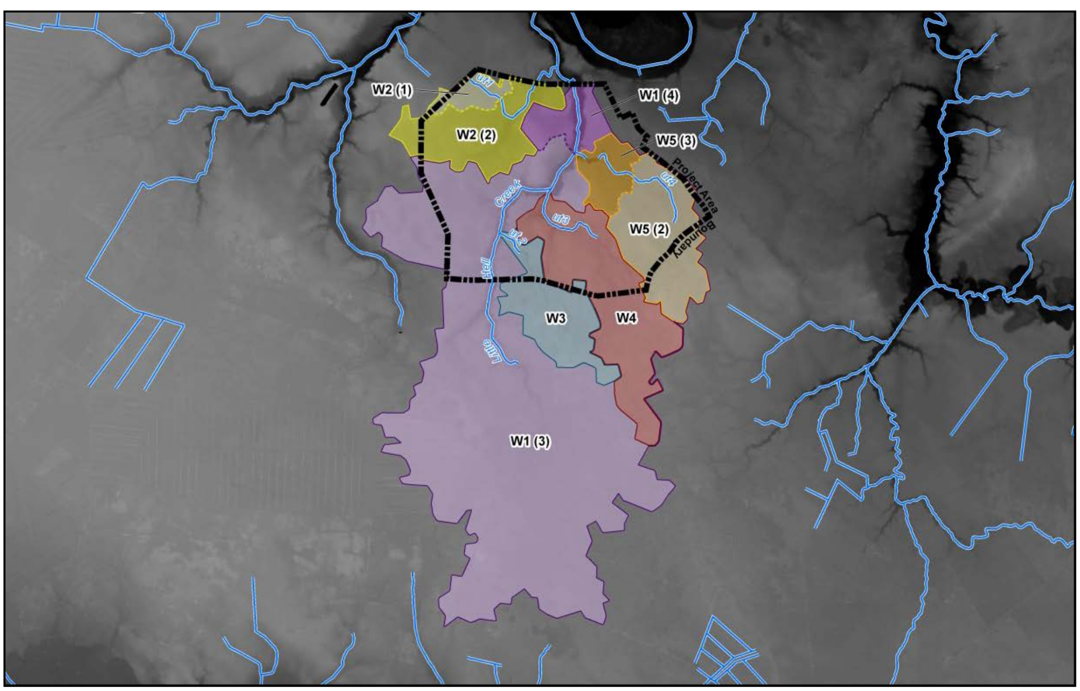



Figure 9B

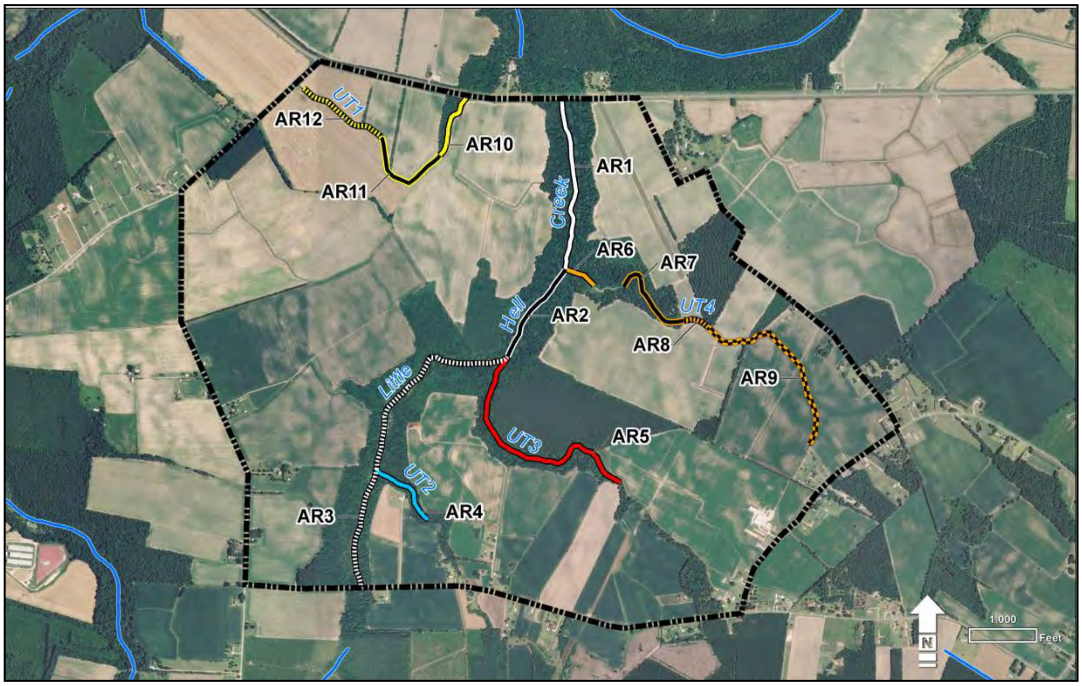



Figure 9C

These figures represent evaluation area determination Example 4. Figure 9C depicts project assessment reaches (AR1 through AR12) on an aerial photograph map, and Figure 9D depicts project assessment reaches (AR1 through AR12) on a topographic map.

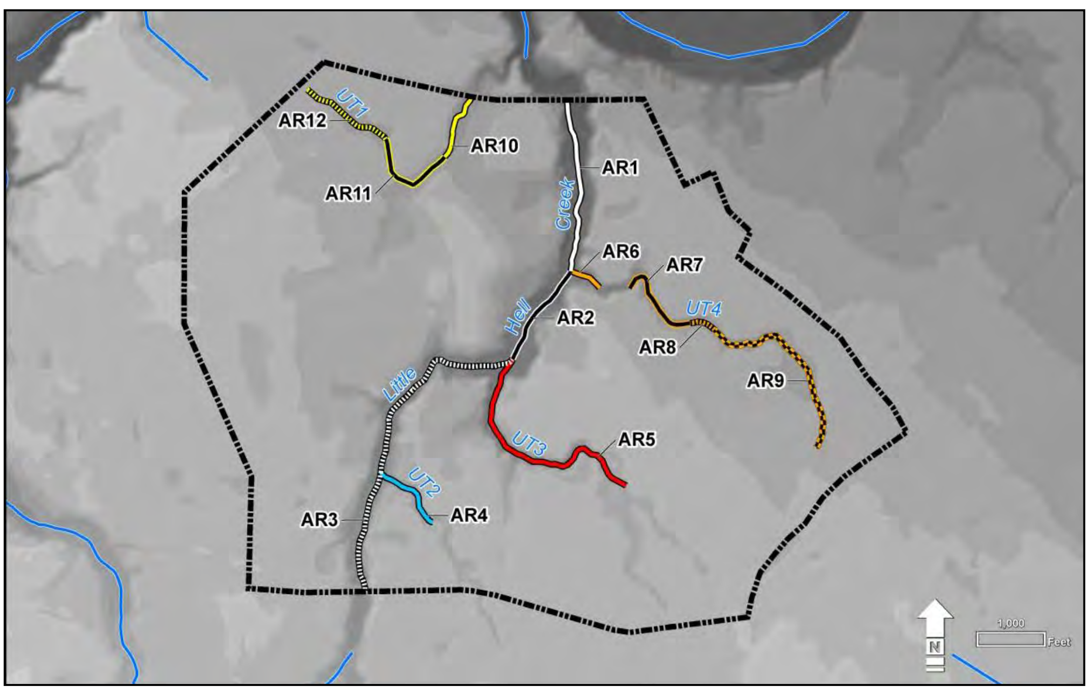



Figure 9D

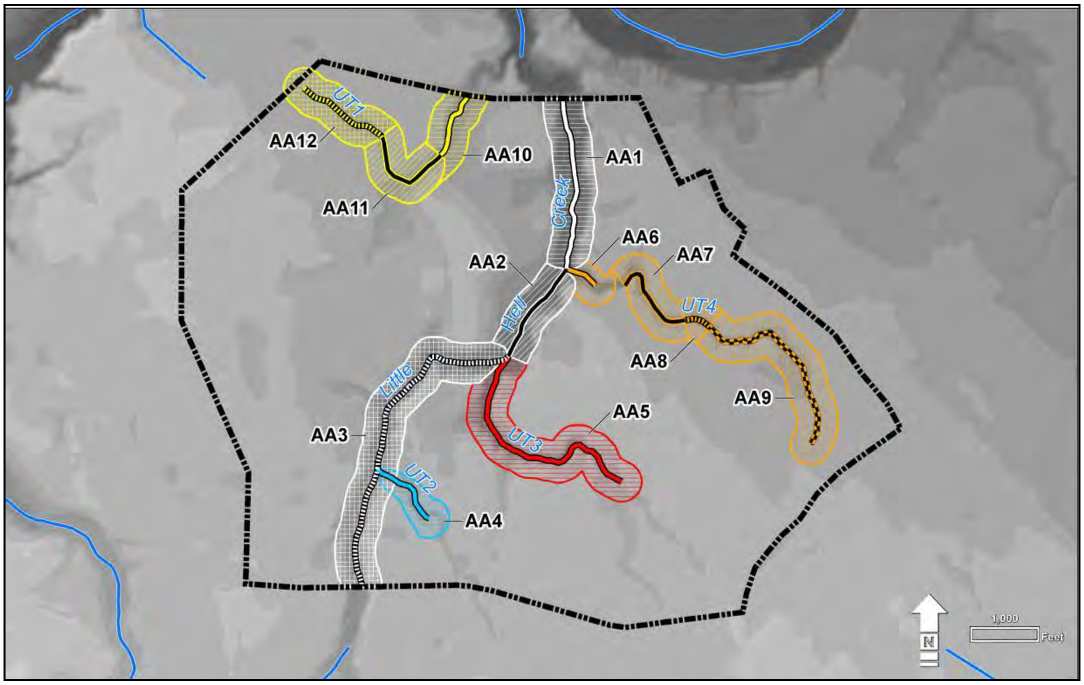



Figure 9E

These figures are associated with evaluation area determination Example 4. Figure 9E depicts the 12 assessment areas (AA1 through AA12) on a topographic map generated from LiDAR data, and Figure 9F depicts the 12 assessment areas on an aerial photograph base.

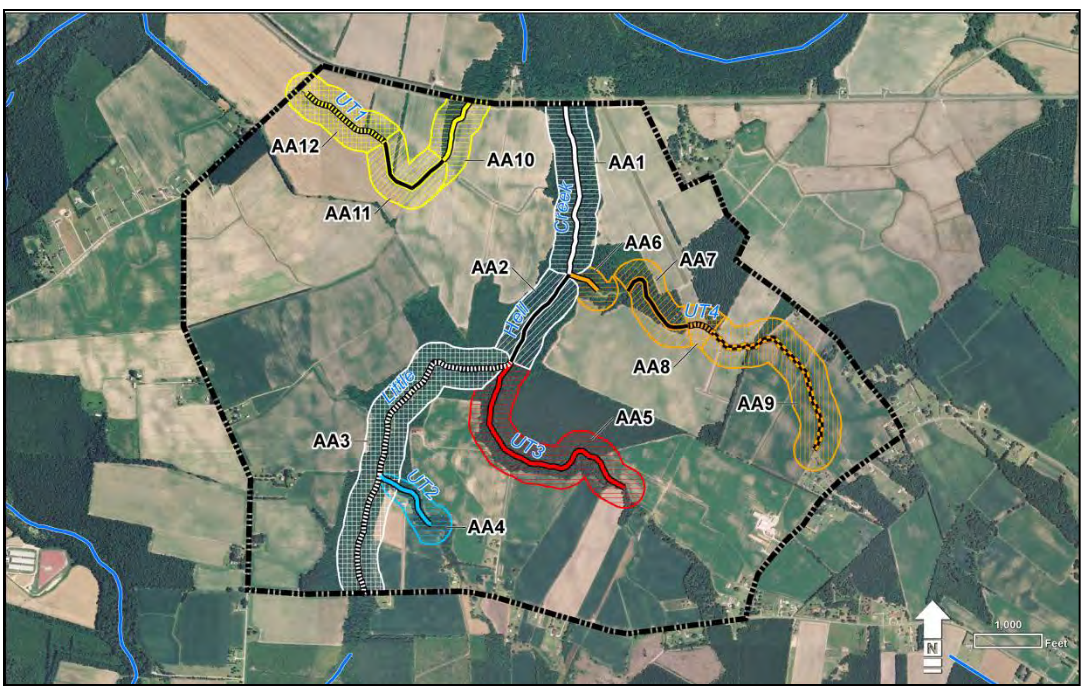



Figure 9F

#### 5.3.5.5 Example 5: Unnamed Tributary to Goose Creek (Tidal Marsh Stream)

**Step 1: Stream Delineation/Determination**

Figures 10A and 10B focus on a project that crosses an unnamed tributary to Goose Creek in Beaufort County. Figure 10A depicts the project area tributary on an aerial photograph base map.

**Step 2: Stream Category Determination**

Guidance provided in Section 3.0 is used for the determination of project stream categories. The project tributary is located in the Inner Coastal Plain NC SAM Zone ("I," see Figure 2 [p. 25]) on the left bank of the Pamlico River. The project tributary is considered a Tidal Marsh Stream because it is subject to tides and is bounded on both banks by an intertidal zone supporting marsh, in this case, N.C. Wetland Assessment Method (NC WAM) general wetland type Salt/Brackish Marsh (Figure 10B). There are no separate size designations for Tidal Marsh Streams, so no watershed size is needed for this stream category.

**Step 3: Assessment Reach Determination**

Guidance provided in Section 4.1.1 (p. 35) is used to identify the project assessment reach. On-site evidence indicates that in-stream and streamside characteristics are similar throughout the project area; therefore, this reach does not need to be subdivided, and the assessment reach will be defined by the location of the project boundaries (Figure 10B).

**Step 4: Streamside Area Determination**

Guidance provided in Section 4.1.2 (p. 40) is used in delineating streamside area boundaries. For Tidal Marsh Streams, the streamside area extends perpendicular from the assessment reach to the edge of marsh or to a distance of 300 feet, whichever is reached first. In this case, the streamside area extends to the edge of marsh, which is less than 100 feet from each bank (Figure 10B).

**Step 5: Assessment Area Determination**

Guidance provided in Section 4.1.3 (p. 40) is used in delineating assessment area boundaries. The assessment area is a defined area of stream and contiguous land that is subject to functional assessment using NC SAM. Each assessment area is composed of an assessment reach and a streamside area. The combined hatched area in Figure 10B depicts the single assessment area associated with this project.


Figure 10A

These figures are associated with evaluation area determination Example 5. Figure 10A depicts a portion of a project that encompasses a road crossing of an unnamed tributary to Goose Creek in Beaufort County. Figure 10B depicts the extent of intertidal zone marsh on each side of the assessment reach, which together form the assessment area.


Figure 10B

## 5.4 NC SAM Documentation

### 5.4.1 Field Assessment Form

Tools needed to complete the Field Assessment Form and associated attachments include (but are not limited to) the following.

- Net with a mesh size between 0.5 and 0.8 millimeters
- Soil auger or sharp-shooter shovel
- Appropriate Munsell soil color chart
- Pocket rod, or other measurement device
- Conductivity meter
- Site and watershed mapping
- Global Positioning System (GPS) or other method for determining location
- Camera for recording site conditions and characteristics
- Familiarity with the guidance for determining NC SAM stream categories
- Familiarity with the guidance for completing the Field Assessment Form
- Familiarity with the guidance for determining NC WAM general wetland types (when in the Coastal Plain NC SAM Zones so that identification of a Tidal Marsh Stream can be appropriately made)

The Field Assessment Form is provided at the beginning of the User Manual (see pp. vii-x). Guidance for completion of the Field Assessment Form is provided in Section 4.2 (p. 41). It is essential that the assessor walk the entire assessment area prior to completing the Field Assessment Form.

Information requested in the box at the beginning of the Field Assessment Form documents general project vicinity information, specific stream information, and regulatory considerations. The Field Assessment Form requests that the evaluator note evidence and extent of stressors on the assessment area, if present. Stream stressors typically include anthropogenic activities that affect one or more stream functions. Potential stream stressors may include, but are not limited to, flow restrictions (man-made or natural), altered pattern and/or profile, bed and/or bank instability, riparian buffer disturbances (vegetation removal or maintenance, ground-surface alterations), hydrological modification (stormwater runoff, ditching), excessive sedimentation, and pollutants degrading water quality (see Section 2.2). The effect of a stressor on a stream depends on the stream category, stressor type and severity, and the amount of time the stream has been subject to the stressor. Assessors are urged to document the evidence of stressors on the Field Assessment Form or attach information for future reference by regulatory personnel and the public.

Completion of the Field Assessment Form should be thorough and accurate. It is important that the assessor include notes concerning assessment area characteristics, especially any that might not be captured when answering metrics on the Field Assessment Form. These forms are not only a means to a functional rating, but also a documentation of assessment reach conditions.

### 5.4.2 Supporting Information

A field map and photographs are the minimal information required to support a stream functional assessment. Other supporting information may be added when available.

- The assessor should attach a field map to each completed Field Assessment Form. The field map may be hand drawn or include a refined base map (such as USGS 7.5-minute quadrangle, aerial photograph, or printed-out map from a web-based geographical information server or local municipality IMS). The map should provide useful information for the identification of area features for evaluation by regulatory agency personnel and the public.
- Photographs of the assessment area taken while on-site should be attached to the completed Field Assessment Form. Attached photographs should show features typical of the assessment area.
- Additional, optional information may be added to the stream assessment package when available or considered important to the assessment results. Such information may include, but is not limited to, stream measurements (such as assessment reach bankfull width, valley width/stream width ratio, and bank height/width ratio), more detailed benthic surveys, NCDWQ stream identification form (NCDWQ 2010), and NC WAM Field Assessment Forms/Wetland Rating Sheets.

## 5.5 Generation of Functional Assessment Ratings

Tools needed for the generation of functional assessment ratings include the following.

- Completed Field Assessment Form and associated attachments
- Rating Calculator

NC SAM utilizes a Boolean logic chain of reasoning to convert the metric evaluation results into functional ratings. The Boolean logic process was developed by the SFAT following extensive discussions regarding the possible interactions of the metrics with various function classes. These results were re-evaluated at numerous field sites. The Boolean logic has been written into a computer program (Rating Calculator, see Appendix K) that generates ratings for stream metrics, function classes, and the overall stream assessment reach. The Rating Calculator is a Microsoft Excel macro that is planned to be made available on an internet site managed by the NCDWQ.

### 5.5.1 Conceptual Data Analysis

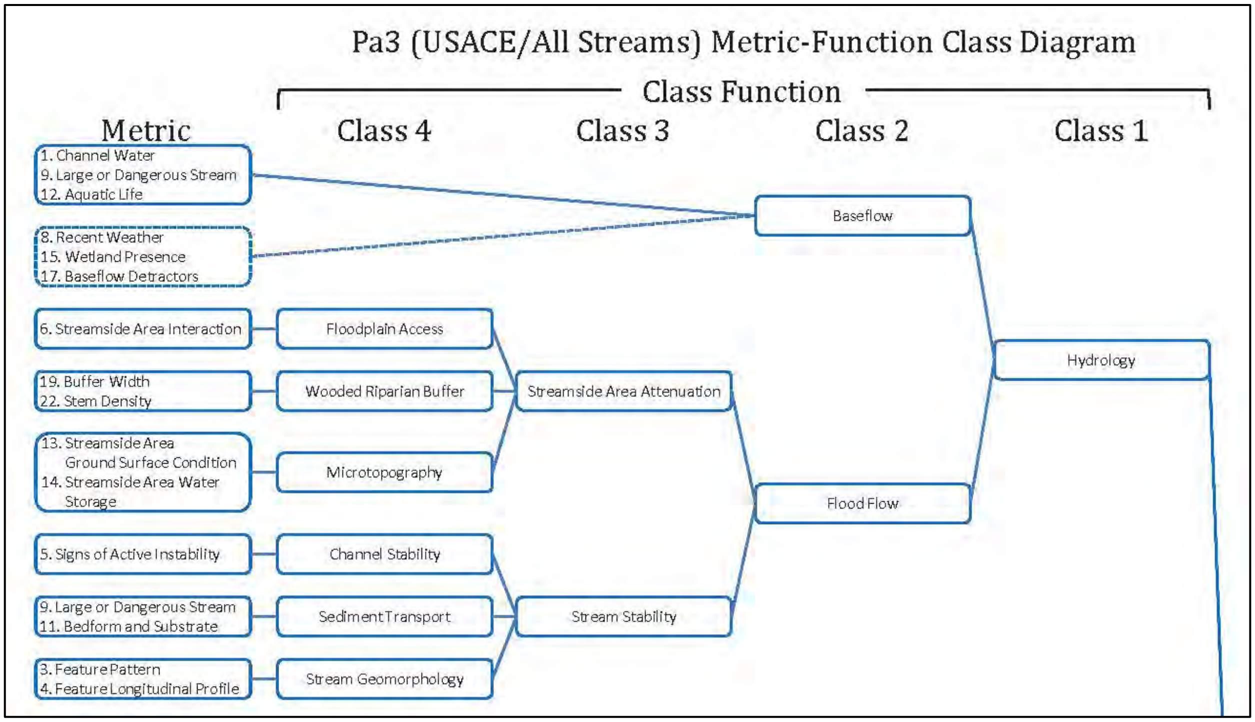
The Boolean process proceeds by utilizing selected descriptors for metrics to generate metric ratings, ratings for four function classes, and finally, an overall functional rating for the assessment area (six levels of function altogether). Each level of function subsumes the next, effectively serving as building blocks for the levels that follow. For instance, of the six levels of functional assessment, the metric level has the narrowest purview. Singularly, metrics pertain to very specific aspects of the stream, such as “evidence of flow restriction” or “feature pattern.” Collectively, however, metrics are organized into sub-classes (Classes 2, 3, and 4). Combining the descriptors of all metrics within a particular sub-class (through the use of Boolean logic) produces a rating that offers a broader account of stream function. Sub-classes are organized into one of three Class 1 functions: Hydrology, Water Quality, and Habitat. The ratings generated for all classes corresponding to a particular Class 1 function (such as the Hydrology function) are combined to produce a rating for the assessment reach. The individual Class 1 ratings provide a still broader account of stream function than the sub-class ratings. Ultimately, the individual Class 1 ratings are combined to produce an overall stream rating. The overall stream rating is the most comprehensive of the six levels of function – an aggregate of all functional levels considered in NC SAM.

The SFAT developed a list of metrics to evaluate the condition of streams from each stream category. The metrics evaluate multiple parameters, which are then compiled to infer the level of stream performance for each class of function. The number and content of metrics were further refined through field testing at sites throughout the state. To ensure a robust method with enough sensitivity to be useful, the SFAT targeted multiple streams from each category that represented the entire continuum of stream health. This effort resulted in the development of a list of metrics for each of the 29 stream categories for a total of 54 metrics. For ease of use in the field, these 54 metrics from all 29 stream categories were condensed into one field form with 25 metrics that can be used to evaluate any stream category within North Carolina (see the Field Assessment Form on pp. vii-x). Descriptors selected on the Field Assessment Form are sorted back into the original metrics used for each specific stream category by the Rating Calculator to generate ratings for all metrics, classes of function, and the overall stream function. Alternative rating methods have also been developed to reflect functions of perennial versus intermittent streams (see the following section).

Appendix C provides a set of metric-function class diagrams for all NC SAM stream categories depicting how the metric ratings are combined to generate functional class ratings and an overall rating. As an example, a brief discussion of the components used to generate a rating for the Hydrology function of a Pa3 stream follows (reference the Pa3 metric-function class diagram in Appendix C or Figure 11 below for this discussion). See Section 4.2.2: Metrics (pp. 47-144) for a description of metrics referenced in the discussion.

The rating for the Class 1 function, Hydrology, is generated from the ratings of the two Class 2 functions, Baseflow and Flood Flow. The Baseflow rating is generated directly from the combination of seven metric ratings (Metric 1 [Channel Water], Metric 9 [Large or Dangerous Stream], Metric 12 [Aquatic Life], Metric 8 [Recent Weather], Metric 15 [Wetland presence], Metric 16 [Baseflow Contributors], and Metric 17 [Baseflow Detractors]). The function-class diagram depicts the first three listed metrics in a solid box connected to Baseflow by a solid line and the latter four metrics in a dashed box connected to Baseflow with a dashed line. The solid line indicates that the first three metrics are used to generate an initial rating for Baseflow. The dashed line indicates that the latter four metrics have the potential to modify the initial rating for Baseflow. The Flood Flow rating is generated from two Class 3 function ratings (Streamside Area Attenuation and Stream Stability), which, in turn, are generated from three Class 4 function ratings for each (Floodplain Access, Wooded Riparian Buffer, and Microtopography for the former and Channel Stability, Sediment Transport, and Stream Geomorphology for the latter). In this example, six Class 4 Hydrology functions are generated from various combinations of descriptors from ten metrics (Metric 6 [Streamside Area Interaction], Metric 19 [Buffer Width], Metric 22 [Stem Density], Metric 13 [Streamside Area Ground Surface Condition], Metric 14 [Streamside Area Water Storage], Metric 5 [Signs of Active Instability], Metric 9 [Large or Dangerous Stream], Metric 11 [Bedform and Substrate], Metric 4 [Feature Pattern], and Metric 4 [Feature Longitudinal Profile). Using the Rating Calculator, the ratings of these metrics and classes of function are automatically organized and filtered to provide the assessor with a simple rating for Pa2 stream Hydrology, as well as allowing for more in-depth analysis of the separate classes.

Figure 11. A depiction of how the metric components are used to generate a rating for the Hydrology function of a Pa3 stream (reference the Pa3 metric-function class diagram in Appendix C for a depiction of how all metric components are used for the overall rating of a Pa3 stream).




### 5.5.2 The Rating Calculator and the Stream Rating Sheet

The Rating Calculator provides a screen that approximates the Field Assessment Form. The assessor completes the form within the Rating Calculator by selecting the appropriate descriptor boxes and option buttons. The program generates function ratings from the completed form. The assessor can then print a hard copy of the rating results (Stream Rating Sheet) for the assessed stream. A blank example of the Stream Rating Sheet is provided as p. xi at the beginning of the User Manual.

The Stream Rating Sheet is comprised of three sections: project information, additional information, and function class rating summary.

Project Information

Project information at the top of the Stream Rating Sheet provides limited site information including stream site name, stream category, date of assessment, and the assessor's name and organization. This information is copied from sections completed in the Rating Calculator Field Assessment Form.

Additional Information

Next is a list of four items of interest concerning the assessed stream. The first three include a Yes/No toggle to allow the Stream Rating Sheet to indicate if one or more of these items applies to this assessment area. The last one indicates type of NC SAM stream feature selected for Field Assessment Form Information 14 (perennial flow, intermittent flow, or Tidal Marsh Stream).

Functional Class Rating Summary

Ratings (High, Medium, or Low) are provided for each class function and the overall stream. The overall rating is provided at the bottom. Class 1 functions are indicated by a "1" within parentheses – (1) – in front of the function class name, and so forth.

Ratings are provided in two columns: "USACE/All Streams" and "NCDWQ Intermittent." For all assessed streams, the overall and different levels of class ratings are provided in the USACE/All Streams column. For streams determined with the use of the current NCDWQ Stream Identification Form to be intermittent, a second set of overall and class ratings is provided in the NCDWQ Intermittent column. The second set of function ratings is provided for use by NCDWQ, which requires mitigation for impacts to intermittent streams (NCDWQ Public Memorandum, August 18, 2009). If the assessed stream was not determined to be intermittent, ratings are provided in the USACE/All Streams column, and the entire NCDWQ Intermittent column is shaded gray. A detailed explanation of how the generation of USACE/All Streams ratings differs from the generation of NCDWQ Intermittent ratings is provided in the following section.

Note that "NA" (Not Applicable) will appear in the rating column for any function class not used by the Rating Calculator for an evaluated stream. The presence of NA is not indicative of a problem with the Rating Calculator.

USACE/All Stream Ratings Versus NCDWQ Intermittent Stream Ratings

Initially, the SFAT developed a Boolean logic framework for generation of ratings for all streams based primarily on NC SAM stream categories. Subsequently, the SFAT developed alternative Boolean logic to reflect a potential difference in amount of function provided by streams determined with the NCDWQ Stream Identification Form to be intermittent.

The alternative Boolean logic only differentiates NCDWQ intermittent streams for Size 1 and 2 streams; there is no separate calculation for Size 3 and 4 streams. The alternative Boolean logic utilizes identical metrics and function classes for Size 1 streams, but has different thresholds for High, Medium, and Low ratings. The alternative Boolean logic utilizes different metrics and function classes for Size 2 streams.

An example of how the Boolean logic used to generate ratings for the USACE/All Streams column differs from the alternative Boolean logic used to generate separate ratings for the NCDWQ Intermittent column follows. Appendix C provides a metric-function class diagram for each stream category, as well as the separate metric-function class diagrams used for Size 2 streams for generation of USACE/All Streams and NCDWQ Intermittent ratings. For this example, reference the two Pa2 metric-function class diagrams (Pa2 – USACE/All Streams and Pa2 – NCDWQ Intermittent). The primary difference in Boolean logic of USACE/All Streams versus NCDWQ Intermittent streams happens in the Class 2 Baseflow and Class 3 In-stream Habitat functions. For NCDWQ Intermittent streams, the Baseflow function (which is used in the calculation of ratings for all three Class 1 functions) is generated from a combination of Metric 15 (Wetland Presence), Metric 16 (Baseflow Contributors), and Metric 17 (Baseflow Detractors) only. For USACE/All Streams, the Baseflow function is generated from a combination of Metrics 15, 16, 17, 1 (Channel Water), 8 (Recent Weather), 9 (Large or Dangerous Stream), and 12 (Aquatic Life). This reflects the fact that the normal hydrologic cycle of NCDWQ intermittent streams is to be dry during part of the year.

The In-stream Habitat function (which is used only in the calculation of rating of the Habitat Class 1 function) for both USACE/All Streams and NCDWQ Intermittent streams is rated using a combination of Metric 2 (Evidence of Flow Restriction), Metric 10 (Natural In-stream Habitat Types), and Metric 11 (Bedform and Substrate). However, for NCDWQ Intermittent streams, the rating is less stringent in the number of habitats required to receive a High rating – one habitat present equates to High for intermittent streams as opposed to three or more for USACE/All streams. This reflects the habitat condition of several NCDWQ Intermittent reaches observed by SFAT members during development of the method.

The Aquatic Life Class 2 function is a special case. The rating of this function is determined by the rating of only Metric 12 (Aquatic Life). This function is omitted from the rating calculation of the Class 1 Water Quality function if descriptor “C,” “No water in assessment reach,” is selected for Metric 1 (Channel Water).

### 5.5.3 Final Product

The use of NC SAM is expected to result in generation of a functional rating for each assessed stream and ratings for each specific functional class for that particular stream. It is also expected to result in documentation of observed conditions contributing to the ratings. The product resulting from implementation of NC SAM includes, but is not limited to, a completed Field Assessment Form (with assessor notes), a completed Stream Rating Sheet, a site map, site photographs, and additional notes if appropriate/available. This product is intended to be utilized by land owners, planners, and local, state, and federal regulatory agency personnel.

## 6.0 TECHNICAL RESOURCES

This version of NC SAM contains supporting information in Appendices A through K. Additional information supporting NC SAM, presented as Appendices M through O, will be made available on the internet through the NCDWQ website. The contents of these additional appendices are described briefly below.

Appendix M Field Metric Evaluation Sheets. This appendix includes the original Field Metric Evaluation Sheet developed by the SFAT for each stream category.

Appendix N Cross-walk from the Field Metric Evaluation Sheets to the Field Assessment Form. This appendix depicts the relationships between the original metrics developed on the Field Metric Evaluation Sheets and the metrics presented on the current Field Assessment Form.

Appendix O Function Rating Boolean Logic for Each Stream Category. This appendix provides a depiction of the Boolean logic chain of reasoning used to convert the metric evaluation results into function ratings for classes and the assessment area, in sequence.

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# APPENDIX A

## Acronyms and Abbreviations

# Appendix A: Acronyms and Abbreviations

| | |
|---|---|
| Action Identification | AID |
| Area of Environmental Concern | AEC |
| Best Management Practices | BMPs |
| Coastal Area Management Act | CAMA |
| Diameter at Breast Height | DBH |
| Essential Fish Habitat | EFH |
| Degrees Fahrenheit | °F |
| Geographic Information System | GIS |
| High Quality Waters | HQW |
| Hydrogeomorphic Method | HGM |
| Information Mapping System | IMS |
| Light Detection and Ranging | LiDAR |
| Microsiemens | µS |
| Nephelometric turbidity units | NTU |
| N.C. Coastal Resources Commission | NCCRC |
| N.C. Department of Agriculture and Consumer Services | NCDA&CS |
| N.C. Department of Environment and Natural Resources | NCDENR |
| N.C. Department of Transportation | NCDOT |
| N.C. Division of Coastal Management | NCDCM |
| N.C. Division of Marine Fisheries | NCDMF |
| N.C. Division of Water Quality | NCDWQ |
| N.C. Ecosystem Enhancement Program | NCEEP |
| N.C. Marine Resources Commission | NCMFC |
| N.C. Natural Heritage Program | NCNHP |
| N.C. Stream Assessment Method | NC SAM |
| N.C. Stream Functional Assessment Team | SFAT |
| N.C. Wetland Assessment Method | NC WAM |
| N.C. Wetland Functional Assessment Team | WFAT |
| N.C. Wildlife Resources Commission | NCWRC |
| Nutrient Sensitive Waters | NSW |
| Outstanding Resource Waters | ORW |
| Primary Nursery Area | PNA |
| Submerged Aquatic Vegetation | SAV |
| Total Suspended Solids | TSS |
| Trout waters | Tr |
| U.S. Army Corps of Engineers | USACE |
| U.S. Environmental Protection Agency | USEPA |
| U.S. Federal Highway Administration | FHWA |
| U.S. Fish and Wildlife Service | USFWS |
| U.S. Geological Survey | USGS |
| U.S. National Marine Fisheries Service | NMFS |
| U.S. Natural Resources Conservation Service | NRCS |

# APPENDIX B

## Analysis of NC SAM Data Evaluations

ATKINS

TO: Members of the NC Stream Functional Assessment Team (SFAT)

CC: Sandy Smith (Axiom)
Matt Cusack (Atkins)

FROM: John Dorney, Atkins
Brad Allen, Atkins

RE: Analysis of NC SAM data evaluations – A High Level Analysis and Comparison Between Functional Ratings

DATE: January 10, 2013
Revised February 20, 2013

Interest has been expressed by LeiLani Paugh, Larry Eaton and Todd Tugwell to provide some initial statistical analysis of our North Carolina Stream Assessment Method (NC SAM) data in order to provide input to North Carolina Stream Functional Assessment Team (Team) members with respect to some high-level statistical patterns that might shed light on the draft methodology and support its review during the forthcoming public notice process. Based on this request, we have conducted the following analysis.

## 1. NC SFAT Stream set

### *a. Background*

The following analysis was done using a dataset representative of potential impact sites the Team has visited in order to review general statistical patterns in the data. The following comparison examines the association between the three Class 1 functions (Hydrology, Water Quality, and Habitat), the overall rating, and the metric which asks whether the percent impervious cover is greater than 24% (Metric 17 – Baseflow Detractors, descriptor C). As you may know, Susan Gale from North Carolina Division of Water Quality (NCDWQ) is beginning her thesis work at North Carolina State University (NCSU) to compare NC SAM results to macrobenthos and stream gage data, so a more comprehensive analysis will be completed in a few years. In fact, some of the data for this analysis were collected with her in November 2012 while helping to calibrate her understanding of NC SAM.

For our comparison, we used the Fischer's Exact Test to evaluate the existence of an association between two categorical types of data, and the Spearman's ρ correlation coefficient since it is more appropriate for ordinal data (Choi et al. 2010) to quantify the degree of association between the three NC SAM Class 1 function ratings, the overall rating, and the impervious surface answer for Metric 17. Possible ratings are High (H), Medium (M), and Low (L). These tests are appropriate tests to use for the type of data that are available from the NC SAM dataset. Our dataset (see attached) consists of 55 stream sites in the piedmont (39 sites), mountains (10 sites), and inner coastal plain (6 sites) that either the Team had visited and evaluated or Team members had visited and evaluated for various purposes since January 2011, including the calibration with Susan Gale accompanied by Larry Eaton on November 6, 2012. The January 2011 date was chosen since changes to the NC SAM Field Assessment Form since that date have mostly be minor and cosmetic in nature.

*b. Results*

Summaries of the data are displayed in Table 1 to Table 4. It is clear from Table 1 that the Overall rating and the Hydrology, Water Quality, or Habitat Class 1 functions do not correlate perfectly. For a correlation of 1 to occur, one would expect all the observations to fall along the diagonal of the two-way table (e.g., cells H-H, M-M or L-L), which is not the case in this dataset. Finally, the comparison with Water Quality and Percent Impervious Surface (Yes-No greater than 24% impervious) showed the general trend that we would expect – namely, few sites had High Water Quality ratings with > 24% impervious cover, and few sites had Low Water Quality with < 24% impervious cover.

With respect to statistical comparisons, Hydrology, Water Quality, and Habitat showed significant correlations with Overall rating as expected since these three function ratings make up the Overall rating. Overall rating was not significantly correlated with urban % impervious cover ($p=0.1087$, Fischer Exact Test), and habitat was not significantly correlated with urban % impervious cover ($p=0.4468$, Fischer Exact Test). The Spearman's ρ correlation coefficient was used to calculate the association between Overall rating (standard errors in parenthesis) and the other NC SAM function ratings and percent impervious surface with the following results:

| | |
|---|---|
| Overall and Hydrology | 0.8601 (0.0551) |
| Overall and Water Quality | 0.5994 (0.1013) |
| Overall and Habitat | 0.7642 (0.0735) |
| Water Quality and % impervious | -0.6015 (0.0864) |
| Hydrology and Water Quality | 0.5497 (0.0896) |
| Hydrology and Habitat | 0.5738 (0.1036) |
| Water Quality and Habitat | 0.3985 (0.1215) |

*c. Conclusions*

It appears from this analysis that NC SAM shows the expected relationship with percent impervious surface (lower water quality ratings with more impervious surface) and that while the function ratings (Hydrology, Water Quality and Habitat) are highly correlated with the Overall rating (as expected), none of the correlations are perfect. GENMOD (SAS ®) was used to evaluate the association between Overall ratings and all the Class 1 function ratings. Analysis results suggest that all three Class 1 function ratings are statistically significant predictors ($p<0.001$), which shows that all of them are good predictors of the Overall rating. Full and reduced model approaches were explored to evaluate the assumption that one of the function ratings can be eliminated as predictors of the Overall rating. The Bayesian information criterion (BIC) and Akaike's information criterion (AIC) were used to evaluate if any of the function ratings could be eliminated as predictors of the Overall rating. Results suggested that the best model that predicts Overall rating must contain all three Class 1 function ratings. Based on this analysis, we believe that the general approach that the Team has taken for NC SAM (including the underlying Boolean logic) seems to appropriately reflect what the Team has expected for this dataset.

This analysis was based on potential impact sites as opposed to potential (or constructed) mitigation sites. It is possible that NC SAM could be used for mitigation sites as a screening tool to help select mitigation sites and to evaluate constructed mitigation sites. For instance, Burton (2008) examined the use of NC WAM on mitigation sites and found that most sites rated High for Hydrology, High for Water Quality, and Low for Habitat (mainly because the vegetation was young). However, she also found 5 sites that rated Low for Hydrology or Water Quality and 10 sites that rated Medium for Hydrology or Water Quality out of the 37 assessment areas which were evaluated, mainly due to the presence of various stressors. If a similar pattern is shown to apply on stream mitigation sites, then it is possible that NC SAM (and NC WAM) could be used to identify constructed mitigation sites with problems when the results are not as expected even though this method has not been designed to determine the success of constructed stream mitigation projects.

If you have any questions or additional analyses you would like us to perform, please advise.

## 2. Citation

Burton, E. 2008. Classifying wetlands and assessing their functions: Using the NC Wetlands Assessment Method (NC WAM) to analyze wetland mitigation sites in the coastal plain region. MS Thesis. University of North Carolina –Wilmington. Wilmington, NC.

Choi, J, Peters, M and Mueller, RO. 2010. Correlational analysis of ordinal data: from Pearson's r to Bayesian polychoric correlation. Asia Pacific Educ. Rev., 11:459–466.

**Overall Rating (columns) versus Hydrology (rows)**

Expected results if 1:1 correlation

Table 1. Counts of streams by Hydrology and Overall Rating

| | **Overall Rating** | | |
|---|---|---|---|
| **Hydrology** | **High** | **Medium** | **Low** |
| **High** | 19 | 2 | 1 |
| **Medium** | 0 | 5 | 0 |
| **Low** | 0 | 9 | 19 |

**Overall Rating (columns) versus Water Quality (rows)**

Expected results if 1:1 correlation

Table 2. Counts of streams by Water Quality and Overall Rating

| | **Overall Rating** | | |
|---|---|---|---|
| **Water Quality** | **High** | **Medium** | **Low** |
| **High** | 8 | 2 | 3 |
| **Medium** | 7 | 12 | 6 |
| **Low** | 0 | 2 | 15 |

**Overall Rating (columns) versus Habitat (rows)**

Expected results if 1:1 correlation

Table 3. Counts of streams by Habitat and Overall Rating

| **Habitat** | **Overall Rating** | | |
|---|---|---|---|
| | **High** | **Medium** | **Low** |
| **High** | 16 | 4 | 0 |
| **Medium** | 2 | 8 | 3 |
| **Low** | 1 | 4 | 17 |

**Percent impervious surface > 24% (columns) versus Water Quality (rows)**

Table 4. Number of streams by Water Quality and percent impervious surface

| **Water Quality** | **Percent Impervious surface > 24%** | |
|---|---|---|
| | **Yes** | **No** |
| **High** | 6 | 12 |
| **Medium** | 8 | 9 |
| **Low** | 11 | 9 |

# APPENDIX C

## Metric-Function Class Diagrams

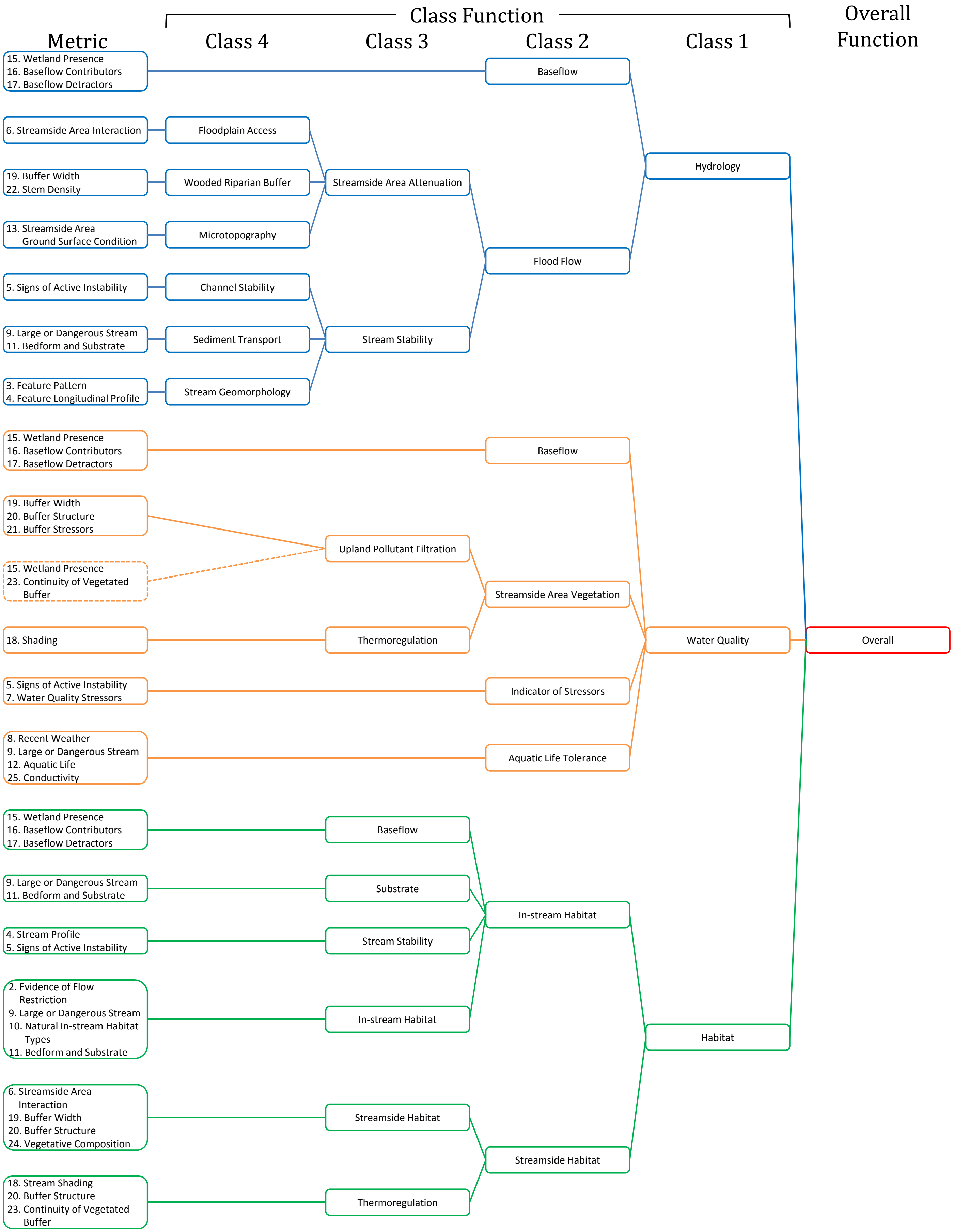
# Appendix C: Metric-Function Class Diagrams

Metric-function class diagrams included in this appendix are provided in the following order. An explanation of stream category terminology is provided in Section 3.0 of the User Manual (p. 23). An explanation of USACE/All Streams and NCDWQ Intermittent is provided in Section 5.5.2 of the User Manual (p. 172).

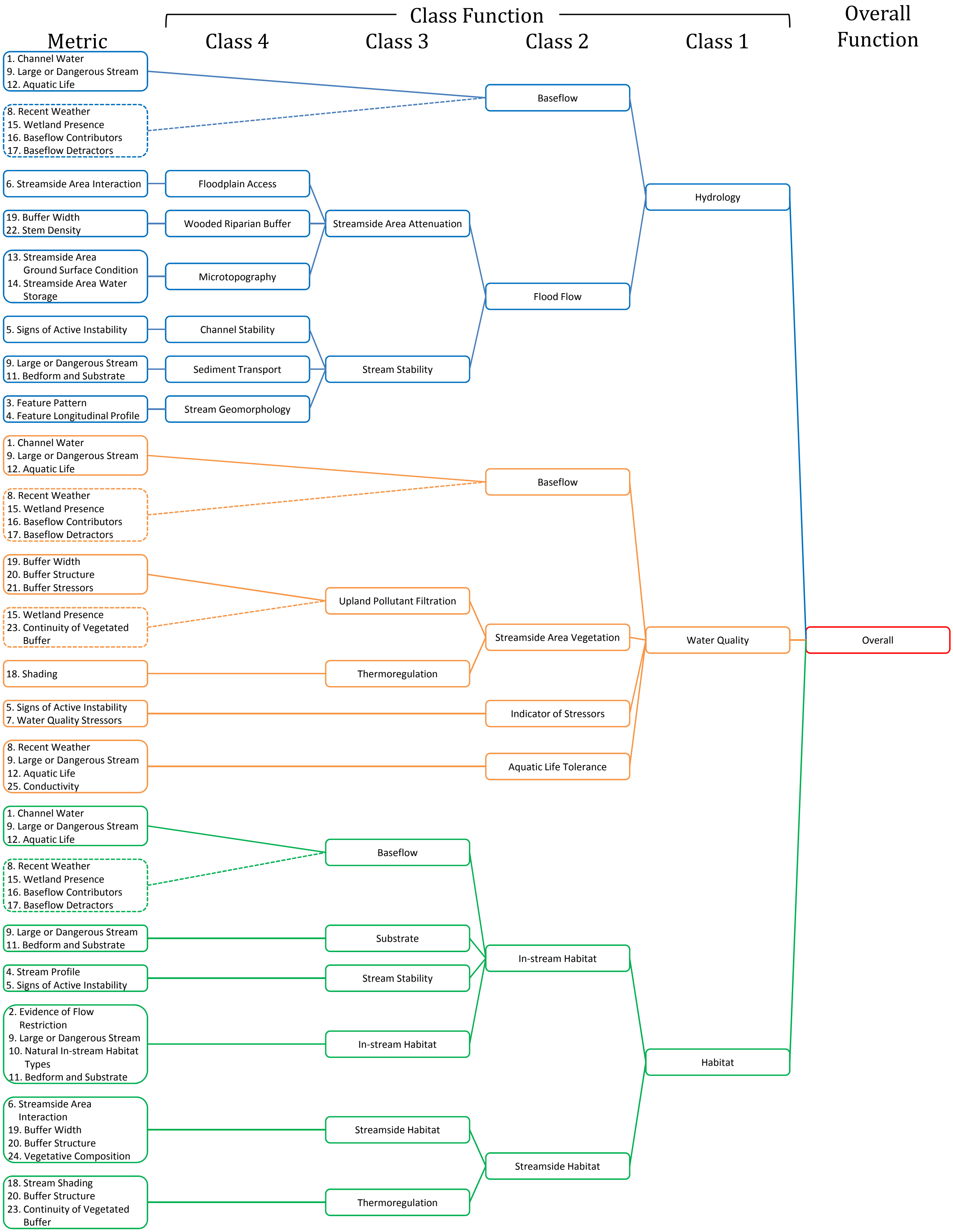
| | Stream Category | | |
|---|---|---|---|
| Metric-Function Class Diagram Title | NCSAM Zone | Valley Type | Watershed Size |
| Ma1 - USACE/All Streams and NCDWQ Intermittent | Mountains | a | 1 |
| Ma2 - USACE/All Streams | Mountains | a | 2 |
| Ma2 - NCDWQ Intermittent | Mountains | a | 2 |
| Ma3 - USACE/All Streams | Mountains | a | 3 |
| Ma4 - USACE/All Streams | Mountains | a | 4 |
| Mb1 - USACE/All Streams and NCDWQ Intermittent | Mountains | b | 1 |
| Mb2 - USACE/All Streams | Mountains | b | 2 |
| Mb2 - NCDWQ Intermittent | Mountains | b | 2 |
| Mb3 - USACE/All Streams | Mountains | b | 3 |
| Mb4 - USACE/All Streams | Mountains | b | 4 |
| Pa1 - USACE/All Streams and NCDWQ Intermittent | Piedmont | a | 1 |
| Pa2 - USACE/All Streams | Piedmont | a | 2 |
| Pa2 - NCDWQ Intermittent | Piedmont | a | 2 |
| Pa3 - USACE/All Streams | Piedmont | a | 3 |
| Pa4 - USACE/All Streams | Piedmont | a | 4 |
| Pb1 - USACE/All Streams and NCDWQ Intermittent | Piedmont | b | 1 |
| Pb2 - USACE/All Streams | Piedmont | b | 2 |
| Pb2 - NCDWQ Intermittent | Piedmont | b | 2 |
| Pb3 - USACE/All Streams | Piedmont | b | 3 |
| Pb4 - USACE/All Streams | Piedmont | b | 4 |
| Ia1 - USACE/All Streams and NCDWQ Intermittent | Inner Coastal Plain | a | 1 |
| Ia2 - USACE/All Streams | Inner Coastal Plain | a | 2 |
| Ia2 - NCDWQ Intermittent | Inner Coastal Plain | a | 2 |
| Ia3 - USACE/All Streams | Inner Coastal Plain | a | 3 |
| Ia4 - USACE/All Streams | Inner Coastal Plain | a | 4 |

|  | Stream Category | | |
| --- | --- | --- | --- |
| Metric-Function Class Diagram Title | NCSAM Zone | Valley Type | Watershed Size |
| Ib1 - USACE/All Streams and NCDWQ Intermittent | Inner Coastal Plain | b | 1 |
| Ib2 - USACE/All Streams | Inner Coastal Plain | b | 2 |
| Ib2 - NCDWQ Intermittent | Inner Coastal Plain | b | 2 |
| Ib3 - USACE/All Streams | Inner Coastal Plain | b | 3 |
| Ib4 - USACE/All Streams | Inner Coastal Plain | b | 4 |
| Oa1 - USACE/All Streams and NCDWQ Intermittent | Outer Coastal Plain | a | 1 |
| Oa2 - USACE/All Streams | Outer Coastal Plain | a | 2 |
| Oa2 - NCDWQ Intermittent | Outer Coastal Plain | a | 2 |
| Oa3 - USACE/All Streams | Outer Coastal Plain | a | 3 |
| Oa4 - USACE/All Streams | Outer Coastal Plain | a | 4 |
| Tidal Marsh Stream | | | |

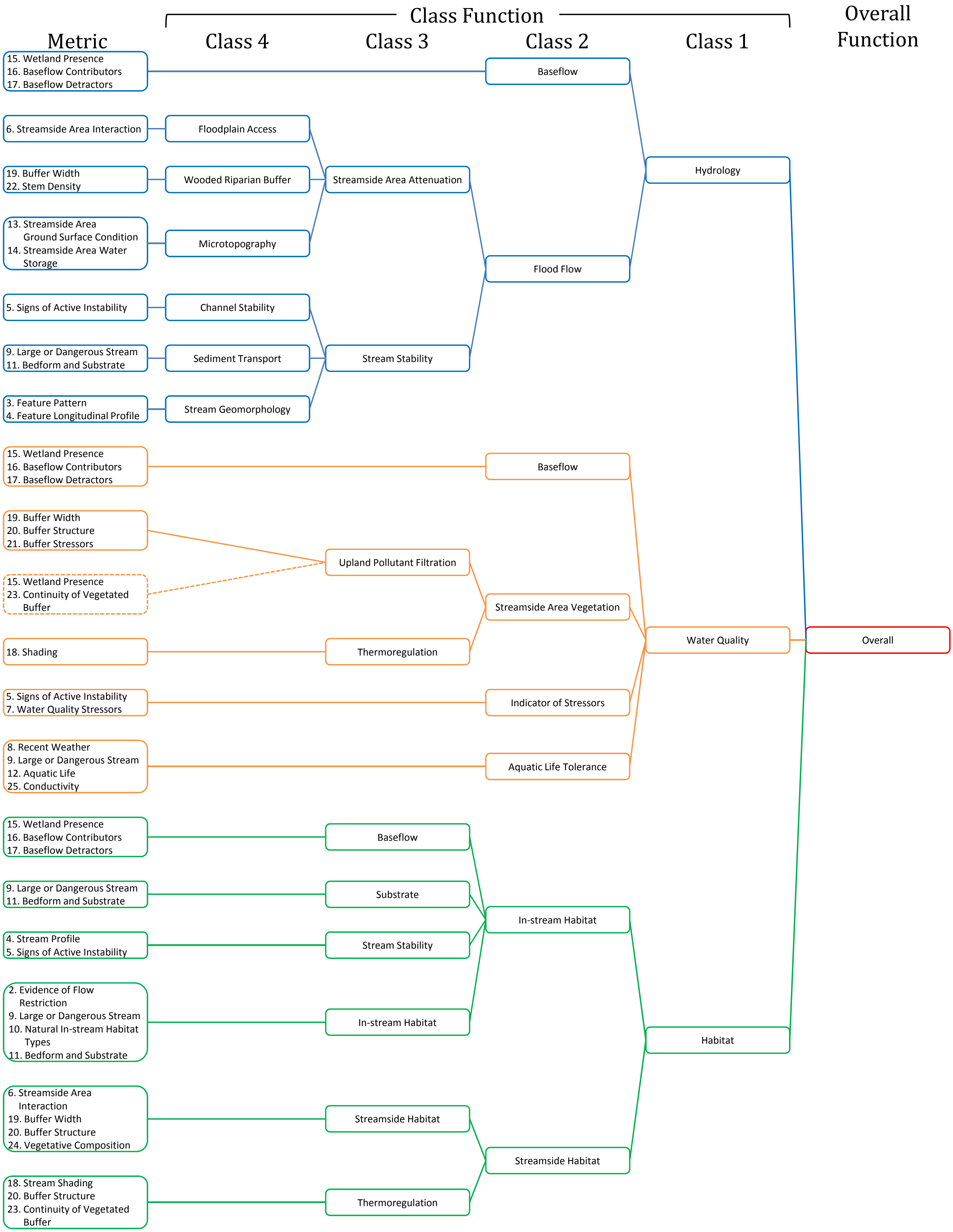
# Ma1 (USACE/All Streams and NCDWQ Intermittent) Metric-Function Class Diagram



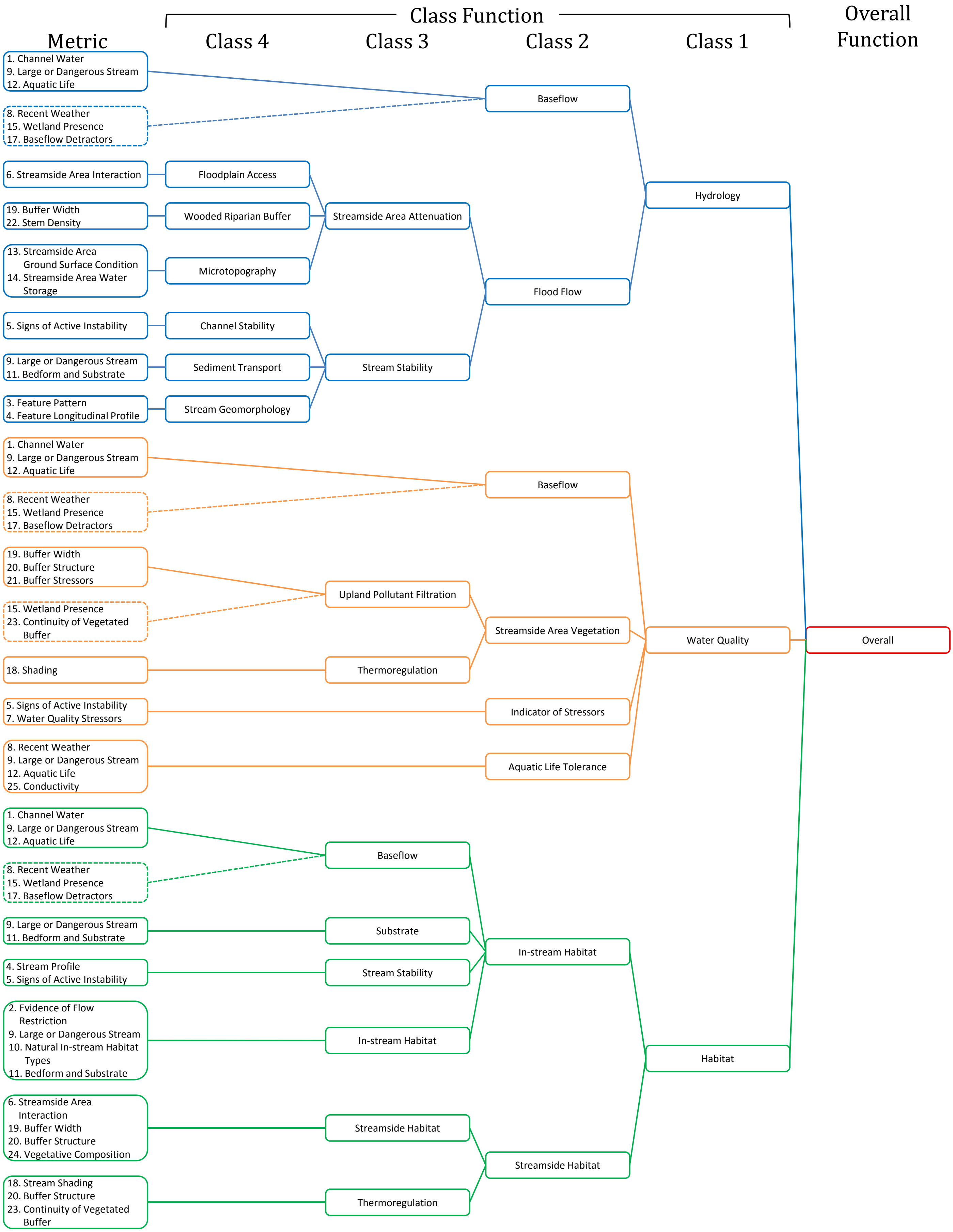
# Ma2 (USACE/All Streams) Metric-Function Class Diagram



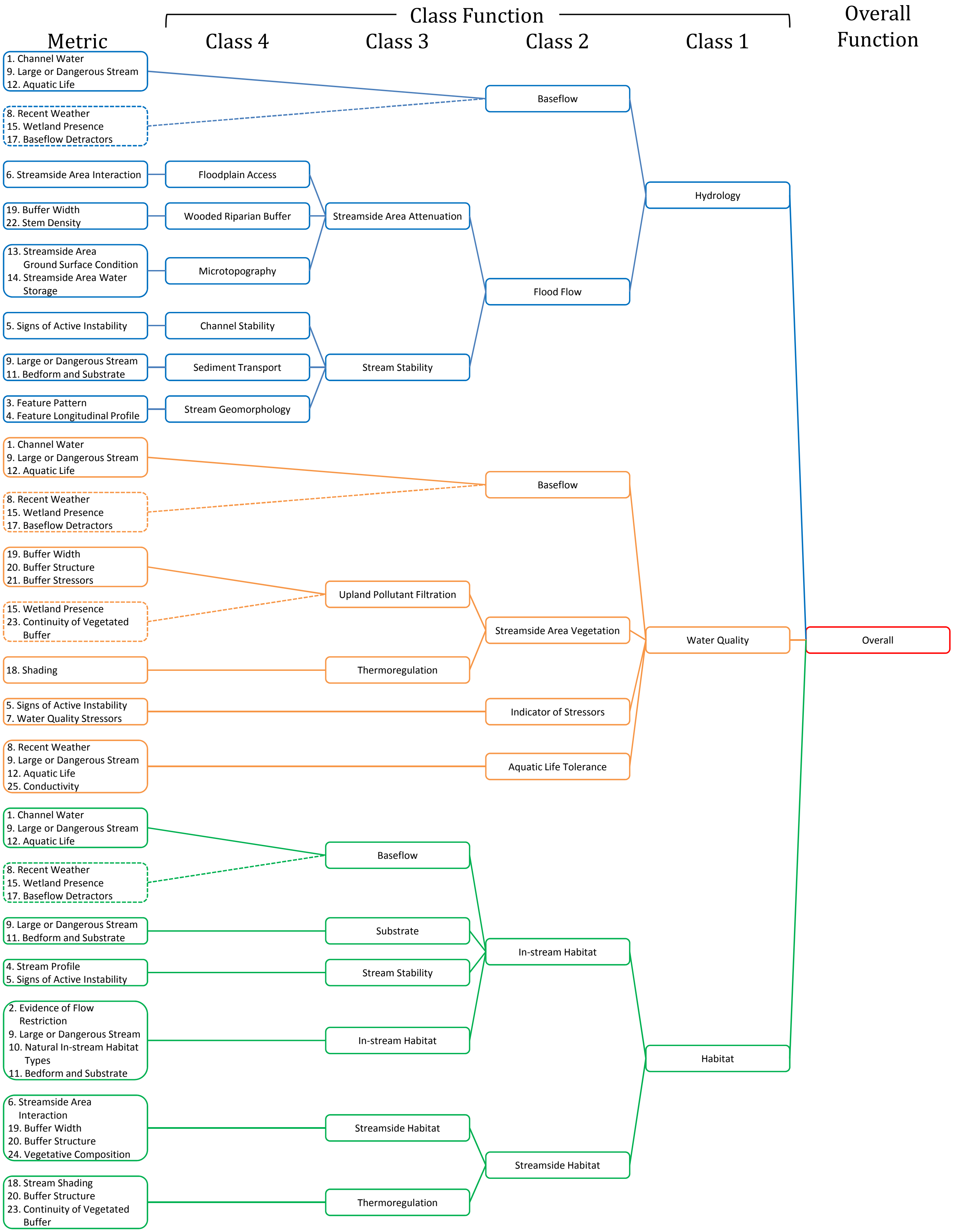
# Ma2 (NCDWQ Intermittent) Metric-Function Class Diagram



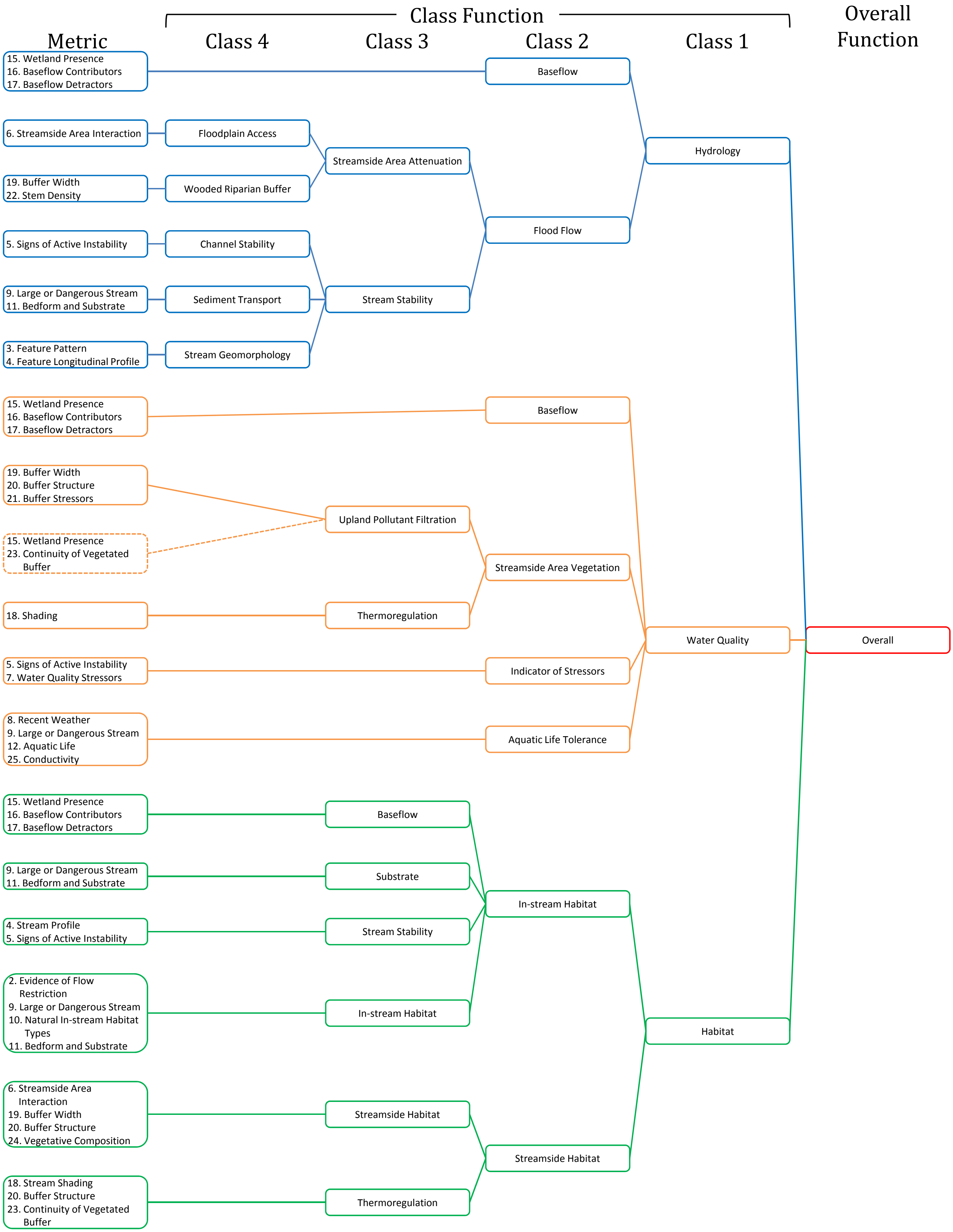
# Ma3 (USACE/All Streams) Metric-Function Class Diagram



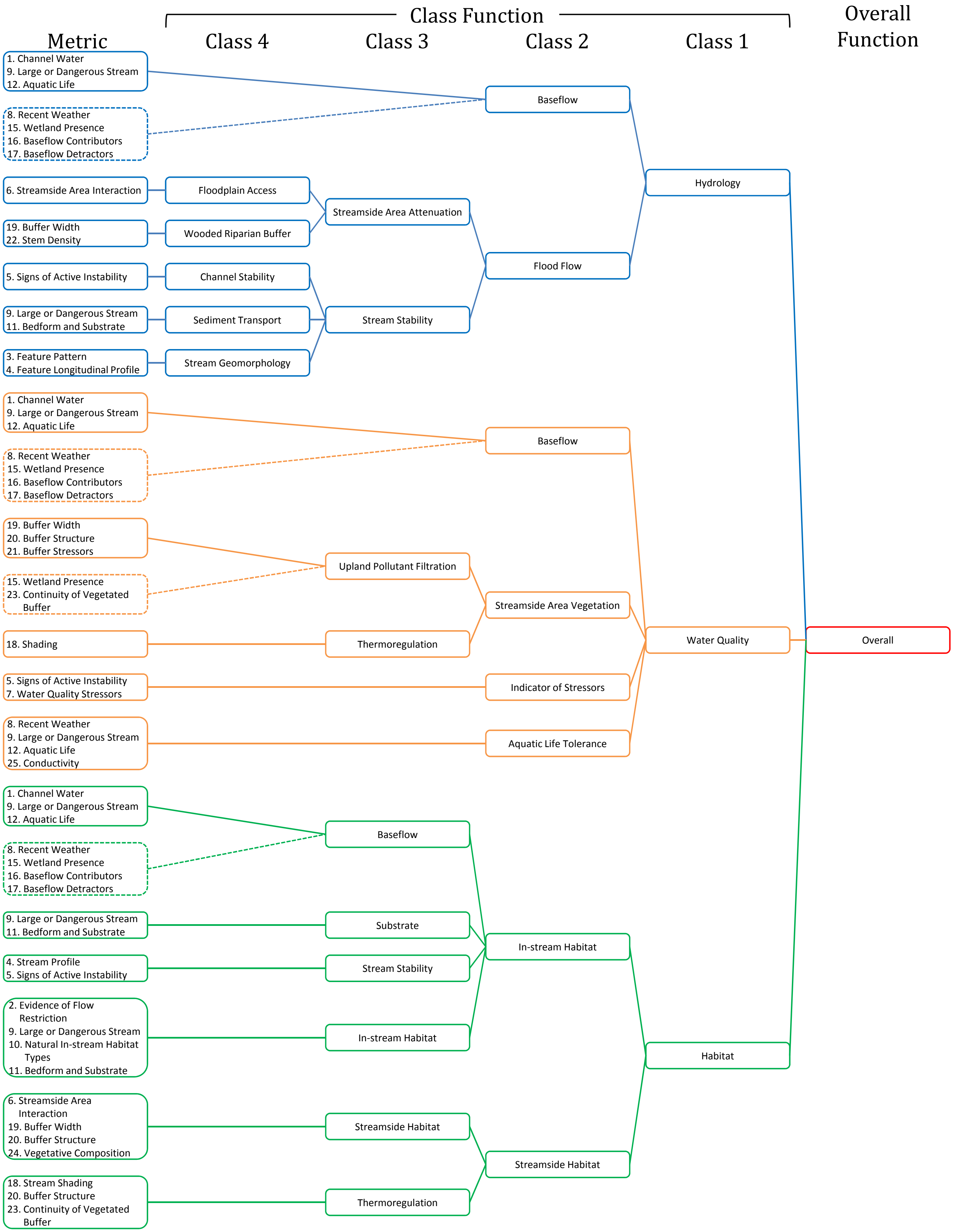
# Ma4 (USACE/All Streams) Metric-Function Class Diagram



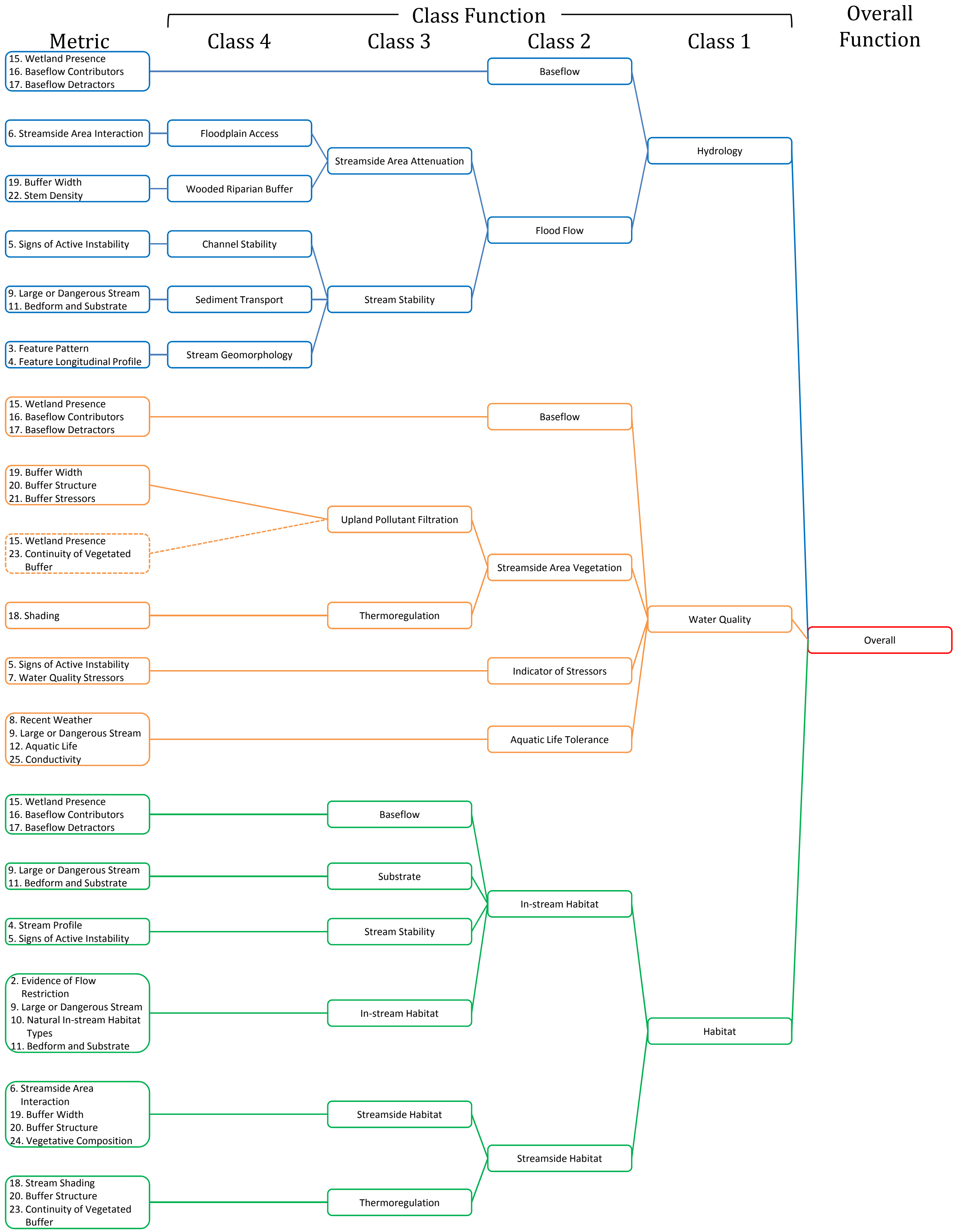
# Mb1 (USACE/All Streams and NCDWQ Intermittent) Metric-Function Class Diagram



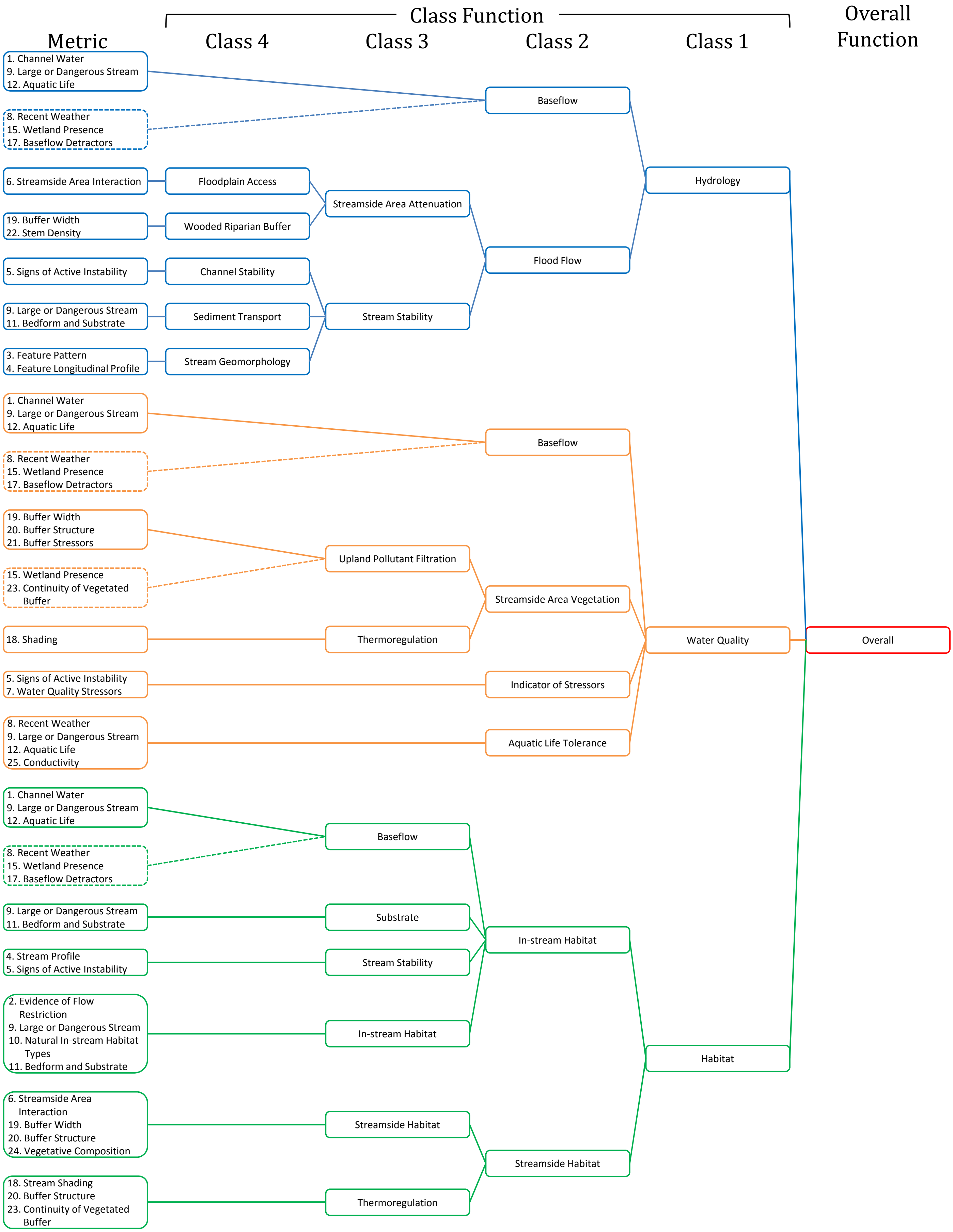
# Mb2 (USACE/All Streams) Metric-Function Class Diagram



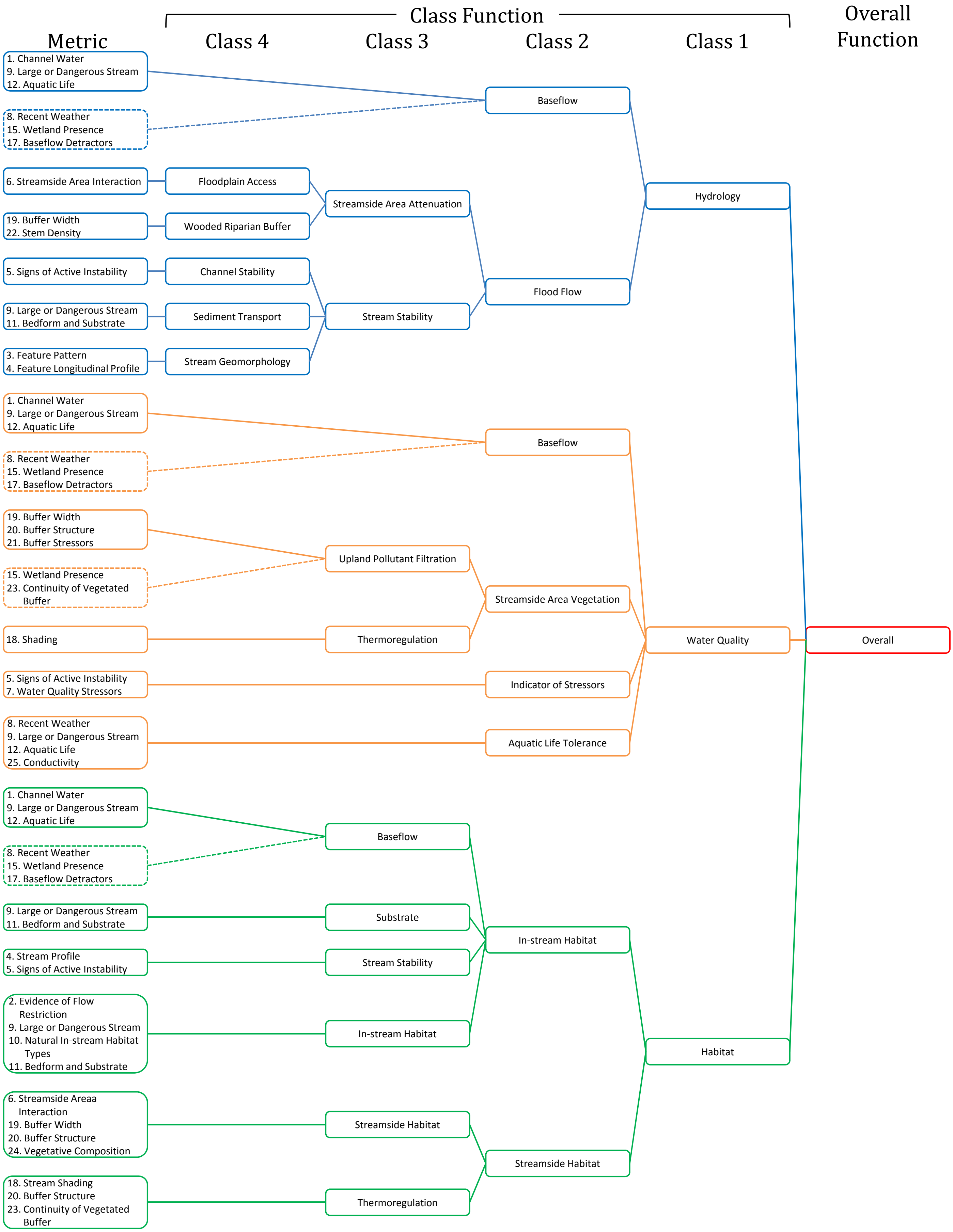
# Mb2 (NCDWQ Intermittent) Metric-Function Class Diagram



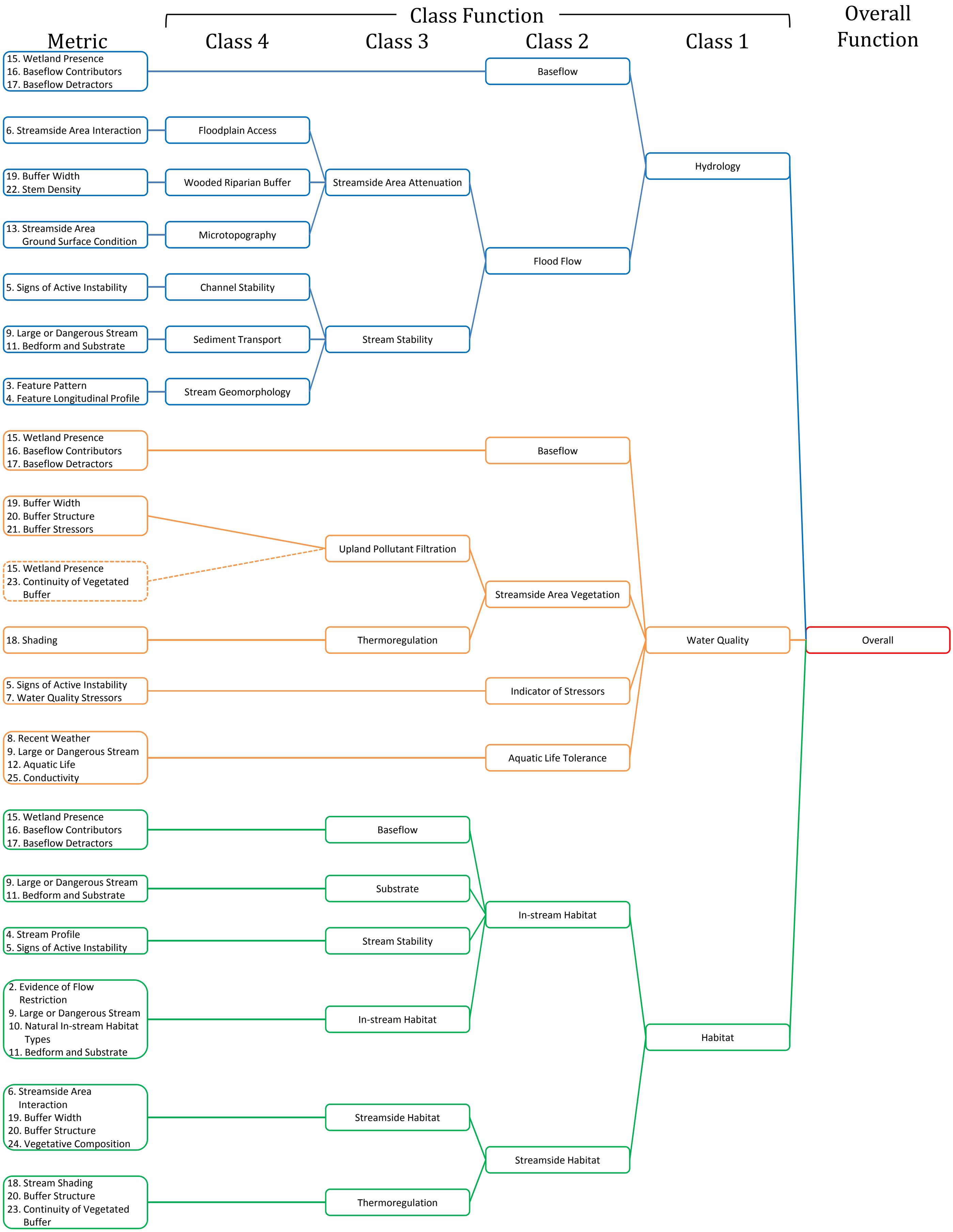
# Mb3 (USACE/All Streams) Metric-Function Class Diagram



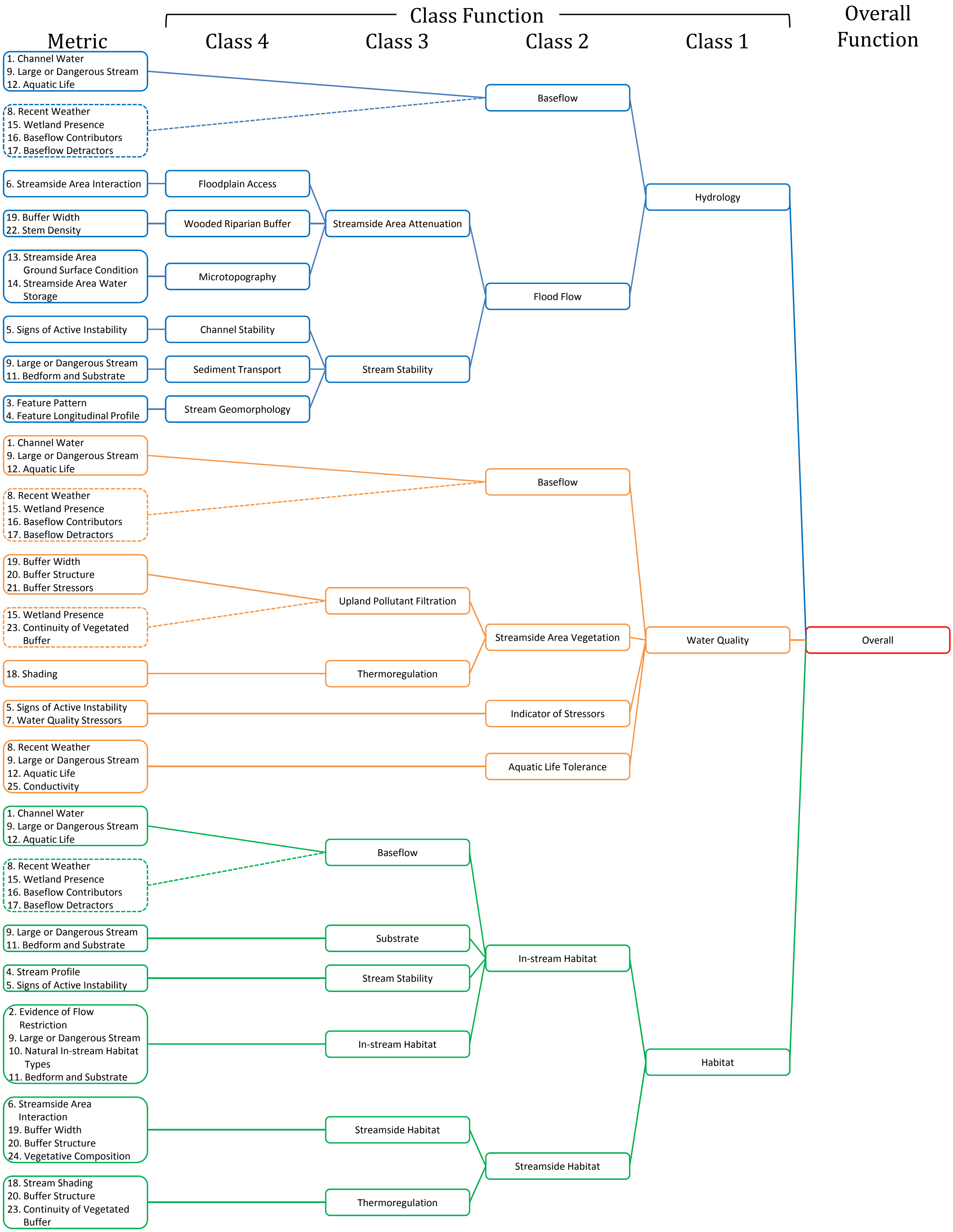
# Mb4 (USACE/All Streams) Metric-Function Class Diagram



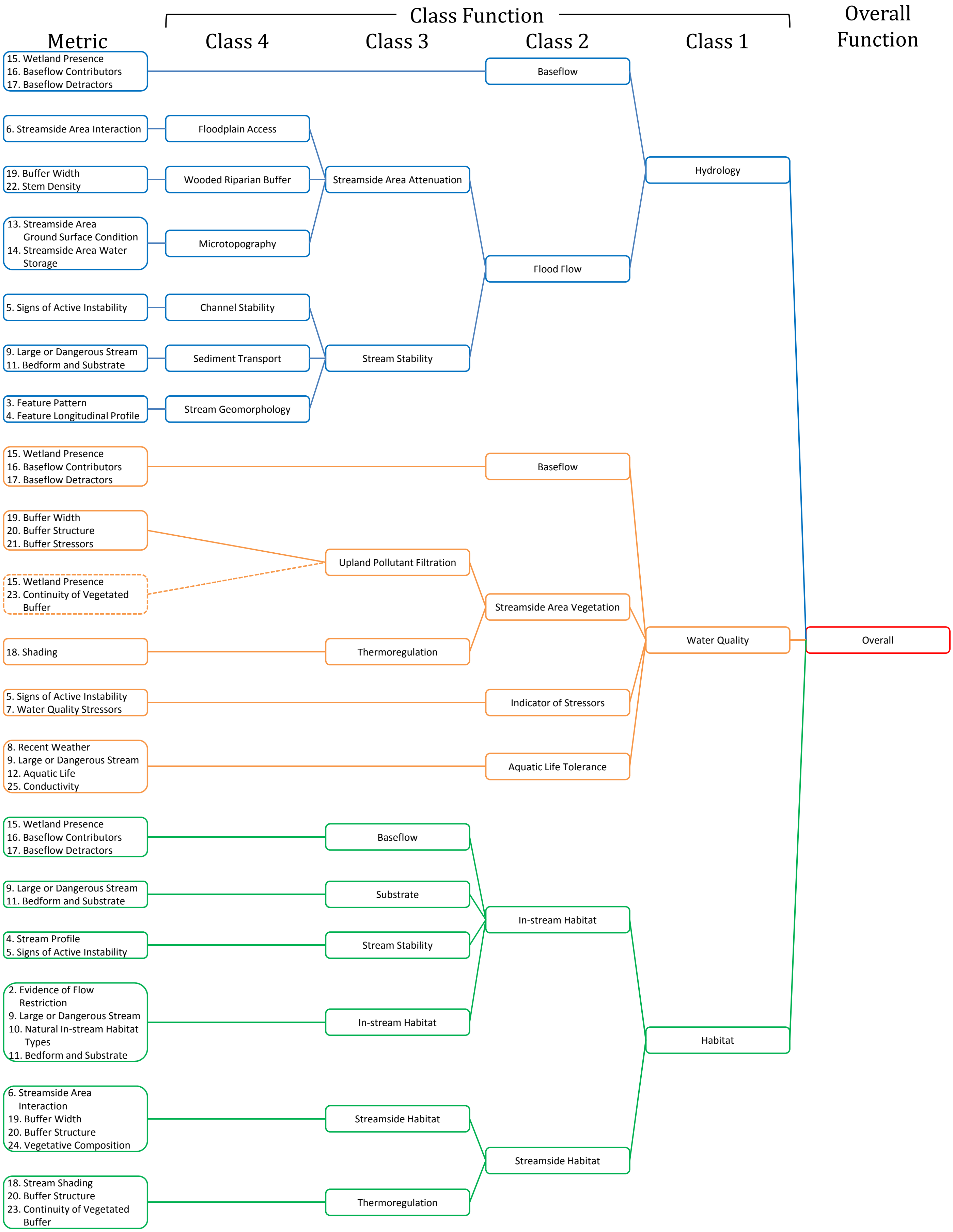
# Pa1 (USACE/All Streams and NCDWQ Intermittent) Metric-Function Class Diagram



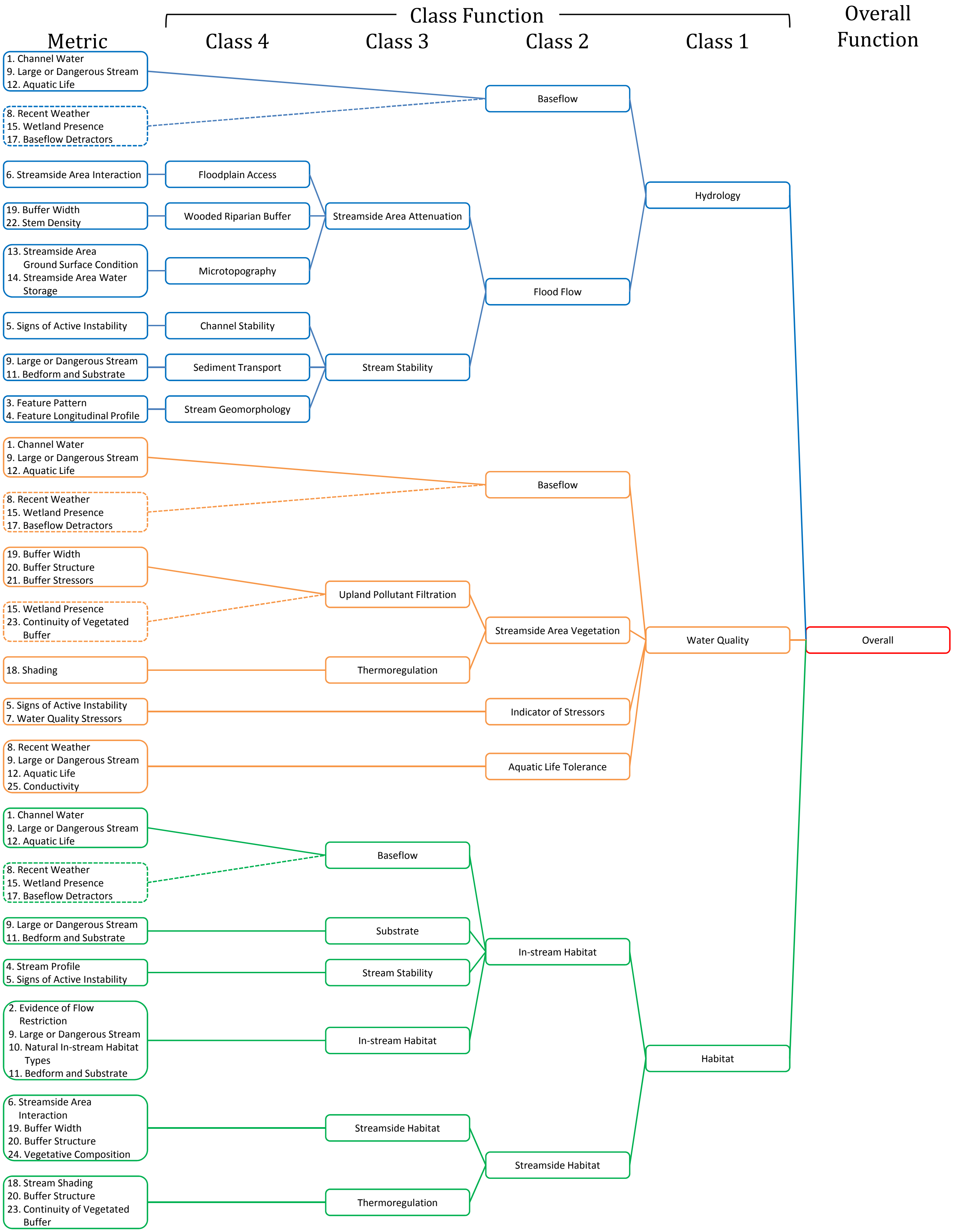
# Pa2 (USACE/All Streams) Metric-Function Class Diagram



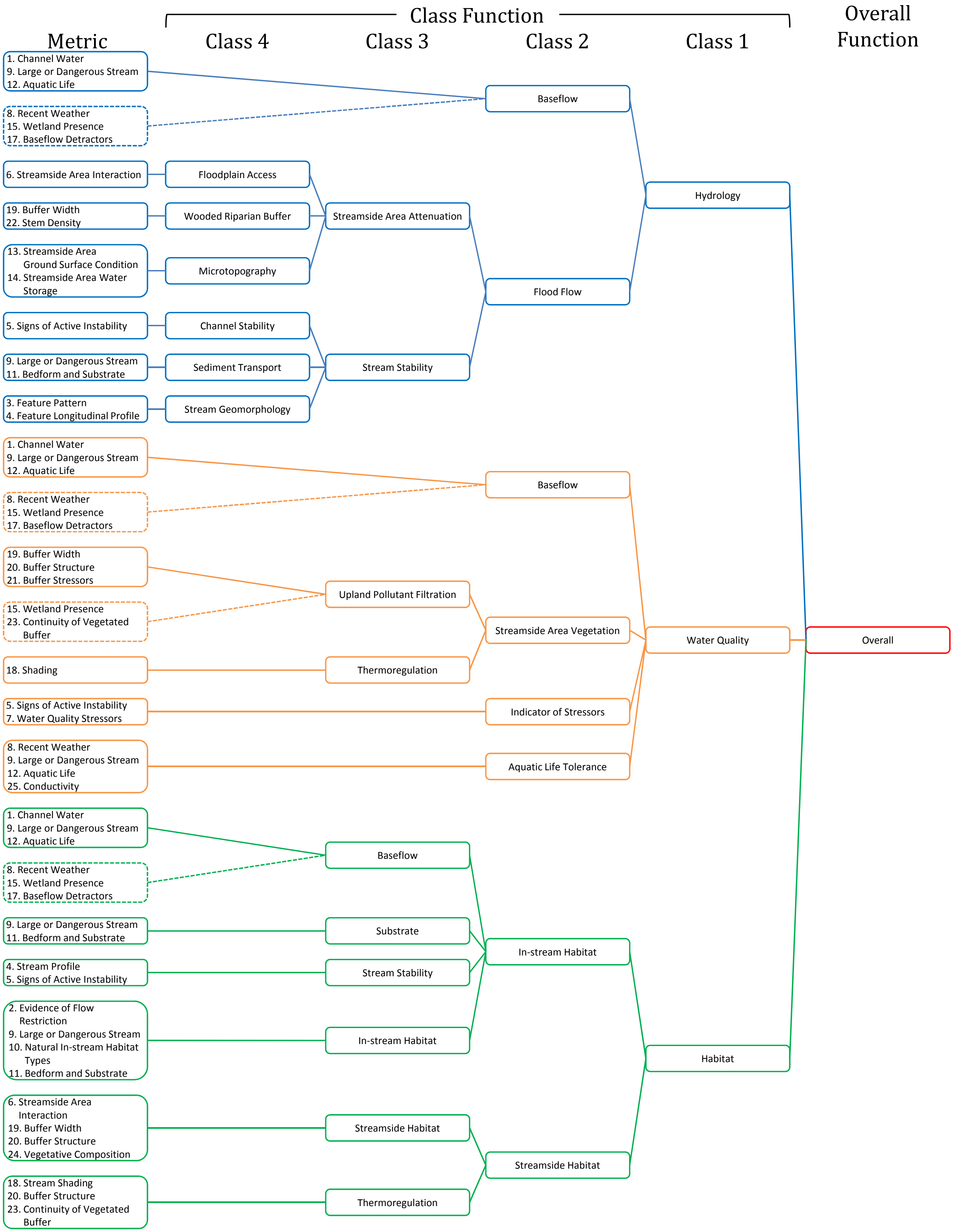
# Pa2 (NCDWQ Intermittent) Metric-Function Class Diagram



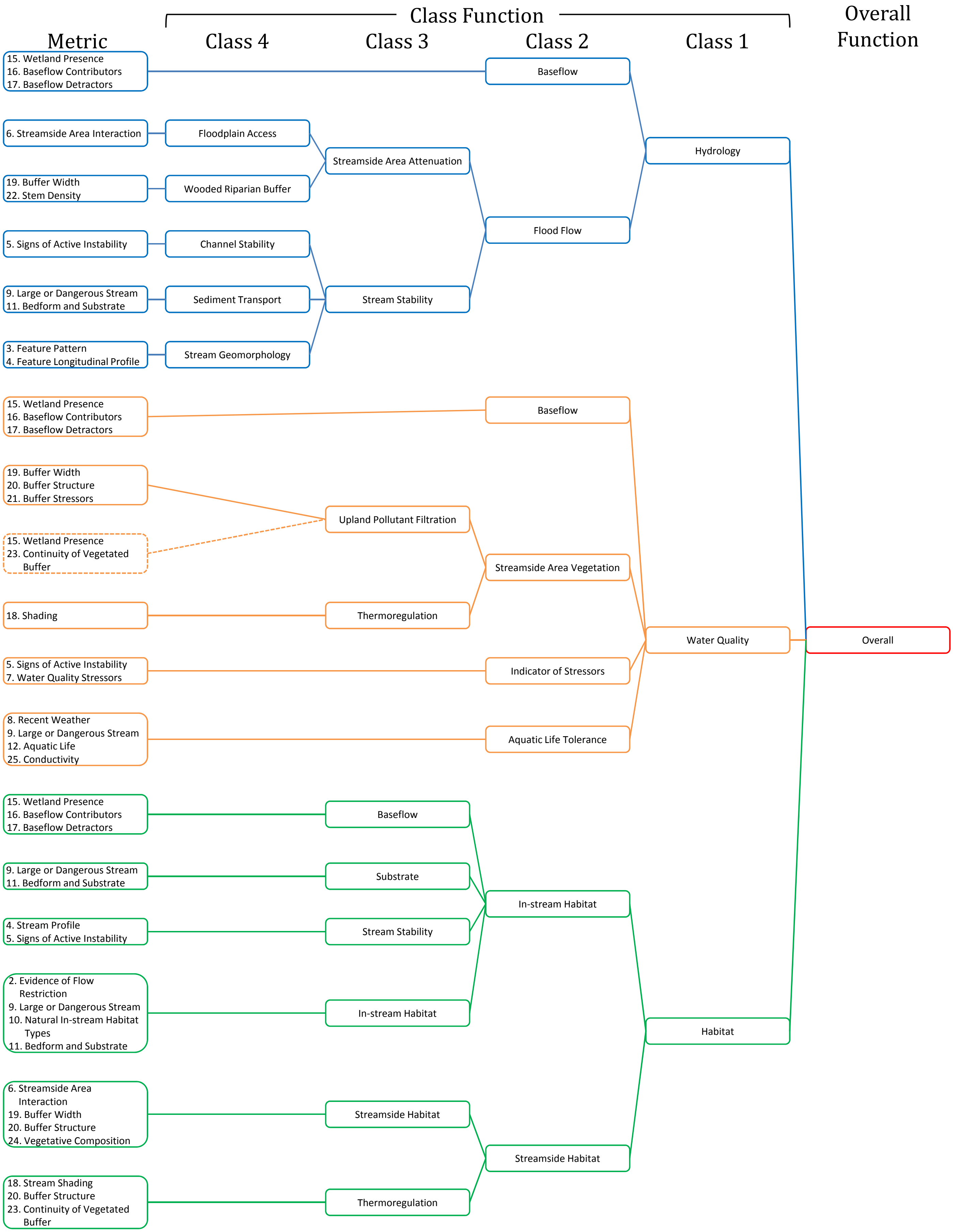
# Pa3 (USACE/All Streams) Metric-Function Class Diagram



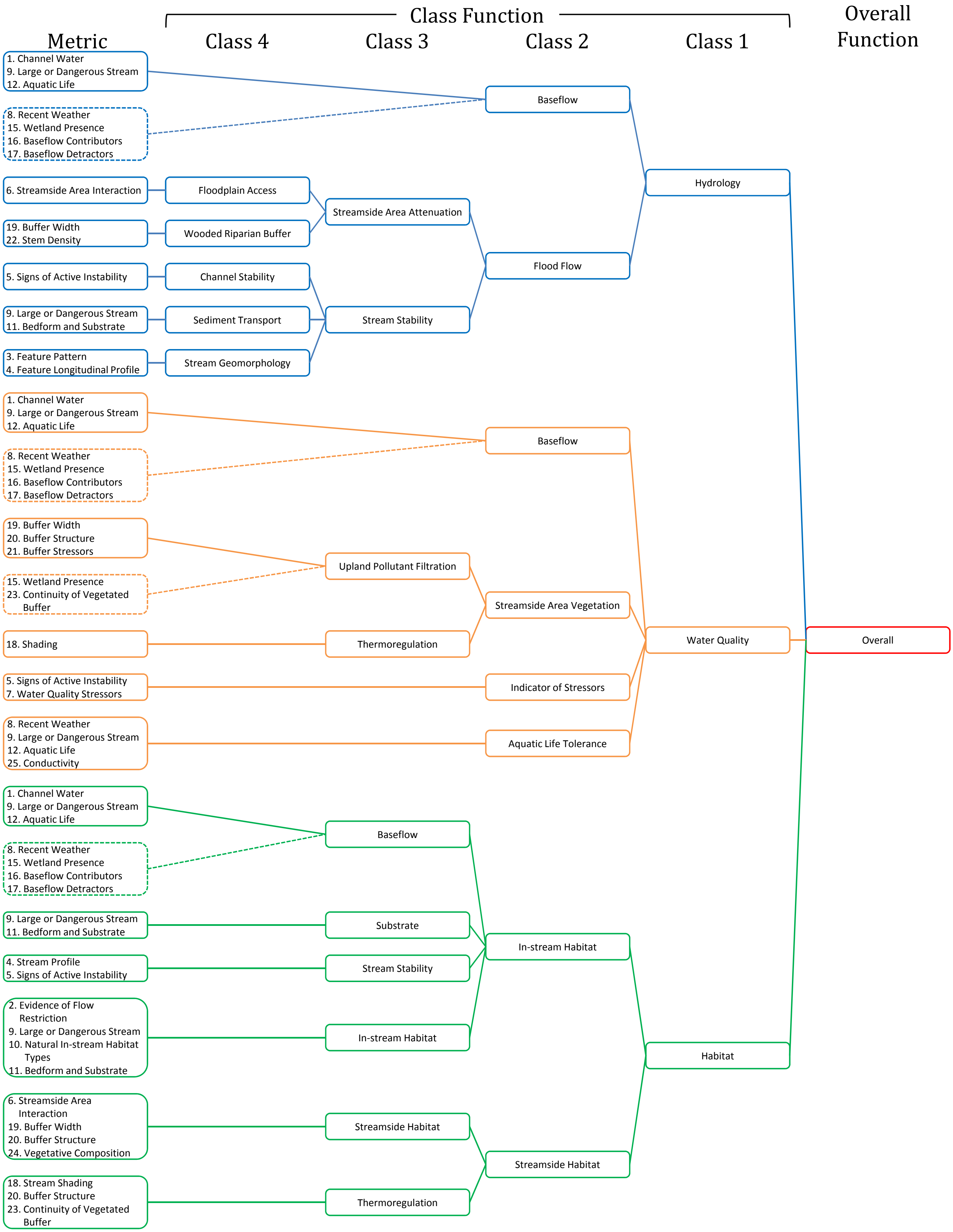
Pa4 (USACE/All Streams) Metric-Function Class Diagram



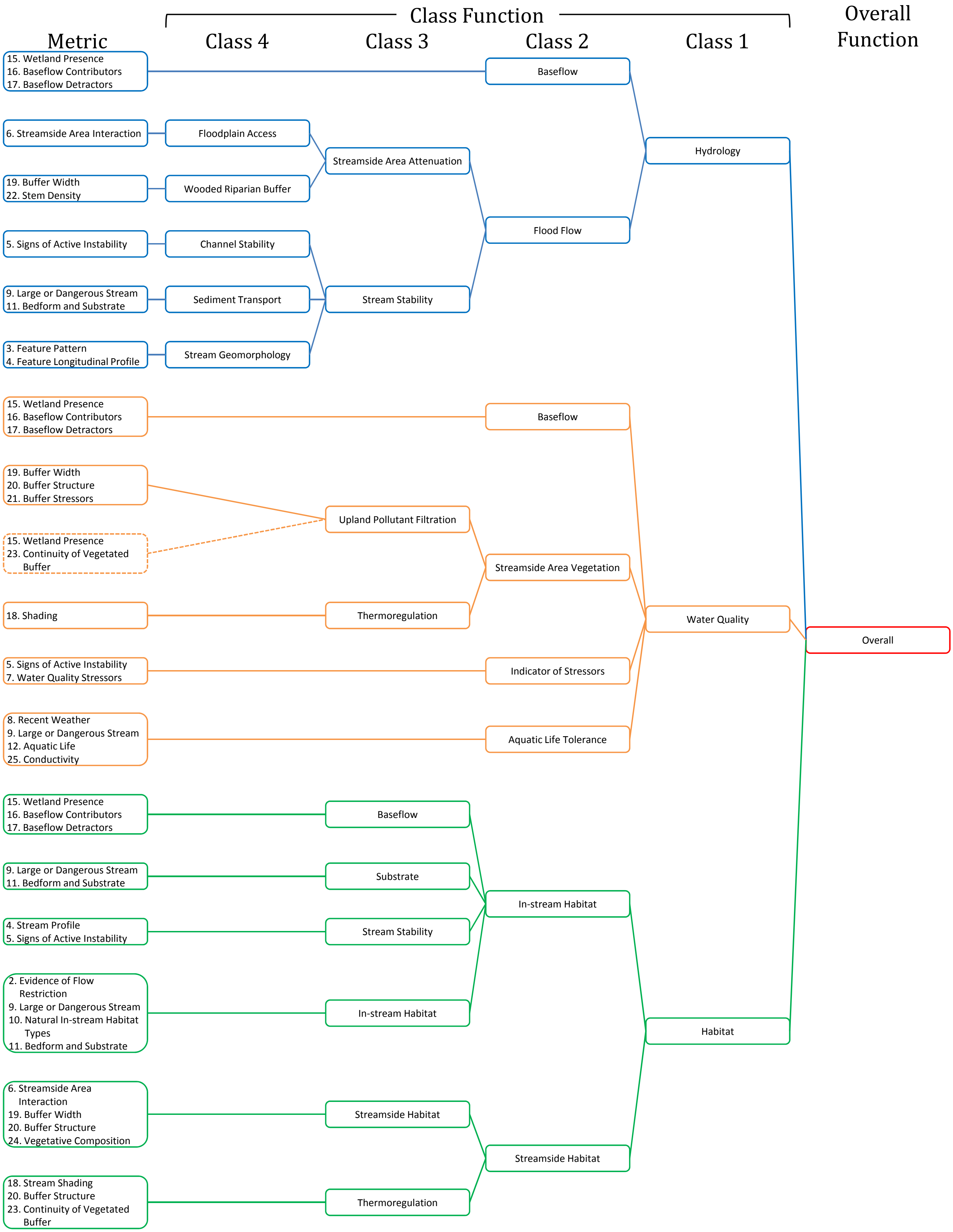
# Pb1 (USACE/All Streams and NCDWQ Intermittent) Metric-Function Class Diagram



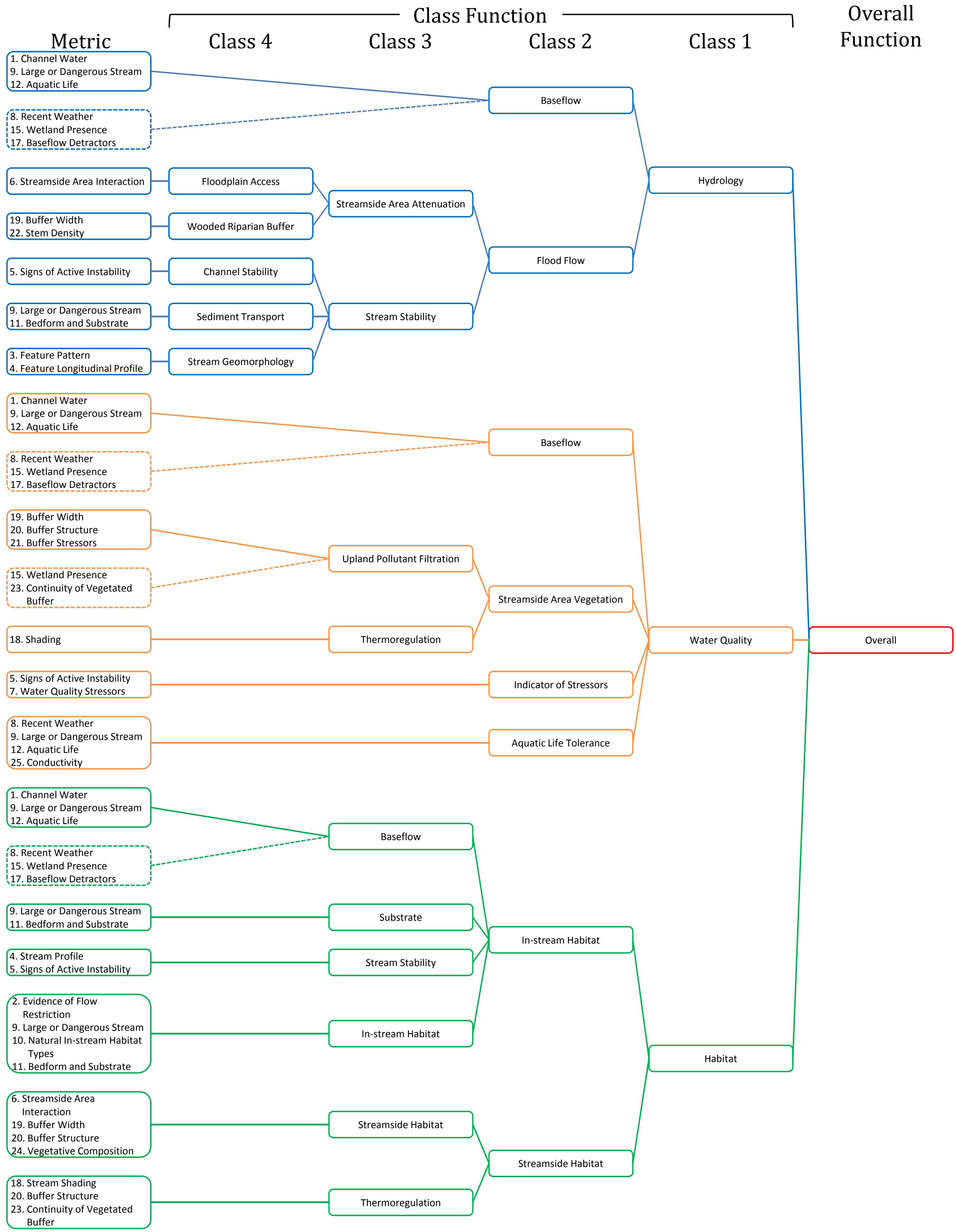
# Pb2 (USACE/All Streams) Metric-Function Class Diagram



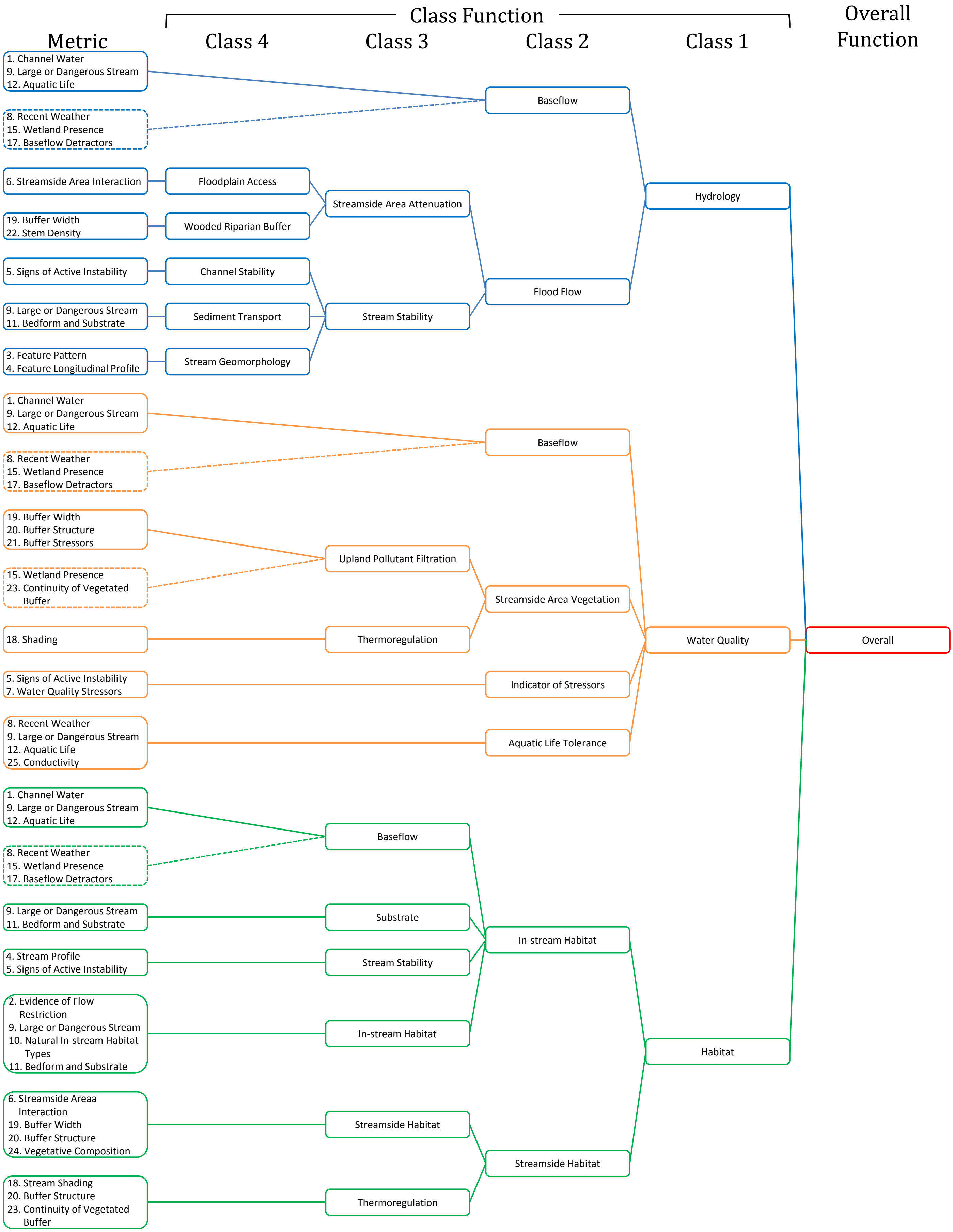
# Pb2 (NCDWQ Intermittent) Metric-Function Class Diagram



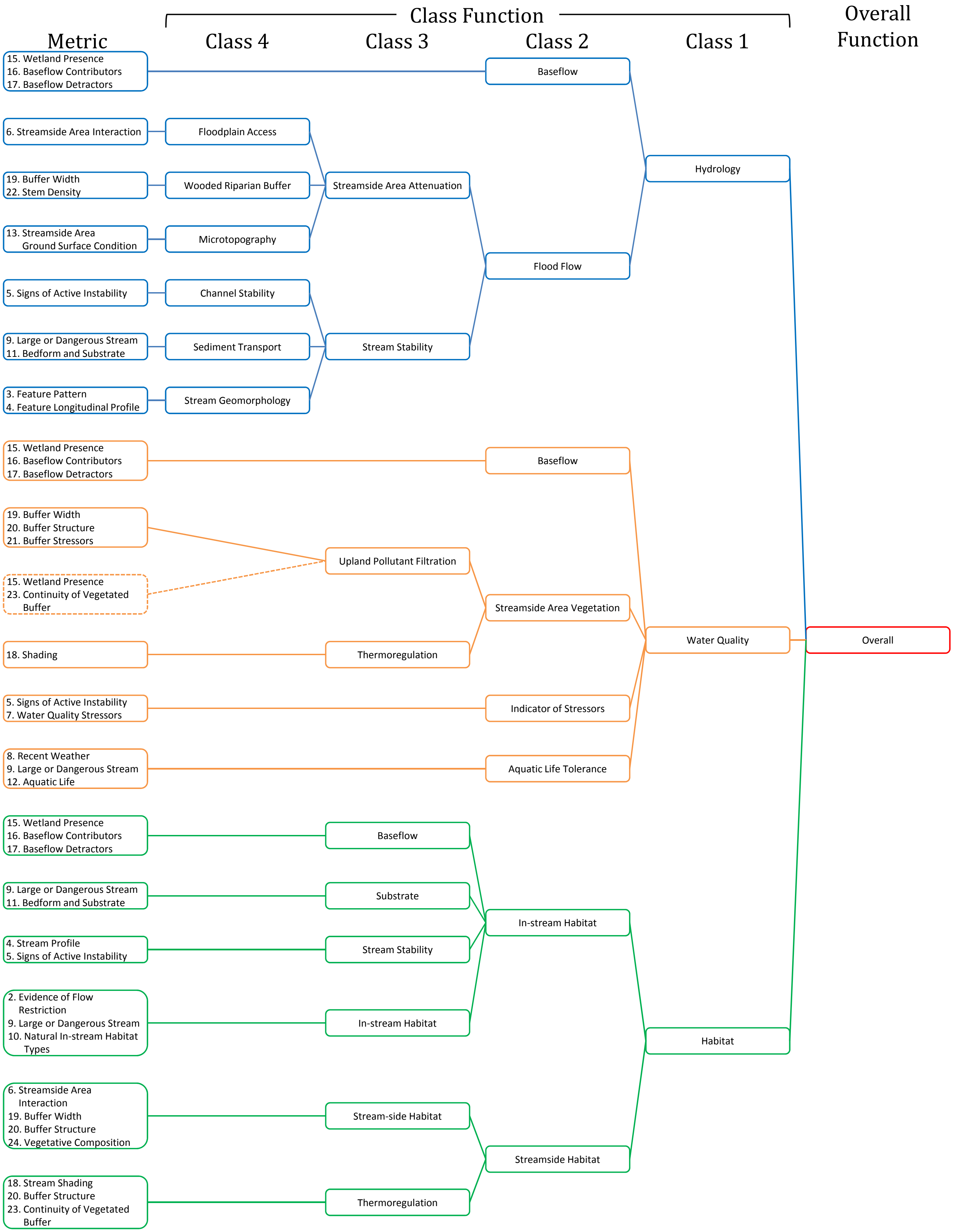
# Pb3 (USACE/All Streams) Metric-Function Class Diagram



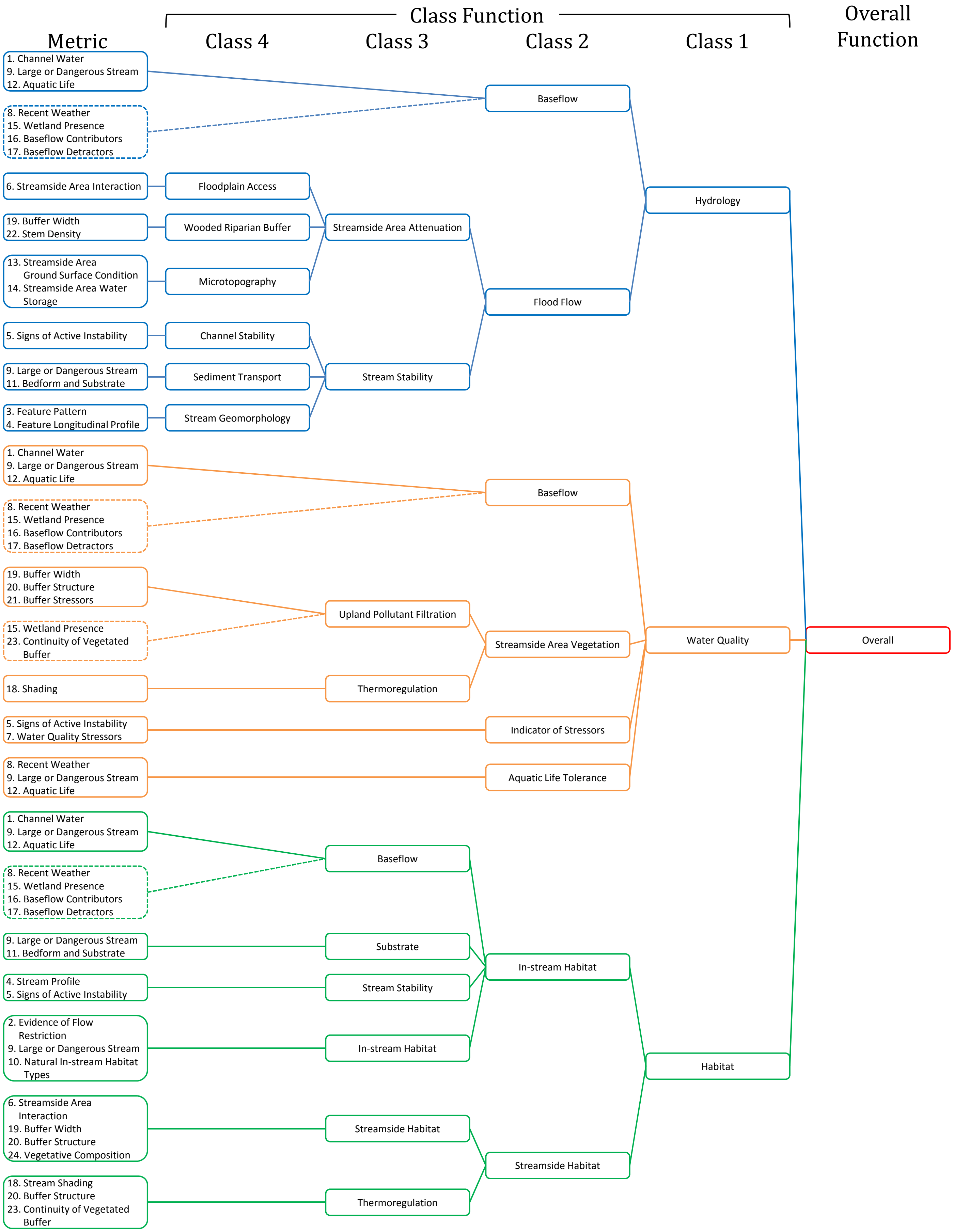
# Pb4 (USACE/All Streams) Metric-Function Class Diagram



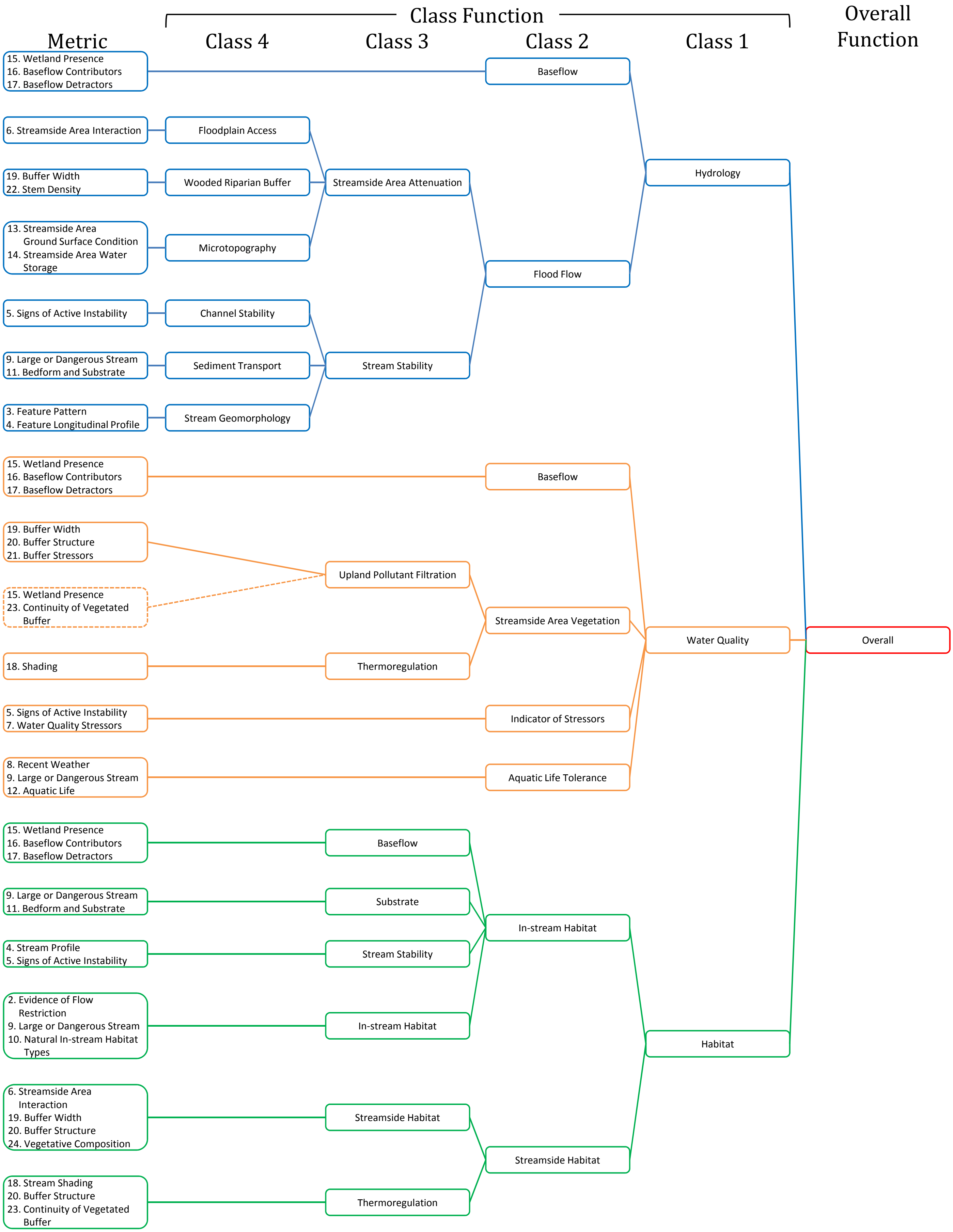
# Ia1 (USACE/All Streams and NCDWQ Intermittent) Metric-Function Class Diagram



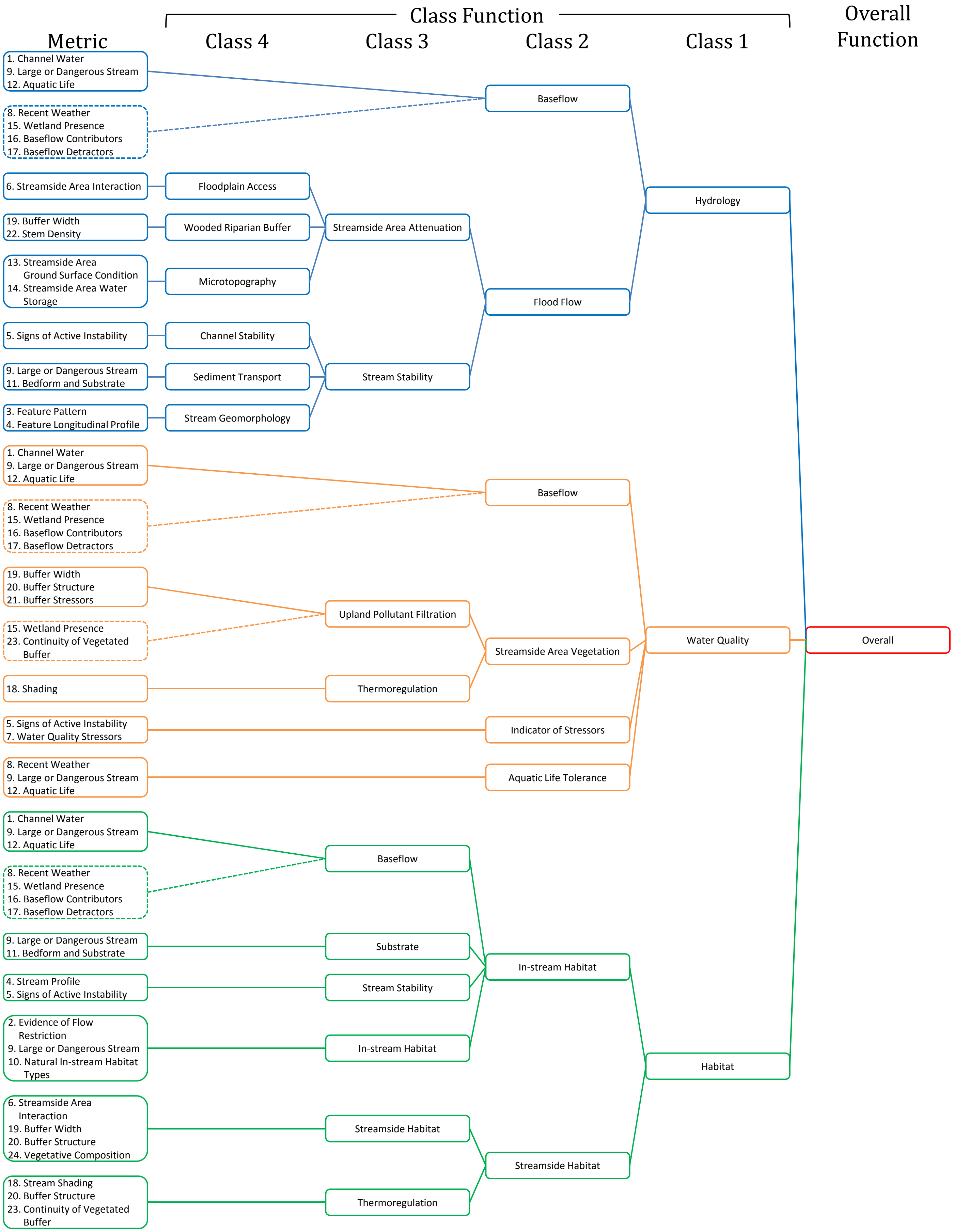
# Ia2 (USACE/All Streams) Metric-Function Class Diagram

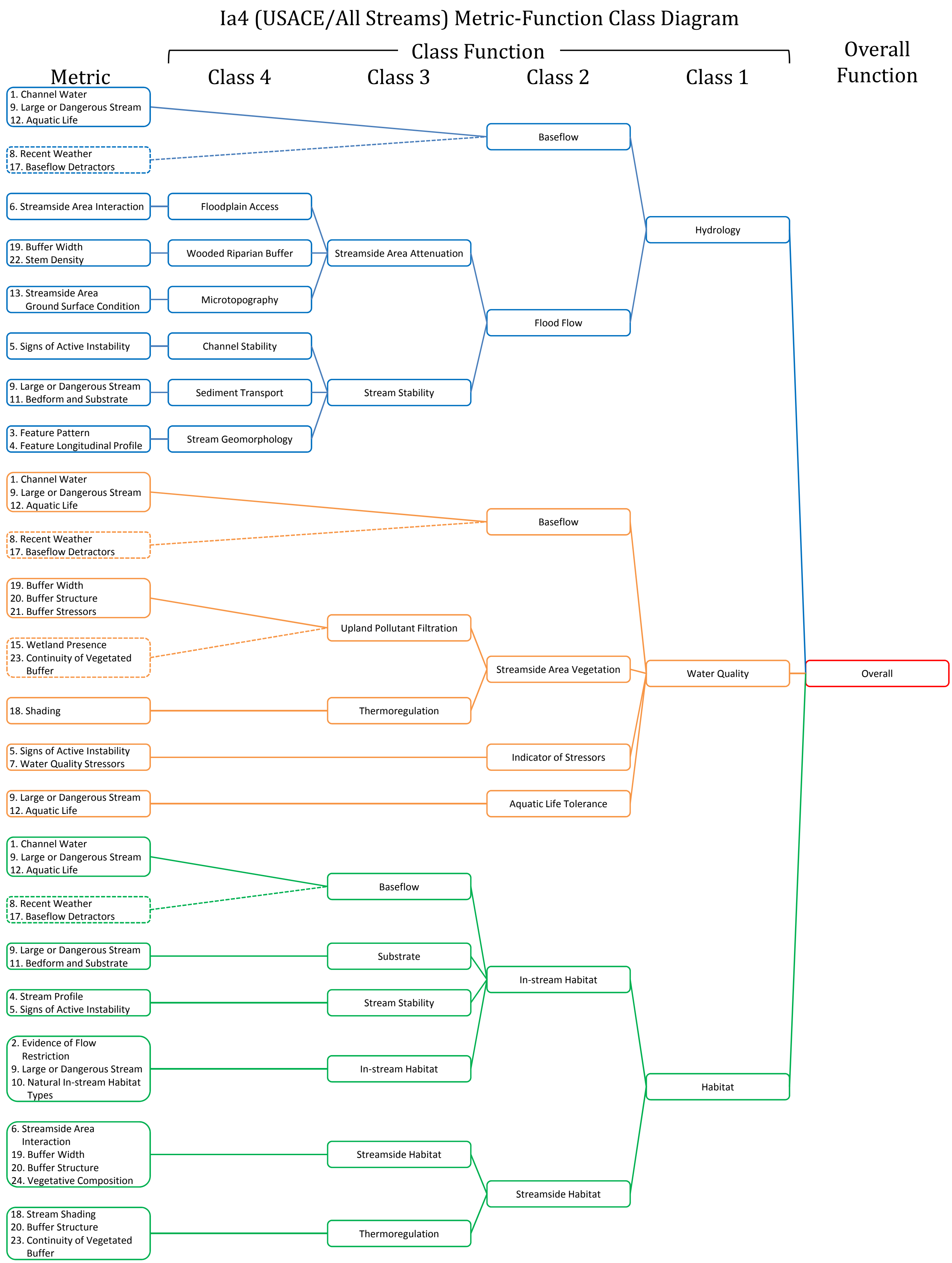


# Ia2 (NCDWQ Intermittent) Metric-Function Class Diagram

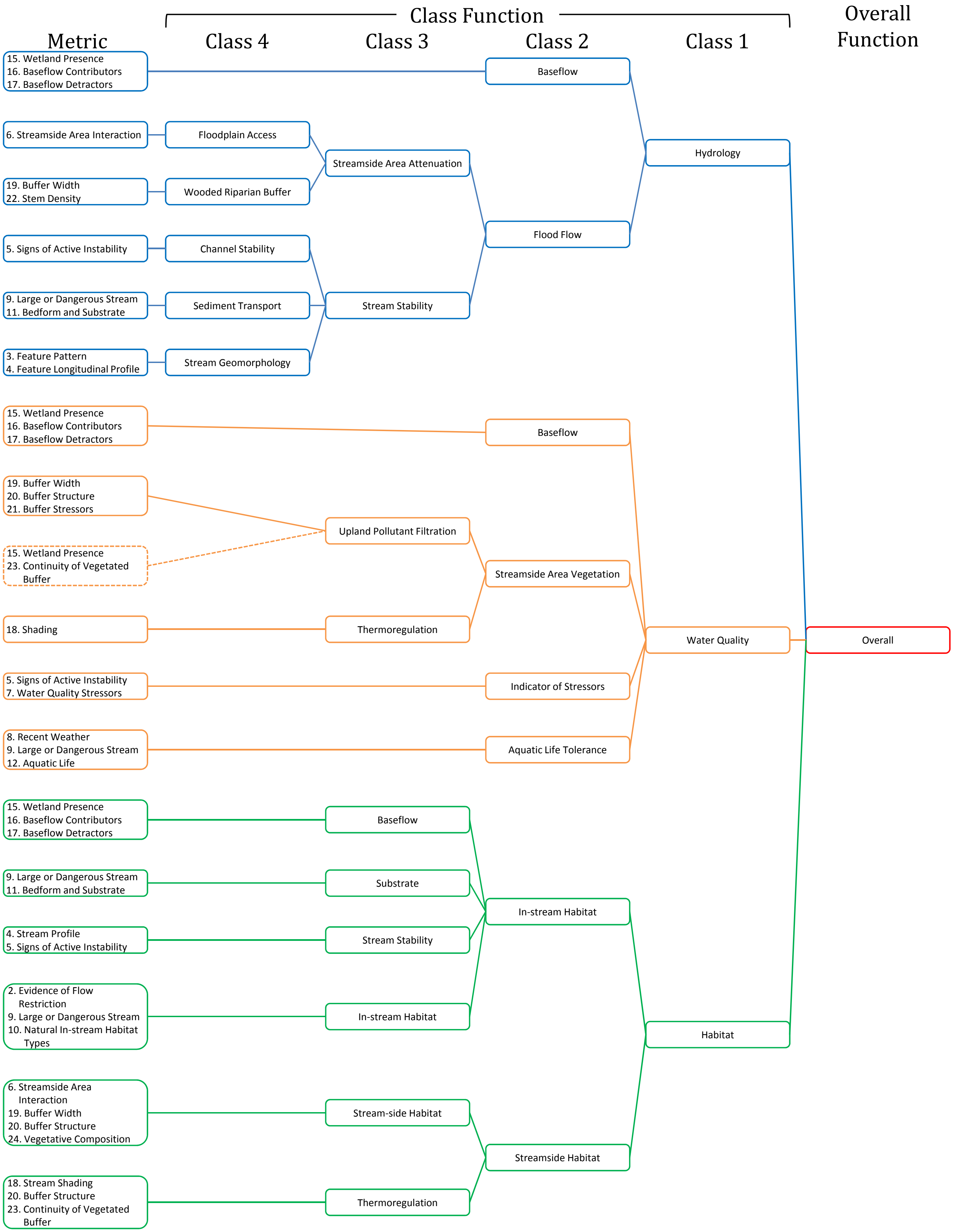


# Ia3 (USACE/All Streams) Metric-Function Class Diagram

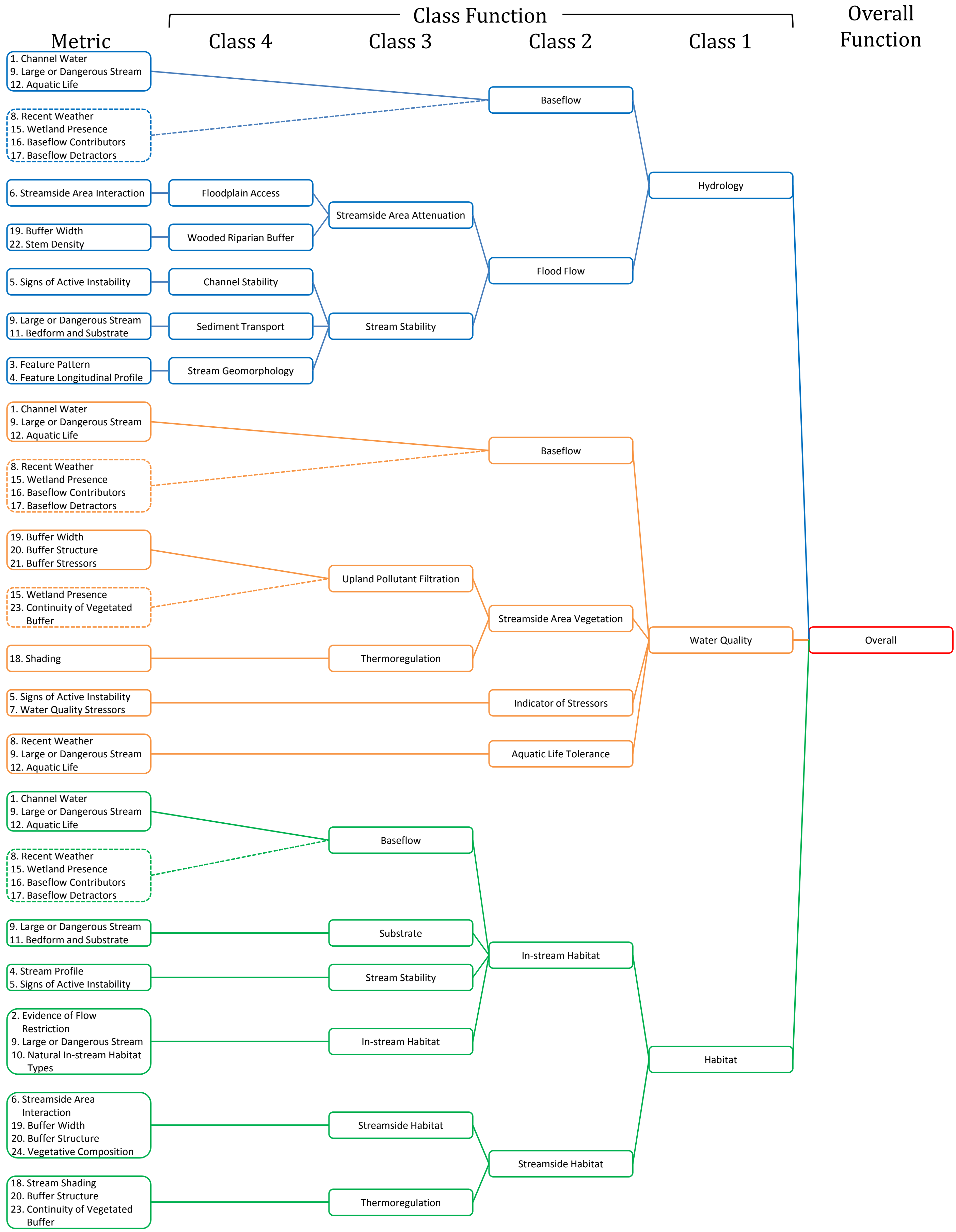


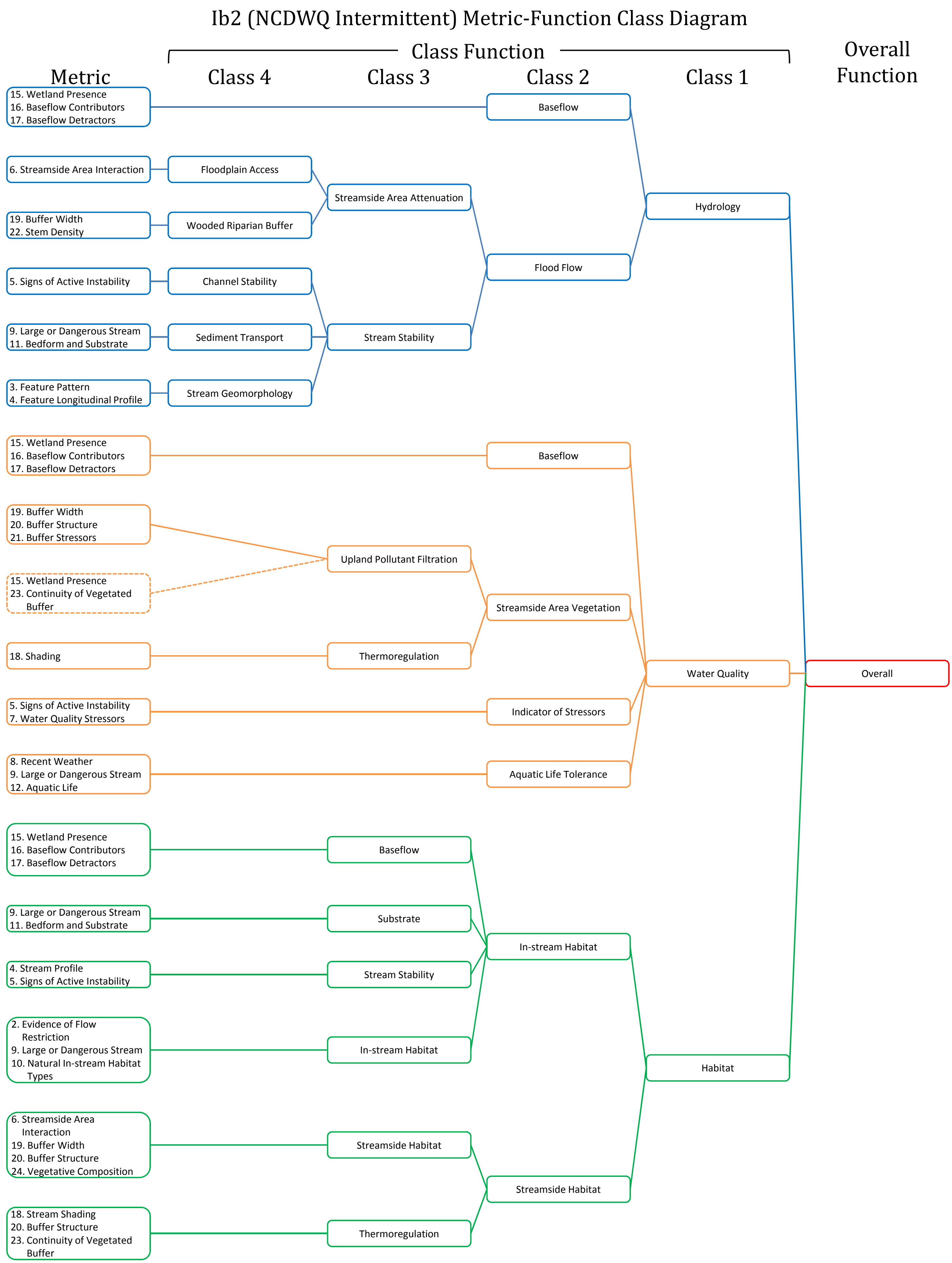

Ia4 (USACE/All Streams) Metric-Function Class Diagram
Class Function
Overall Function
Metric
Class 4
Class 3
Class 2
Class 1
1. Channel Water
9. Large or Dangerous Stream
12. Aquatic Life
8. Recent Weather
17. Baseflow Detractors
Baseflow
6. Streamside Area Interaction
Floodplain Access
19. Buffer Width
22. Stem Density
Wooded Riparian Buffer
Streamside Area Attenuation
13. Streamside Area Ground Surface Condition
Microtopography
Hydrology
Flood Flow
5. Signs of Active Instability
Channel Stability
9. Large or Dangerous Stream
11. Bedform and Substrate
Sediment Transport
Stream Stability
3. Feature Pattern
4. Feature Longitudinal Profile
Stream Geomorphology
1. Channel Water
9. Large or Dangerous Stream
12. Aquatic Life
8. Recent Weather
17. Baseflow Detractors
Baseflow
19. Buffer Width
20. Buffer Structure
21. Buffer Stressors
15. Wetland Presence
23. Continuity of Vegetated Buffer
Upland Pollutant Filtration
Streamside Area Vegetation
Water Quality
Overall
18. Shading
Thermoregulation
5. Signs of Active Instability
7. Water Quality Stressors
Indicator of Stressors
9. Large or Dangerous Stream
12. Aquatic Life
Aquatic Life Tolerance
1. Channel Water
9. Large or Dangerous Stream
12. Aquatic Life
8. Recent Weather
17. Baseflow Detractors
Baseflow
9. Large or Dangerous Stream
11. Bedform and Substrate
Substrate
4. Stream Profile
5. Signs of Active Instability
Stream Stability
In-stream Habitat
2. Evidence of Flow Restriction
9. Large or Dangerous Stream
10. Natural In-stream Habitat Types
In-stream Habitat
Habitat
6. Streamside Area Interaction
19. Buffer Width
20. Buffer Structure
24. Vegetative Composition
Streamside Habitat
Streamside Habitat
18. Stream Shading
20. Buffer Structure
23. Continuity of Vegetated Buffer
Thermoregulation

# Ib1 (USACE/All Streams and NCDWQ Intermittent) Metric-Function Class Diagram

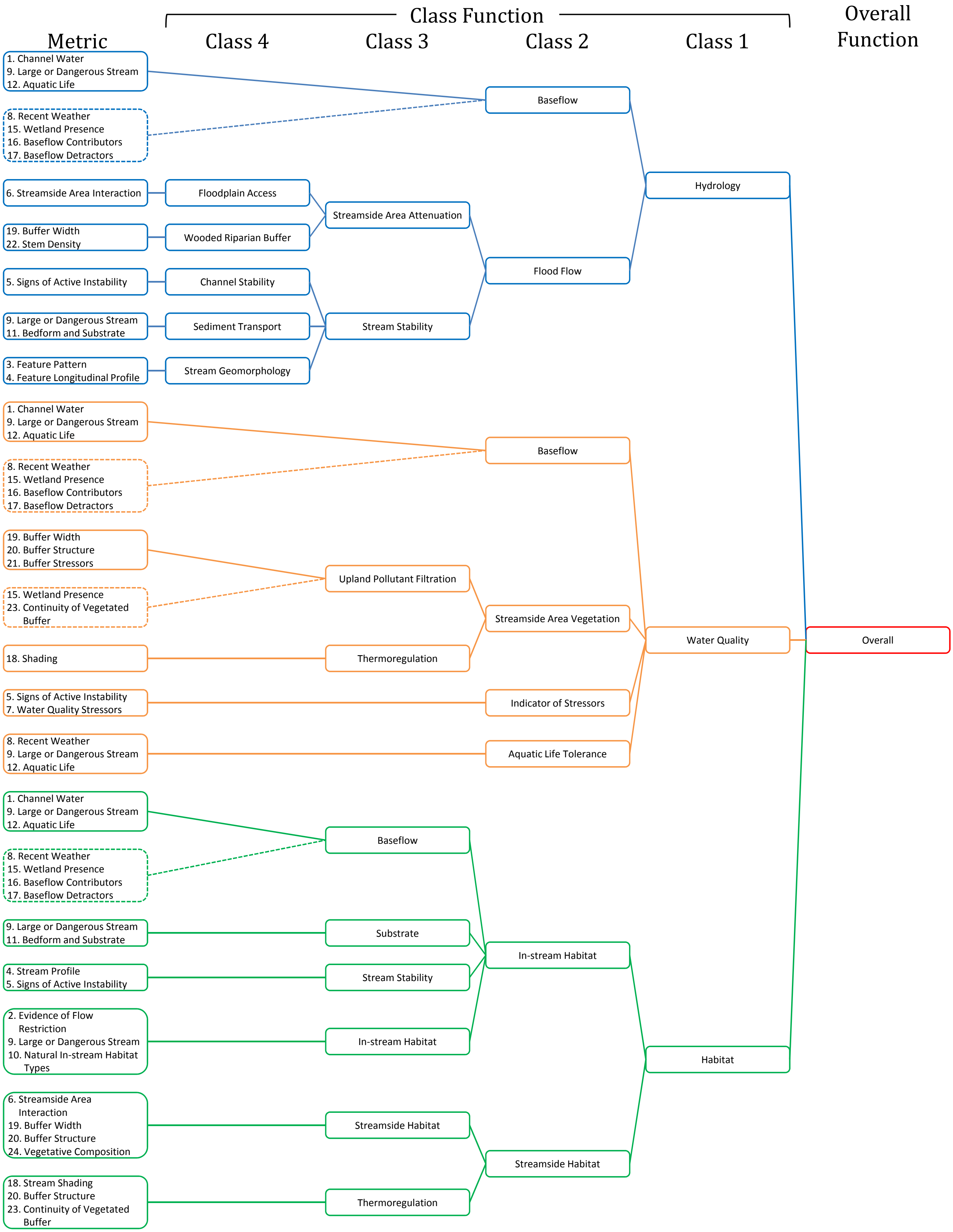


# Ib2 (USACE/All Streams) Metric-Function Class Diagram

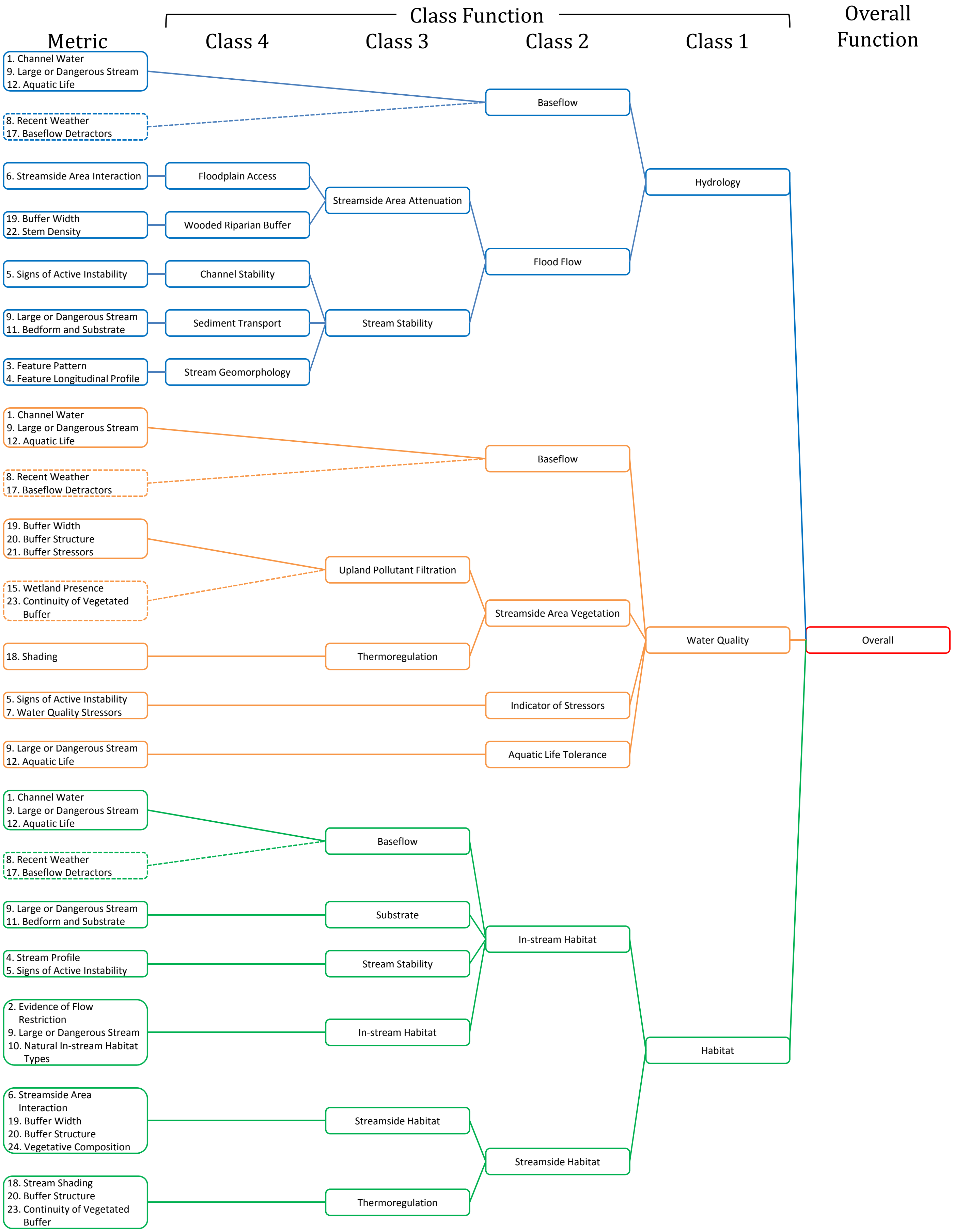



Ib2 (NCDWQ Intermittent) Metric-Function Class Diagram
Class Function
Metric
Class 4
Class 3
Class 2
Class 1
Overall Function
15. Wetland Presence
16. Baseflow Contributors
17. Baseflow Detractors
Baseflow
6. Streamside Area Interaction
Floodplain Access
19. Buffer Width
22. Stem Density
Wooded Riparian Buffer
Streamside Area Attenuation
Hydrology
5. Signs of Active Instability
Channel Stability
Flood Flow
9. Large or Dangerous Stream
11. Bedform and Substrate
Sediment Transport
Stream Stability
3. Feature Pattern
4. Feature Longitudinal Profile
Stream Geomorphology
15. Wetland Presence
16. Baseflow Contributors
17. Baseflow Detractors
Baseflow
19. Buffer Width
20. Buffer Structure
21. Buffer Stressors
Upland Pollutant Filtration
15. Wetland Presence
23. Continuity of Vegetated Buffer
Streamside Area Vegetation
18. Shading
Thermoregulation
Water Quality
Overall
5. Signs of Active Instability
7. Water Quality Stressors
Indicator of Stressors
8. Recent Weather
9. Large or Dangerous Stream
12. Aquatic Life
Aquatic Life Tolerance
15. Wetland Presence
16. Baseflow Contributors
17. Baseflow Detractors
Baseflow
9. Large or Dangerous Stream
11. Bedform and Substrate
Substrate
In-stream Habitat
4. Stream Profile
5. Signs of Active Instability
Stream Stability
2. Evidence of Flow Restriction
9. Large or Dangerous Stream
10. Natural In-stream Habitat Types
In-stream Habitat
Habitat
6. Streamside Area Interaction
19. Buffer Width
20. Buffer Structure
24. Vegetative Composition
Streamside Habitat
Streamside Habitat
18. Stream Shading
20. Buffer Structure
23. Continuity of Vegetated Buffer
Thermoregulation

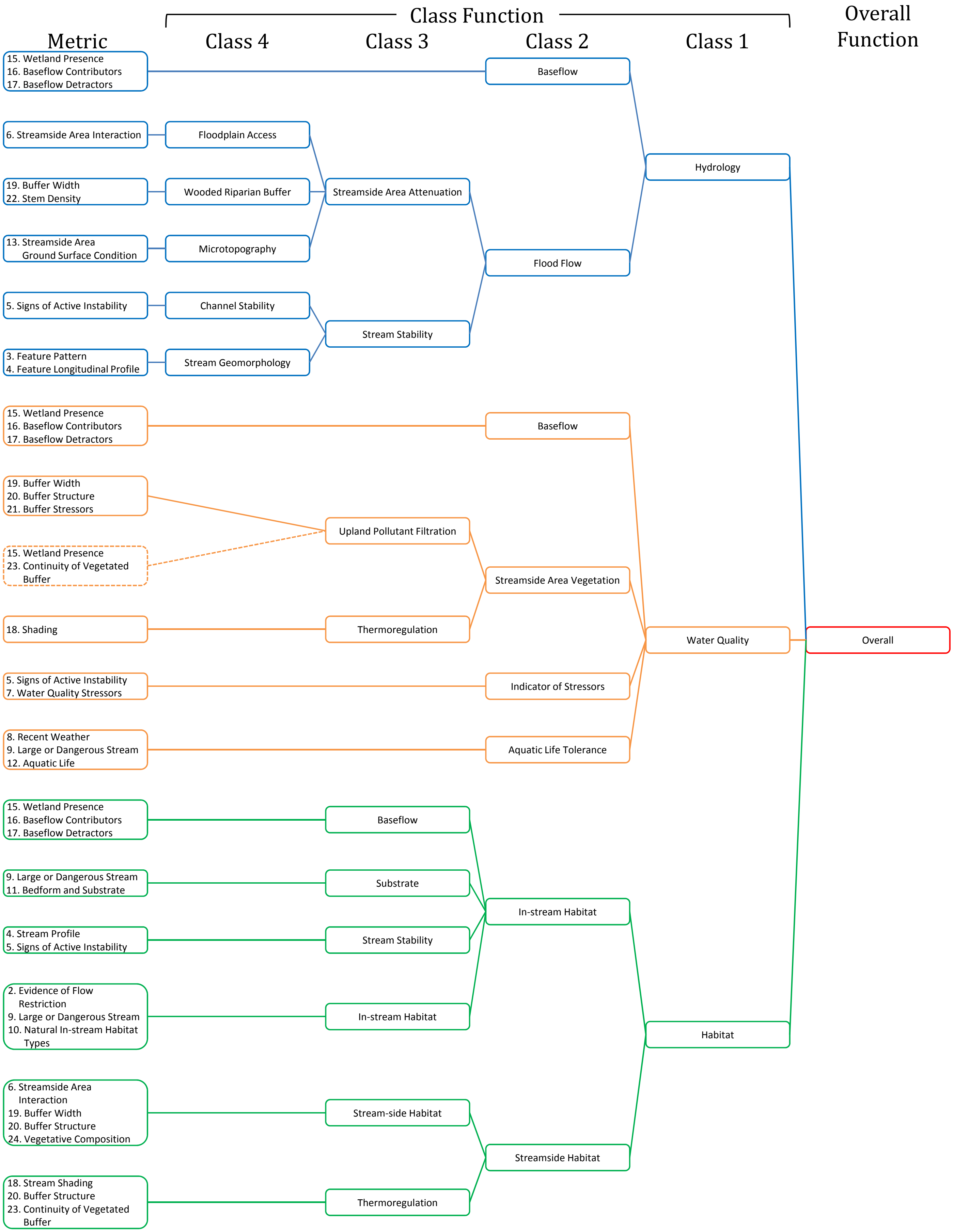
# Ib3 (USACE/All Streams) Metric-Function Class Diagram



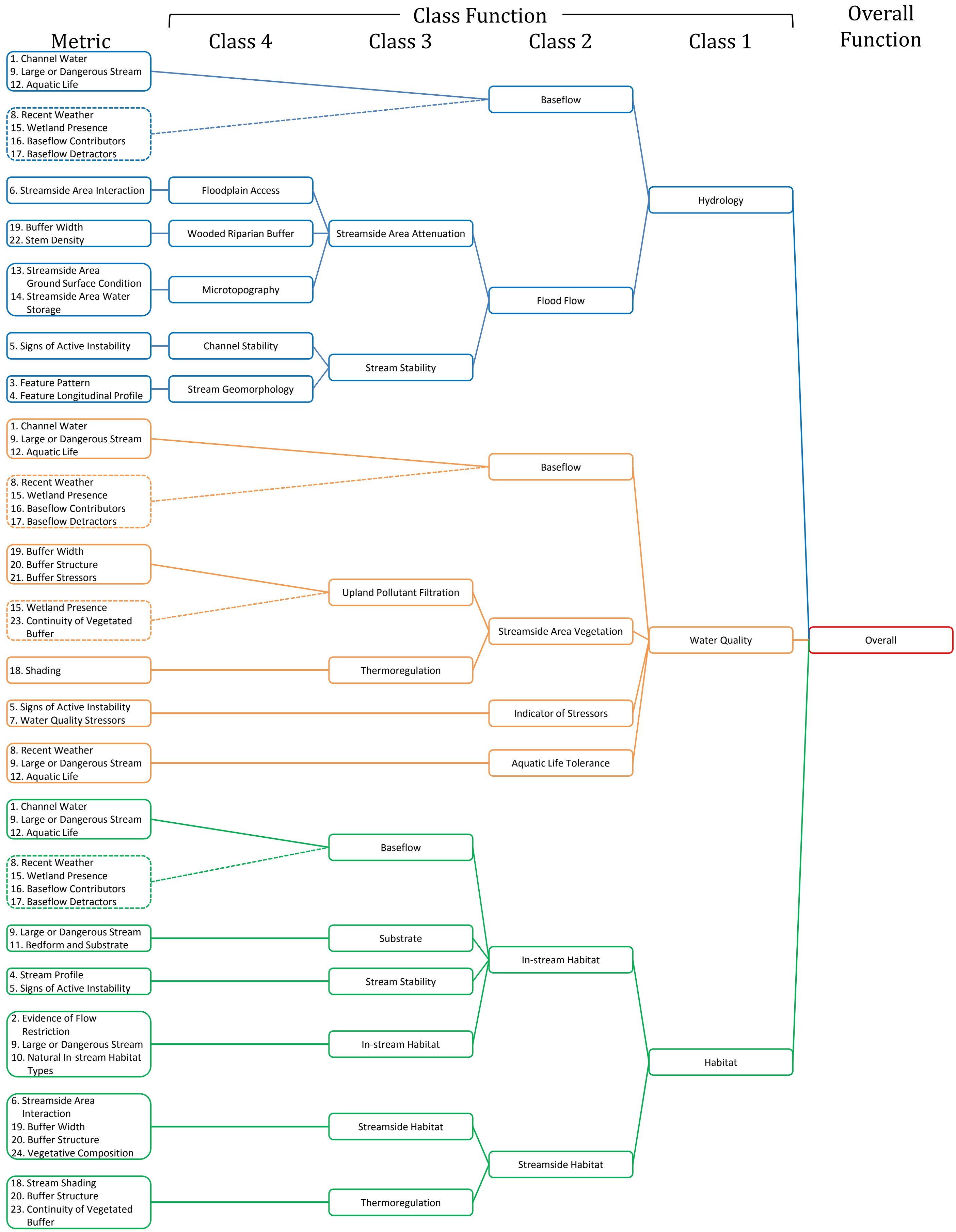
# Ib4 (USACE/All Streams) Metric-Function Class Diagram



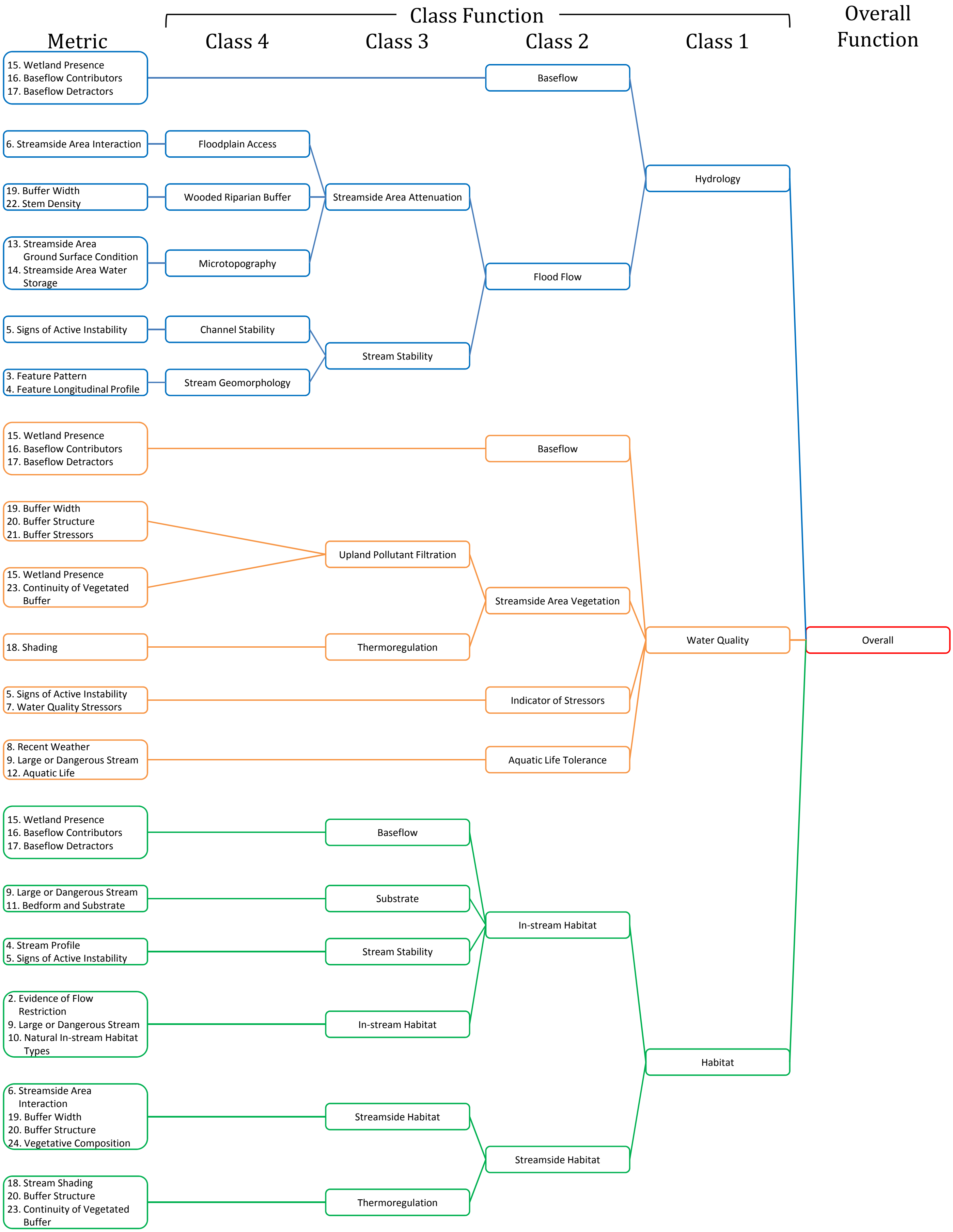
# Oa1 (USACE/All Streams and NCDWQ Intermittent) Metric-Function Class Diagram



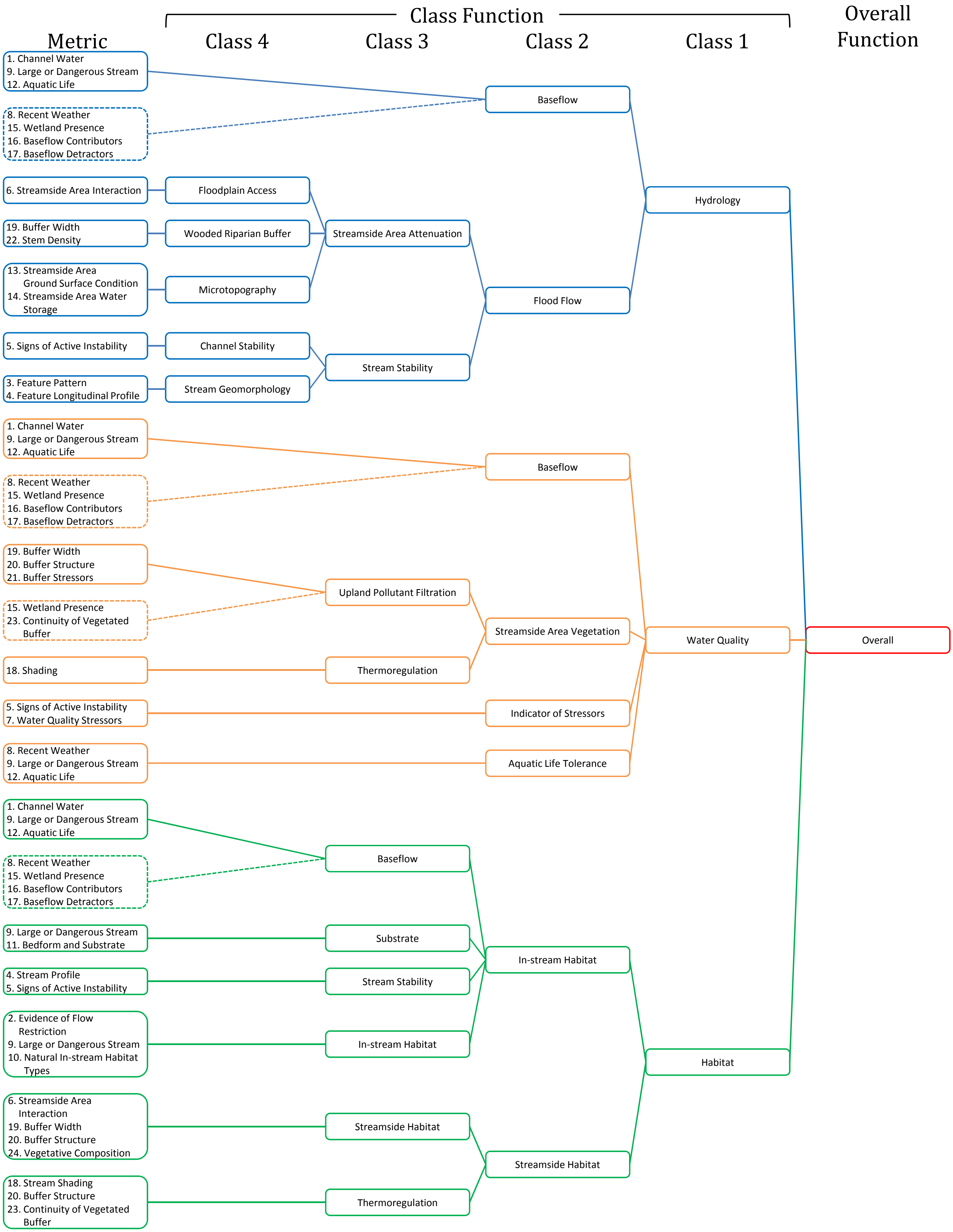
# Oa2 (USACE/All Streams) Metric-Function Class Diagram

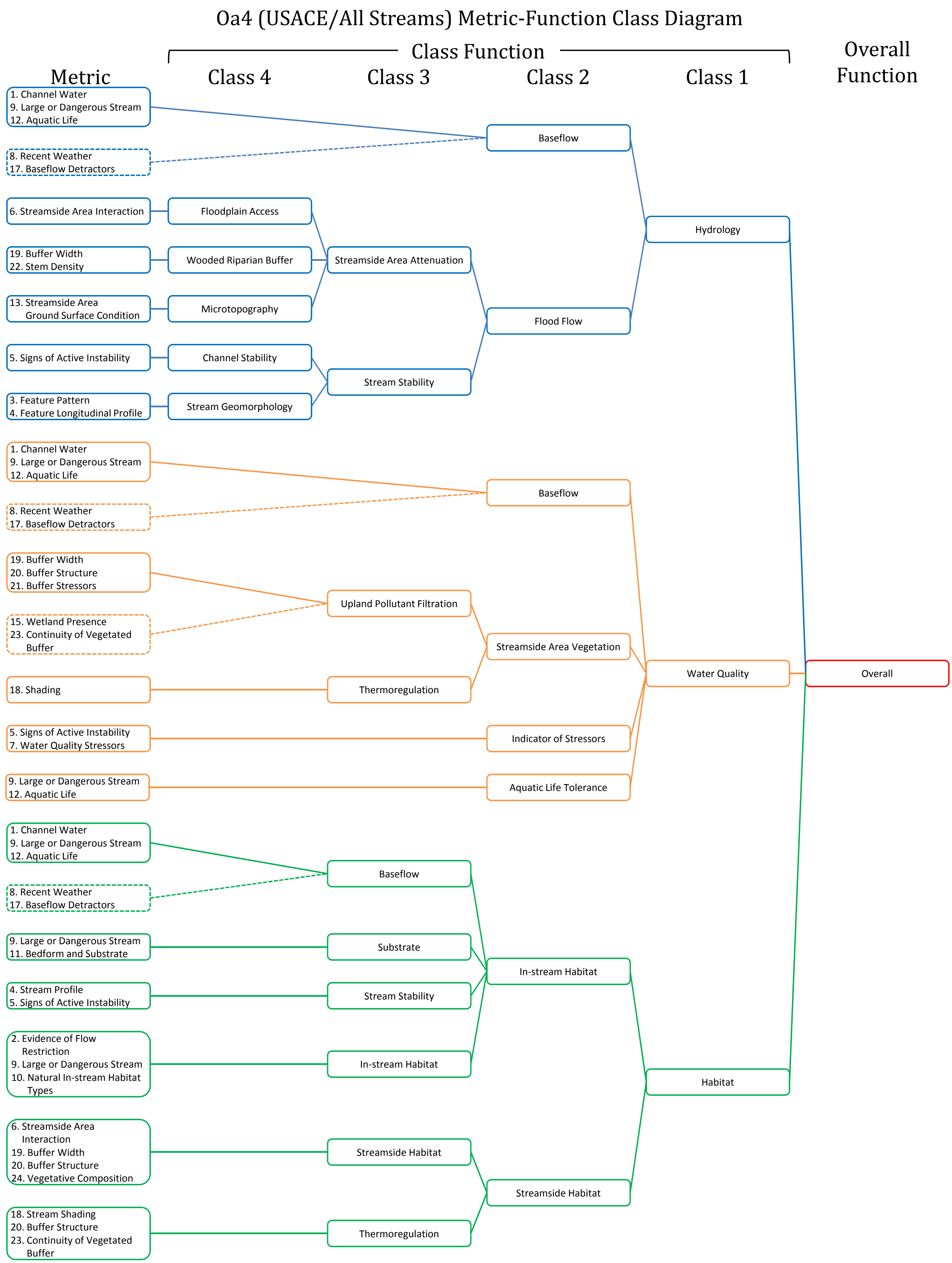


# Oa2 (NCDWQ Intermittent) Metric-Function Class Diagram



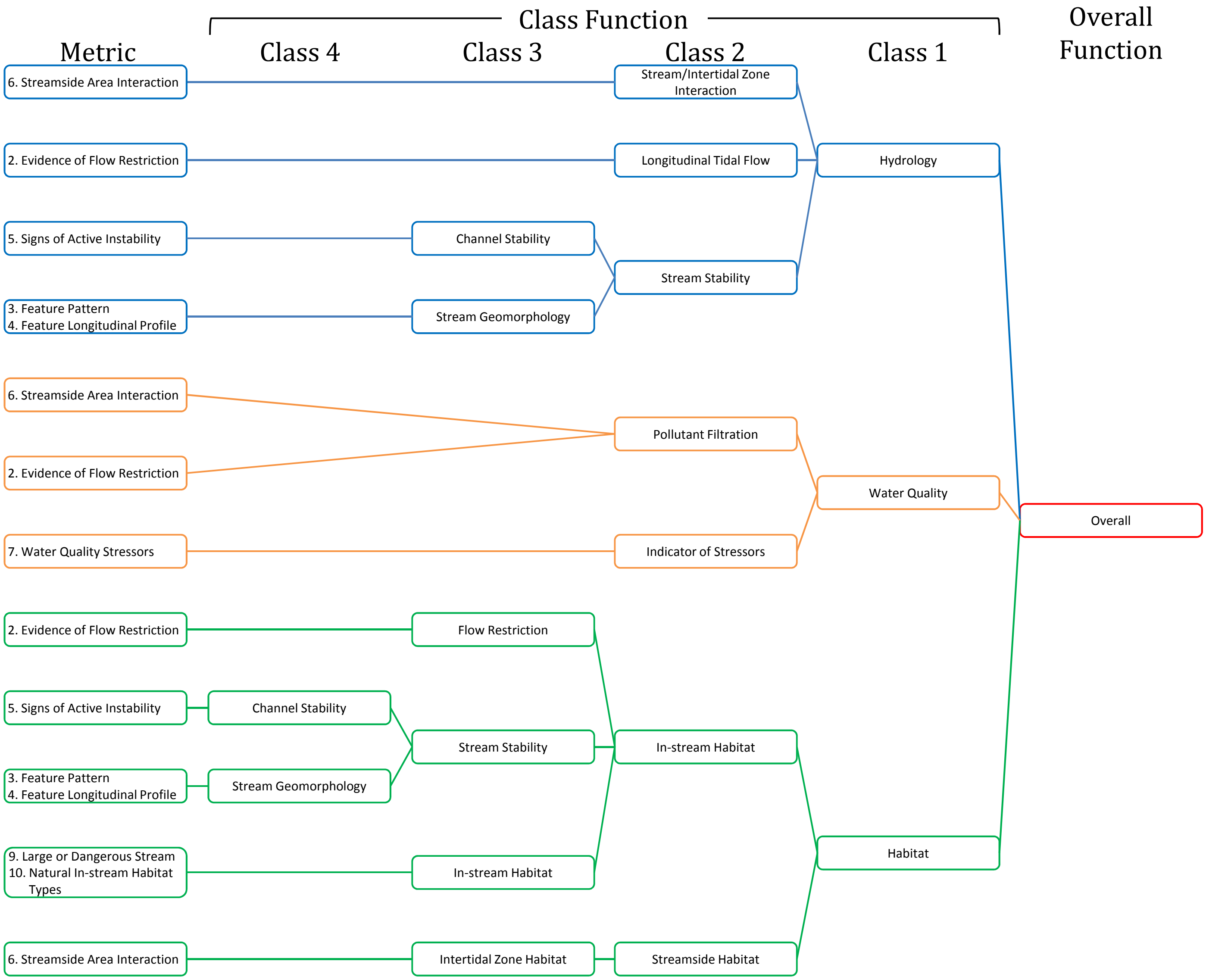
# Oa3 (USACE/All Streams) Metric-Function Class Diagram





Oa4 (USACE/All Streams) Metric-Function Class Diagram
Class Function
Metric
Class 4
Class 3
Class 2
Class 1
Overall Function
1. Channel Water
9. Large or Dangerous Stream
12. Aquatic Life
8. Recent Weather
17. Baseflow Detractors
Baseflow
6. Streamside Area Interaction
Floodplain Access
19. Buffer Width
22. Stem Density
Wooded Riparian Buffer
Streamside Area Attenuation
13. Streamside Area Ground Surface Condition
Microtopography
Hydrology
Flood Flow
5. Signs of Active Instability
Channel Stability
Stream Stability
3. Feature Pattern
4. Feature Longitudinal Profile
Stream Geomorphology
1. Channel Water
9. Large or Dangerous Stream
12. Aquatic Life
Baseflow
8. Recent Weather
17. Baseflow Detractors
19. Buffer Width
20. Buffer Structure
21. Buffer Stressors
Upland Pollutant Filtration
15. Wetland Presence
23. Continuity of Vegetated Buffer
Streamside Area Vegetation
18. Shading
Thermoregulation
Water Quality
Overall
5. Signs of Active Instability
7. Water Quality Stressors
Indicator of Stressors
9. Large or Dangerous Stream
12. Aquatic Life
Aquatic Life Tolerance
1. Channel Water
9. Large or Dangerous Stream
12. Aquatic Life
Baseflow
8. Recent Weather
17. Baseflow Detractors
9. Large or Dangerous Stream
11. Bedform and Substrate
Substrate
In-stream Habitat
4. Stream Profile
5. Signs of Active Instability
Stream Stability
2. Evidence of Flow Restriction
9. Large or Dangerous Stream
10. Natural In-stream Habitat Types
In-stream Habitat
Habitat
6. Streamside Area Interaction
19. Buffer Width
20. Buffer Structure
24. Vegetative Composition
Streamside Habitat
Streamside Habitat
18. Stream Shading
20. Buffer Structure
23. Continuity of Vegetated Buffer
Thermoregulation

# Tidal Marsh Stream Metric-Function Class Diagram



# APPENDIX D

# Index of Stream Category Photos

# Appendix D:  Index of Stream Category Photos

The following table is intended to serve as an index to stream categories shown in photographs in this User Manual.  An explanation of stream category terminology is provided in Section 3.0 of the User Manual (p. 23).

| Stream Category | Photo | Page | Name/Location | County |
|---|---|---|---|---|
| Ma1 | 3-8 | 28 | two unnamed tributaries to Elk Creek | Ashe |
| | 4-19 | 55 | unnamed tributary to Buffalo Creek | Rutherford |
| Ma2 | 4-20 | 55 | unnamed tributary to Wesley Creek | Buncombe |
| | 4-28 | 59 | Little Bugaboo Creek | Wilkes |
| | 4-49 | 67 | unnamed tributary to Second Broad River | McDowell |
| | 4-161 | 134 | unnamed tributary to Squirrel Creek | Avery |
| Ma3 | 3-4 | 27 | Elk Creek | Watauga/Ashe |
| | 4-126 | 110 | Smith Mill Creek | Buncombe |
| | 4-157 | 133 | Elk Creek | Ashe |
| Ma4 | 2-26 | 15 | Little Buck Creek | McDowell |
| | 2-33 | 19 | Little Tennessee River | Macon |
| | 2-36 | 20 | Flat Creek | Buncombe |
| | 4-48 | 66 | Turkey Creek | Transylvania |
| | 4-55 | 70 | Tuckaseegee River confluence | Jackson |
| | 4-139 | 116 | Linville River | Burke |
| | 4-140 | 118 | Hunting Creek | Wilkes |
| Mb1 | 3-8 | 28 | 2 unnamed tributaries to Elk Creek | Ashe |
| | 4-8 | 50 | unnamed tributary to the Davidson River | Transylvania |
| Mb2 | None | | | |
| Mb3 | 3-9 | 29 | Three Tops Creek | Ashe |
| | 4-60 | 73 | Kitchen Branch | Buncombe |
| | 4-81 | 88 | Three Tops Creek | Ashe |
| Mb4 | 3-10 | 29 | Cold Springs Creek | Haywood |
| | 4-84 | 88 | Mill Creek | McDowell |
| | 4-85 | 89 | North Toe River | Mitchell/Yancey |
| | 4-97 | 95 | Toxaway Falls | Transylvania |

| Stream Category | Photo | Page | Name/Location | County |
|---|---|---|---|---|
| Pa1 | 2-1 | 7 | unnamed tributary to Swift Creek | Wake |
| | 2-7 | 8 | unnamed tributary to Jimmy's Creek | Davidson |
| | 2-15 | 12 | unnamed tributary to Newfound Creek | Alamance |
| | 4-7 | 50 | unnamed tributary to Jimmy's Creek | Davidson |
| | 4-33 | 61 | unnamed tributary to Ledge Creek | Granville |
| | 4-39 | 62 | unnamed tributary to Marsh Creek | Wake |
| | 4-93 | 91 | unnamed tributary to Crabtree Creek | Wake |
| | 4-123 | 109 | unnamed tributary to the Haw River | Alamance |
| | 4-150 | 128 | unnamed tributary to Swift Creek | Wake |
| | 4-163 | 135 | unnamed tributary to Crabtree Creek | Wake |
| Pa2 | 2-22 | 13 | unnamed tributary to Grant's Creek | Rowan |
| | 2-37 | 21 | unnamed tributary to Grant's Creek | Rowan |
| | 3-3 | 27 | confluence, 2 unnamed tributaries to Crabtree Cr. | Wake |
| | 4-22 | 58 | unnamed tributary to Lake Rogers | Granville |
| | 4-25 | 59 | Sal's Branch | Wake |
| | 4-29 | 60 | unnamed tributary to Lyle Creek | Caldwell |
| | 4-30 | 60 | unnamed tributary to Cane Creek | Alamance |
| | 4-36 | 61 | Pigeon House Creek | Wake |
| | 4-46 | 66 | unnamed tributary to Marsh Creek | Wake |
| | 4-56 | 70 | Bush Creek | Chatham |
| | 4-86 | 89 | unnamed tributary to Stinking Creek | Chatham |
| | 4-90 | 90 | unnamed tributary to Sycamore Creek | Wake |
| | 4-91 | 90 | Sal's Branch | Wake |
| | 4-92 | 90 | Sal's Branch | Wake |
| | 4-98 | 95 | unnamed tributary to Stinking Creek | Chatham |
| | 4-108 | 97 | unnamed tributary to Marsh Creek | Wake |
| | 4-134 | 115 | unnamed tributary to Grant's Creek | Rowan |
| | 4-153 | 128 | Rocky Creek | Wake |
| | 4-158 | 134 | unnamed tributary to Back Creek | Mecklenburg |
| | 4-162 | 135 | unnamed tributary to Wildcat Branch | Wake |
| | 4-166 | 136 | unnamed tributary to Crabtree Creek | Wake |
| Pa3 | 2-4 | 7 | Church Creek | Rowan |
| | 2-9 | 9 | unnamed tributary to Knapp of Reeds Creek | Granville |
| | 2-13 | 11 | Black Creek | Wake |
| | 2-14 | 11 | Back Creek | Mecklenburg |
| | 2-17 | 12 | Middle Prong Hammer Creek | Montgomery |
| | 2-18 | 12 | South Muddy Creek | McDowell |
| | 2-19 | 13 | unnamed tributary to Little River | Montgomery |
| | 3-11 | 31 | Pigeon House Creek | Wake |
| | 3-12 | 31 | Pigeon House Creek | Wake |
| | 4-6 | 50 | Church Creek | Rowan |

| Stream Category | Photo | Page | Name/Location | County |
|---|---|---|---|---|
| Ia1 | 2-32 | 18 | unnamed tributary to Stonyton Creek | Lenoir |
| | 4-12 | 53 | unnamed tributary to Skewakee Gut | Martin |
| | 4-23 | 58 | unnamed tributary to Skewakee Gut | Martin |
| | 4-110 | 98 | unnamed tributary to Little River | Moore |
| | 4-113 | 100 | Beaverdam Creek | Martin |
| | 4-142 | 118 | unnamed tributary to Turkey Creek | Pender |
| Ia2 | 2-16 | 12 | Belch Branch | Lenoir County |
| | 2-23 | 14 | unnamed tributary to Beaverdam Swamp | Sampson |
| | 3-2 | 27 | unnamed tributary to the Neuse River | Johnston |
| | 4-3 | 38 | unnamed tributary to the Neuse River | Johnston |
| | 4-4 | 48 | unnamed tributary to Carvers Creek | Cumberland |
| | 4-9 | 50 | unnamed tributary to the Neuse River | Wayne |
| | 4-10 | 51 | unnamed tributary to the Neuse River | Craven |
| | 4-11 | 51 | unnamed tributary to Stonyton Creek | Lenoir |
| | 4-13 | 53 | unnamed tributary to Beaverdam Creek | Martin |
| | 4-26 | 59 | Mosley Creek | Lenoir |
| | 4-32 | 70 | unnamed tributary to the Cape Fear River | Cumberland |
| | 4-37 | 62 | Skewakee Gut | Martin |
| | 4-47 | 66 | unnamed tributary to Stonyton Creek | Lenoir |
| | 4-52 | 69 | unnamed tributary to Carvers Creek | Cumberland |
| | 4-96 | 91 | unnamed tributary to Pages Creek | New Hanover |
| | 4-114 | 100 | unnamed tributary to Carvers Creek | Cumberland |
| | 4-118 | 104 | unnamed tributary to the Neuse River | Lenoir |
| | 4-147 | 123 | Raynor Mill Branch | Wayne |
| | 4-149 | 124 | unnamed tributary to Falling Creek | Lenoir |
| | 4-154 | 133 | unnamed tributary to Stonyton Creek | Lenoir |
| | 4-159 | 134 | unnamed tributary to the New River | Onslow |
| | 4-165 | 137 | unnamed tributary to Beaverdam Creek | Martin |
| | 4-168 | 137 | unnamed tributary to Burnt Coat Swamp | Halifax |
| | 4-171 | 139 | unnamed tributary to Bear Swamp | Robeson |
| Ia3 | 2-5 | 8 | unnamed tributary to the Scuppernong River | Tyrrell |
| | 2-21 | 13 | Skewakee Gut | Martin |
| | 4-5 | 48 | Hector Creek | Moore |
| | 4-17 | 55 | unnamed tributary to the Neuse River | Lenoir |
| | 4-43 | 65 | Reedy Creek | Craven |
| | 4-44 | 65 | Fork Swamp | Pitt |
| | 4-94 | 91 | Holly Creek | Edgecombe |
| | 4-111 | 98 | Holly Creek | Edgecombe |
| | 4-132 | 115 | Turkey Creek | Pender |
| | 4-135 | 115 | East Prong of Slocumb Creek | Craven |
| | 4-141 | 118 | Burnt Mill Creek | New Hanover |

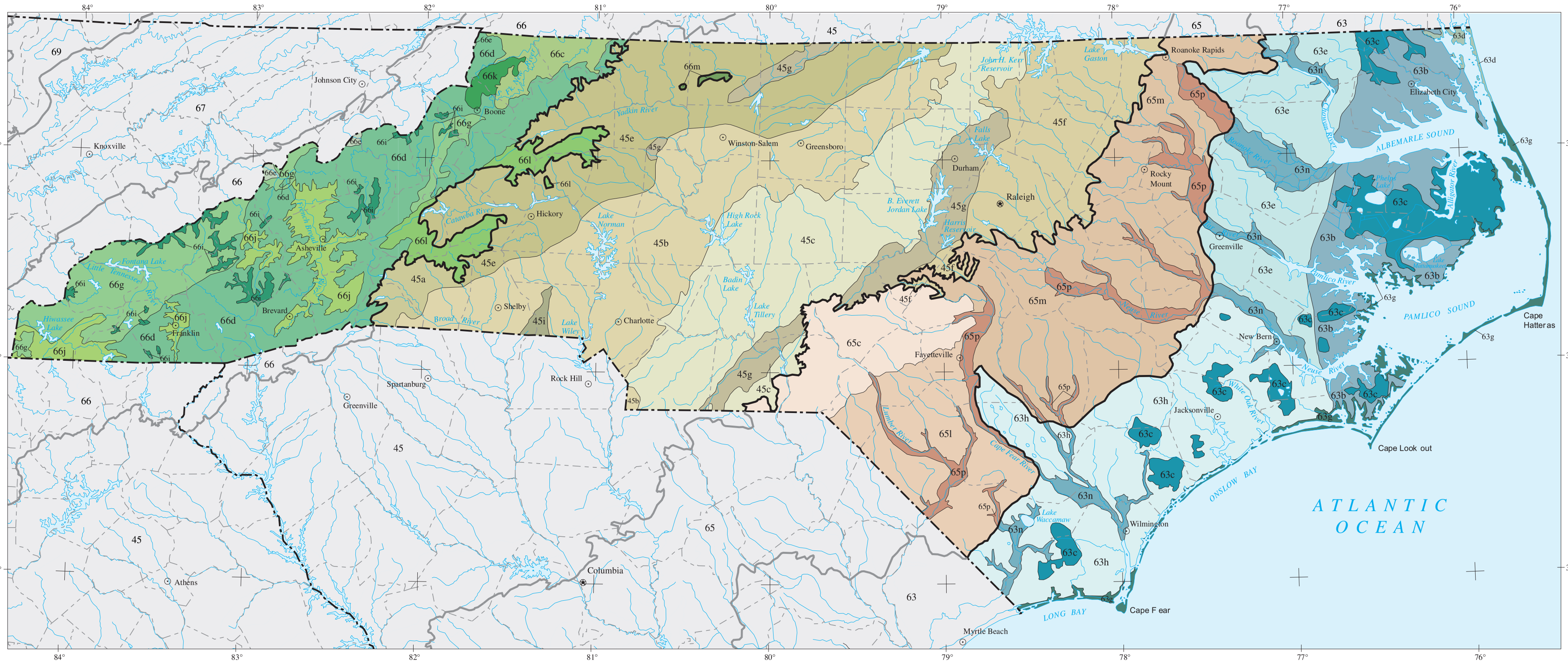
| Stream Category | Photo | Page | Name/Location | County |
|---|---|---|---|---|
| | 4-148 | 124 | unnamed tributary to Briery Run | Lenoir |
| | 4-155 | 133 | unnamed tributary to New River | Onslow |
| | 4-156 | 133 | Holly Creek | Edgecombe |
| | 4-169 | 139 | Atkins Branch | Lenoir |
| Ia4 | 2-11 | 11 | Turkey Creek | New Hanover |
| | 2-35 | 20 | Brock Millpond on Crooked Run | Jones |
| | 4-24 | 58 | Hendricks Creek | Edgecombe |
| | 4-34 | 61 | Hendricks Creek | Edgecombe |
| | 4-38 | 62 | Crooked Run | Jones |
| | 4-45 | 66 | Brice Creek | Craven |
| | 4-62 | 75 | Northeast Cape Fear River | New Hanover/Pender |
| | 4-95 | 91 | Batarora Branch | Brunswick |
| | 4-120 | 106 | Mill Creek | Johnston |
| | 4-136 | 116 | Hendrick's Creek | Edgecombe |
| | 4-170 | 139 | Roanoke River | Martin/Bertie |
| Ib1 | None | | | |
| Ib2 | 3-5 | 28 | unnamed tributary to the Cape Fear River | Cumberland |
| | 3-6 | 28 | unnamed tributary to the Neuse River | Craven |
| Ib3 | None | | | |
| Ib4 | 4-83 | 88 | Carvers Creek | Cumberland |
| Oa1 | 4-18 | 55 | unnamed tributary to Conaby Creek | Washington |
| | 4-106 | 97 | unnamed tributary to Town Creek | Brunswick |
| | 4-107 | 97 | unnamed tributary to the Pasquotank River | Camden |
| | 4-115 | 104 | unnamed tributary to Town Creek | Brunswick |
| | 4-143 | 118 | unnamed tributary to Atlantic Intracoastal Waterway | Brunswick |
| Oa2 | 2-2 | 7 | unnamed tributary to the Pasquotank River | Camden |
| | 2-20 | 13 | unnamed tributary to Lockwood Folly River | Brunswick |
| | 2-39 | 22 | unnamed tributary to Pages Creek | New Hanover |
| | 3-1 | 27 | unnamed tributary to the Perquimans River | Perquimans |
| | 3-14 | 31 | unnamed tributary to the Albemarle Sound | Tyrrell |
| | 4-14 | 53 | unnamed tributary to the Pasquotank River | Camden |
| | 4-144 | 123 | unnamed tributary to the Albemarle Sound | Tyrrell |
| | 4-145 | 123 | unnamed tributary to Bogue Sound | Carteret |

| Stream Category | Photo | Page | Name/Location | County |
|---|---|---|---|---|
| Oa3 | 2-38 | 22 | unnamed tributary to Joyce Creek | Camden |
| | 3-13 | 31 | unnamed tributary to the Pamlico Sound | Hyde |
| | 4-2 | 38 | Honey Island Swamp | Brunswick |
| | 4-68 | 79 | Little Doe Creek | Brunswick |
| | 4-71 | 81 | Honey Island Swamp | Brunswick |
| | 4-117 | 104 | unnamed tributary to Joyce Creek | Camden |
| | 4-121 | 106 | Portohonk Creek | Camden |
| Oa4 | 4-65 | 78 | Perquimans River | Perquimans |
| | 4-72 | 81 | Vann Swamp Canal | Beaufort |
| | 4-172 | 142 | Conaby Creek | Washington |
| | 4-174 | 142 | Vann Swamp Canal | Beaufort |
| Tidal Marsh Stream | 3-15 | 33 | unnamed tributary to Goose Creek | Beaufort |
| | 3-16 | 33 | Whitehurst Creek | Beaufort |
| | 3-17 | 34 | unnamed tributary to Hidden Lake | Tyrrell |
| | 3-18 | 34 | Russell Creek | Carteret |
| | 3-19 | 34 | unnamed tributary to Pages Creek | New Hanover |
| | 3-20 | 34 | unnamed tributary to Pages Creek | New Hanover |
| | 4-16 | 53 | Hewletts Creek | New Hanover |
| | 4-21 | 58 | unnamed tributary to Middle Sound | New Hanover |
| | 4-40 | 62 | unnamed tributary to Myrtle Grove Sound | New Hanover |
| | 4-59 | 73 | Bradley Creek | New Hanover |
| | 4-61 | 75 | Smith Creek | New Hanover |
| | 4-76 | 82 | Harbor Island Marsh | New Hanover |
| | Fig. 10A-10B | 168 | unnamed tributary to Goose Creek | Beaufort |

# APPENDIX E

## Ecoregion Map of North Carolina

# Ecoregions of North Carolina




## 45 Piedmont

- 45a Southern Inner Piedmont
- 45b Southern Outer Piedmont
- 45c Carolina Slate Belt
- 45e Northern Inner Piedmont
- 45f Northern Outer Piedmont
- 45g Triassic Basins
- 45i Kings Mountain

## 63 Middle Atlantic Coastal Plain

- 63b Chesapeake-Pamlico Lowlands and Tidal Marshes
- 63c Nonriverine Swamps and Peatlands
- 63d Virginian Barrier Islands and Coastal Marshes
- 63e Mid-Atlantic Flatwoods
- 63g Carolinian Barrier Islands and Coastal Marshes
- 63h Carolina Flatwoods
- 63n Mid-Atlantic Floodplains and Low Terraces

## 65 Southeastern Plains

- 65c Sand Hills
- 65l Atlantic Southern Loam Plains
- 65m Rolling Coastal Plain
- 65p Southeastern Floodplains and Low Terraces

## 66 Blue Ridge

- 66c New River Plateau
- 66d Southern Crystalline Ridges and Mountains
- 66e Southern Sedimentary Ridges
- 66g Southern Metasedimentary Mountains
- 66i High Mountains
- 66j Broad Basins
- 66k Amphibolite Mountains
- 66l Eastern Blue Ridge Foothills
- 66m Sauratown Mountains

Level III ecoregion — County boundary
Level IV ecoregion — State boundary

SCALE 1:1 500 000

15 10 5 0 30 60 mi
30 20 10 0 60 120 km

Albers Equal Area Projection


PRINCIPAL AUTHORS: Glenn E. Griffith (NRCS), James M. Omernik (USEPA), Jeffrey A. Comstock (Indus Corporation), Michael P. Schafale (NCDENR), W. Henry McNab (USFS), David R. Lenat (NCDENR), and Trish F. MacPherson (NCDENR).

COLLABORATORS AND CONTRIBUTORS: James E. Harrison (USEPA), David L. Penrose (NCDENR), Roy L.Vick, Jr. (NRCS), Gerard McMahon (USGS), Robert Peet (UNC), Chip Smith (NRCS) and Tom Loveland (USGS).



CITING THIS MAP: Griffith, G.E., Omernik, J.M., Comstock, J.A., Schafale, M.P., McNab, W.H., Lenat, D.R., and MacPherson, T.F., 2002, Ecoregions of North Carolina, U.S. Environmental Protection Agency, Corvallis, OR, (map scale 1:1,500,000).


Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. Ecoregions are directly applicable to many state agency activities, including the selection of regional stream reference sites, the development of biological criteria and water quality standards, and the establishment of management goals for nonpoint-source pollution. They are also relevant to integrated ecosystem management, an ultimate goal of many federal and state resource management agencies.

The approach used to compile this map of North Carolina is based on the premise that ecological regions are hierarchical and can be identified through the analysis of the spatial patterns and the composition of biotic and abiotic phenomena that affect or reflect differences in ecosystem quality and integrity (Wiken 1986; Omernik 1987, 1995). These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another regardless of the hierarchical level. A Roman numeral hierarchical scheme has been adopted for different levels of ecological regions. Level I and Level II divide the North American continent into 15 and 52 regions, respectively (Commission for Environmental Cooperation Working Group 1997). At Level III, the continental United States contains 104 regions (United States Environmental Protection Agency [U.S. EPA] 2000). Level IV is a further subdivision of the Level III ecoregions. Explanations of the methods used to define the U.S. EPA's ecoregions are given in Omernik (1995), Omernik and others (2000), Griffith and others (1994, 1997), and Gallant and others (1989).

The Level III and IV ecoregions were compiled at a scale of 1:250,000 and depict revisions and subdivisions of earlier level III ecoregions that were originally compiled at a smaller scale (U.S. EPA 2000; Omernik 1987). Compilation of this map is part of a collaborative project primarily between the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), the U.S. EPA National Health and Environmental Effects Research Laboratory (NHEERL), U.S. EPA Region IV, and the North Carolina Department of Environment and Natural Resources. This project is also associated with an interagency effort to develop a common framework of ecological regions (McMahon and others 2001). Regional collaborative projects, such as this one in North Carolina where some agreement can be reached among multiple resource management agencies, are a step in the direction of attaining commonality and consistency in ecoregion frameworks for the entire nation.


Comments regarding the Level III and IV Ecoregions of North Carolina map should be addressed to Glenn Griffith, USDA-NRCS, 200 SW 35th Street, Corvallis, OR 97333, (541) 754-4465, FAX: (541) 754-4716, email: griffith.glenn@epa.gov, or to James Omernik, USGS, 200 SW 35th Street, Corvallis, OR 97333, (541) 754-4458, email: omernik.james@epa.gov.


Literature Cited: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# APPENDIX F

## Topographic Mapping and Watershed Delineation

United States Department of Agriculture
NRCS Natural Resources Conservation Service
Federal Building, 2 Madbury Road, Durham, NH 03824-2043 (603) 868-7581 Fax: (603) 868-5301 www.nh.nrcs.usda.gov

# How to Read a Topographic Map and Delineate a Watershed

This fact sheet is an excerpt from Appendix E of the *Method for the Comparative Evaluation of Nontidal Wetlands in New Hampshire*, 1991. Alan Ammann, PhD and Amanda Lindley Stone. This document and method is commonly called "The New Hampshire Method."

## *Interpreting Topographic Maps*

In order to successfully delineate a watershed boundary, the evaluator will need to visualize the landscape as represented by a topographic map. This is not difficult once the following basic concepts of the topographic maps are understood.

Each contour line on a topographic map represents a ground elevation or vertical distance above a reference point such as sea level. A contour line is level with respect to the earth's surface just like the top of a building foundation. All points along any one contour line are at the same elevation.

The difference in elevation between two adjacent contours is called the contour interval. This is typically given in the map legend. It represents the vertical distance you would need to climb or descend from one contour elevation to the next.

The horizontal distance between contours, on the other hand, is determined by the steepness of the landscape and can vary greatly on a given map. On relatively flat ground, two 20 foot contours can be far apart horizontally.

On a steep cliff face two 20 foot contours might be directly above and below each other. In each case the vertical distance between the contour lines would still be twenty feet.

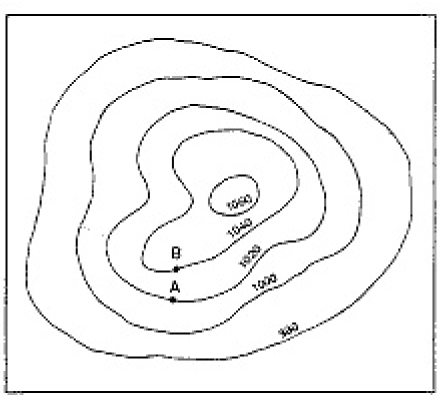



Figure E-1: Isolated Hill

One of the easiest landscapes to visualize on a topographic map is an isolated hill. If this hill is more or less circular the map will show it as a series of more or less concentric circles (Figure E-1). Imagine that a surveyor actually marks these contour lines onto the ground. If two people start walking in opposite directions on the same contour line, beginning at point A, they will eventually meet face to face.

If these same two people start out in opposite directions on different contours, beginning at points A and B respectively, they will pass each other somewhere on the hill and their vertical distance apart would remain 20 feet. Their horizontal distance apart could be great or small depending on the steepness of the hillside where they pass.

A rather more complicated situation is one where two hills are connected by a saddle (Figure E-2). Here each hill is circled by contours but at some point toward the base of the hills, contours begin to circle both hills.

How do contours relate to water flow? A general rule of thumb is that water flow is perpendicular to contour lines. In the case of the isolated hill, water flows down on all sides of the hill. Water flows from the top of the saddle or ridge, down each side in the same way water flows down each side of a garden wall (See arrow on Figure E-2).

As the water continues downhill it flows into progressively larger watercourses and ultimately into the ocean. Any point on a watercourse can be used to define a watershed. That is, the entire drainage area of a major river like the Merrimack can be considered a watershed, but the drainage areas of each of its tributaries are also watersheds.

Each tributary in turn has tributaries, and each one of these tributaries has a watershed. This process of subdivision can continue until very small, local watersheds are defined which might only drain a few acres, and might not contain a defined watercourse.

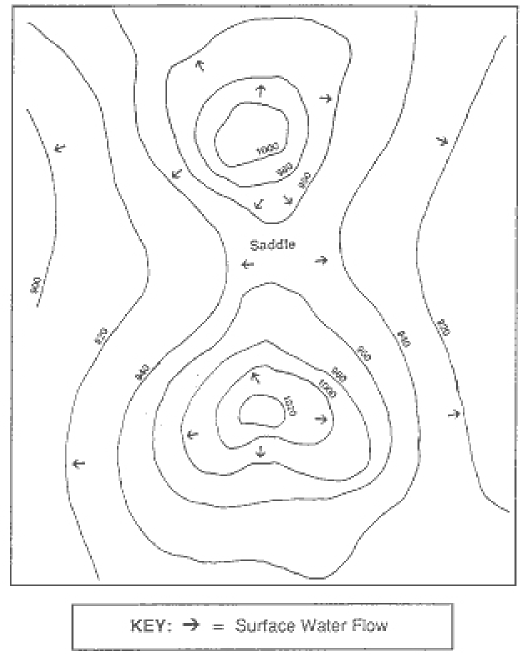



Figure E-2: Saddle

Figure E-3 shows an idealized watershed of a small stream. Water always flows downhill perpendicular to the contour lines. As one proceeds upstream, successively higher and higher contour lines first parallel then cross the stream. This is because the floor of a river valley rises as you go upstream. Likewise the valley slopes upward on each side of the stream. A general rule of thumb is that topographic lines always point upstream. With that in mind, it is not difficult to make out drainage patterns and the direction of flow on the landscape even when there is no stream depicted on the map. In Figure E-3, for example, the direction of streamflow is from point A to point B.

Ultimately, you must reach the highest point upstream. This is the head of the watershed, beyond which the land slopes away into another watershed. At each point on the stream the land slopes up on each side to some high point then down into another watershed. If you were to join all of these high points around the stream you would have the watershed boundary. (High points are generally hill tops, ridge lines, or saddles).

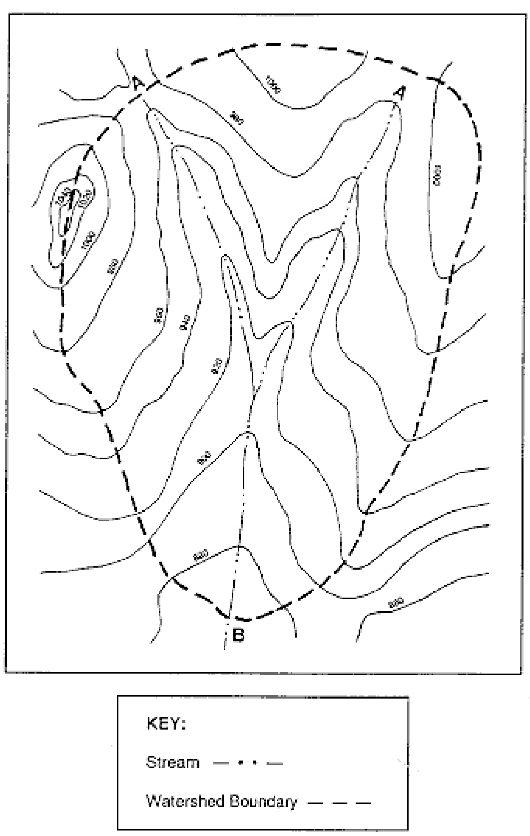



Figure E-3: Idealized Watershed Boundary

## *Delineating a Watershed*

The following procedure and example will help you locate and connect all of the high points around a watershed on a topographic map shown in Figure F-4 below. Visualizing the landscape represented by the topographic map will make the process much easier than simply trying to follow a method by rote.

1. Draw a circle at the outlet or downstream point of the wetland in question (the wetland is the hatched area shown in Figure E-4 to the right)
2. Put small "X's" at the high points along both sides of the watercourse, working your way upstream towards the headwaters of the watershed.
3. Starting at the circle that was made in step one, draw a line connecting the "X's" along one side of the watercourse (Figure E-5, below left). This line should always cross the contours at right angles (i.e. it should be perpendicular to each contour line it crosses).
4. Continue the line until it passes around the head of the watershed and down the opposite side of the watercourse. Eventually it will connect with the circle from which you started.

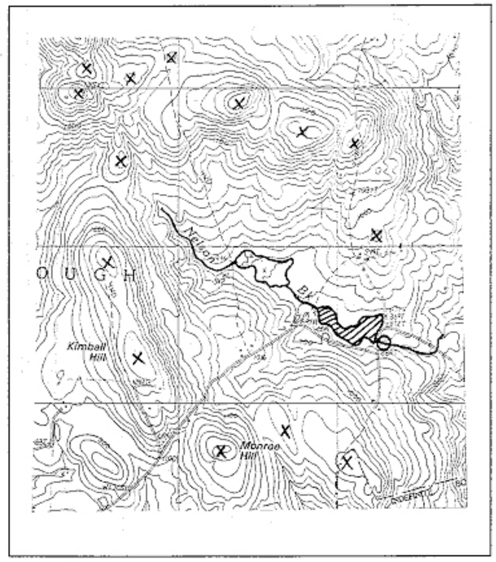



Figure E-4: Delineating a Watershed Boundary - Step 1

At this point you have delineated the watershed of the wetland being evaluated.

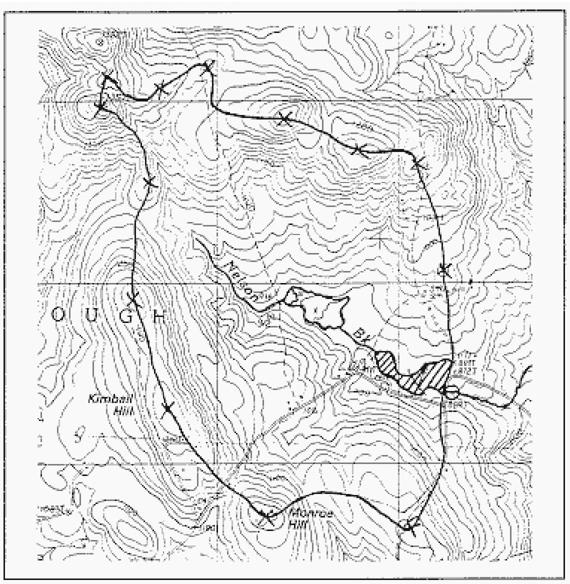



Figure E-5: Delineating a Watershed Boundary - Step 2

The delineation appears as a solid line around the watercourse. Generally, surface water runoff from rain falling anywhere in this area flows into and out of the wetland being evaluated. This means that the wetland has the potential to modify and attenuate sediment and nutrient loads from this watershed as well as to store runoff which might otherwise result in downstream flooding.

## *Measuring Watershed Areas*

There are two widely available methods for measuring the area of a watershed: a) Dot Grid Method, and b) Planimeter. These methods can also be used to measure the area of the wetland itself as required by The New Hampshire Method.

a) The dot grid method is a simple technique which does not require any expensive equipment. In this method the user places a sheet of acetate or mylar, which has a series of dots about the size of the period at the end of this sentence printed on it, over the map area to be measured. The user counts the dots which fall within the area to be measured and multiplies by a factor to determine the area. A hand held, mechanical counting device is available to speed up this procedure.

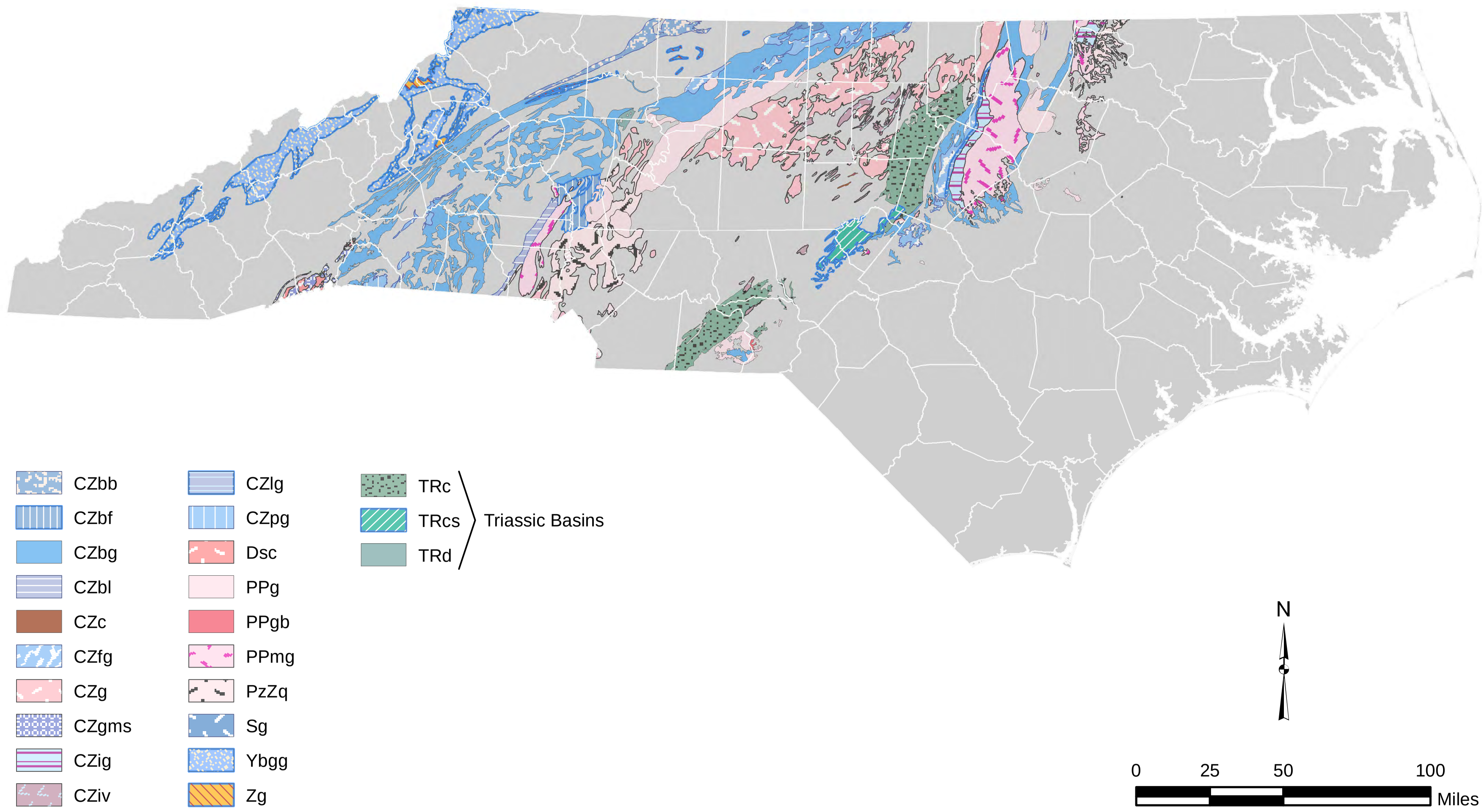
b) The second of these methods involves using a planimeter, which is a small device having a hinged mechanical arm. One end of the arm is fixed to a weighted base while the other end has an attached magnifying lens with a cross hair or other pointer. The user spreads the map with the delineated area on a flat surface. After placing the base of the planimeter in a convenient location the user traces around the area to be measured with the pointer. A dial or other readout registers the area being measured.

Planimeters can be costly depending on the degree sophistication. For the purposes of The New Hampshire Method, a basic model would be sufficient. Dot counting grids are significantly more affordable. Both planimeters and dot grids are available from engineering and forestry supply companies. Users of either of these methods should refer to the instructions packaged with the equipment they purchase.

**For more information on The New Hampshire Method, wetlands restoration programs, conservation planning, ecosystem restoration, and other technical references, visit www.nh.nrcs.usda.gov or call (603) 868-7581.**

# Appendix G

## Potential Sand-bed Stream Areas in the Piedmont and Mountains




Note: key provided on the following page

NC SAM USER MANUAL

**LITHOLOGIES IN PIEDMONT AND MOUNTAIN NC SAM ZONES WITH THE POTENTIAL TO SUPPORT SAND-BED STREAMS**

**BASED ON THE GEOLOGIC MAP OF NORTH CAROLINA, 1985**

APPENDIX

# G

## Appendix G: Potential Sand-bed Stream Areas in the Piedmont and Mountains

Key to Map Units Depicted on the Appendix G Figure

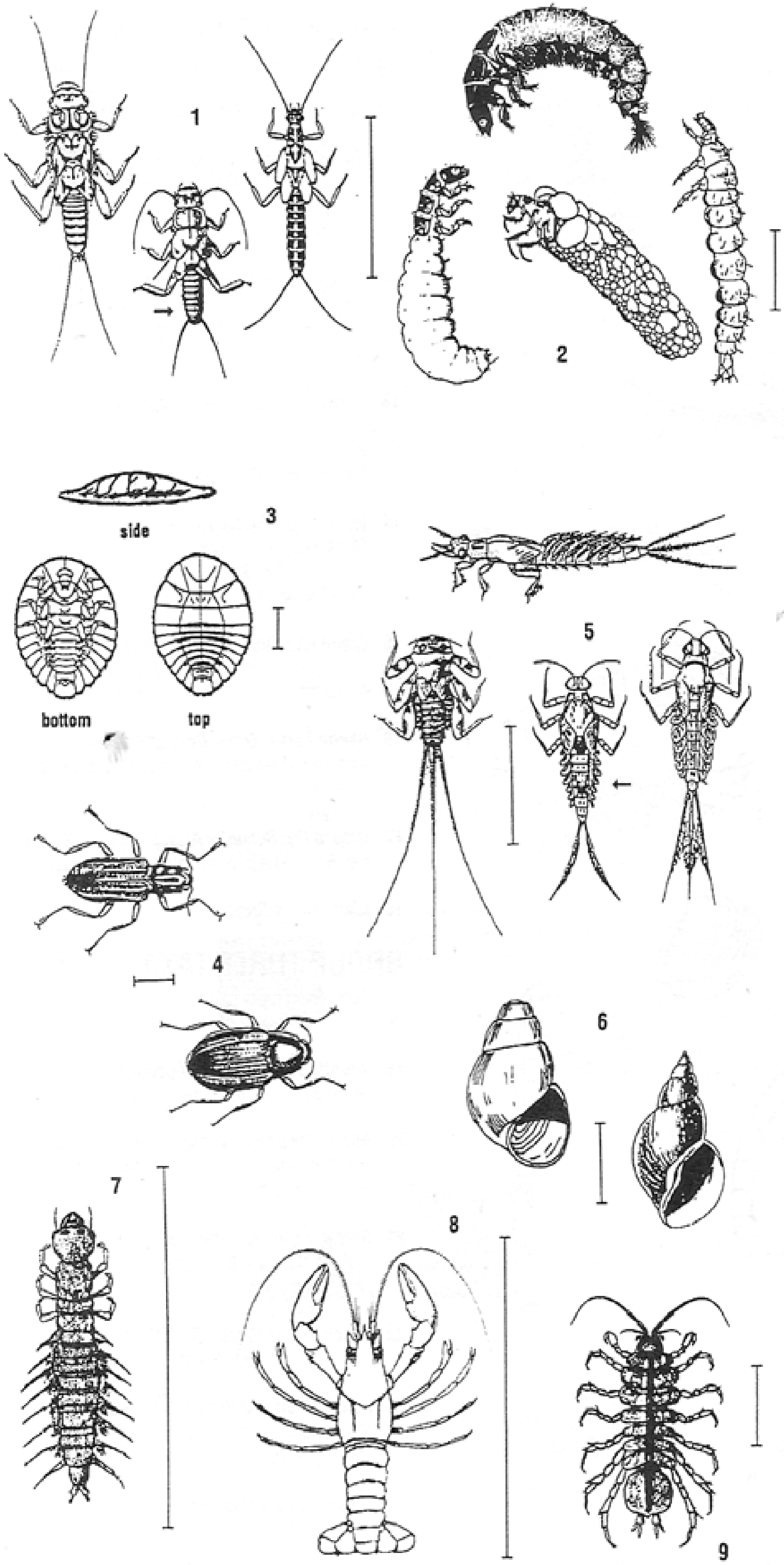
| Map Label | Name |
|---|---|
| CZbb | Banded Gneiss (Cambrian/Late Proterozoic) |
| CZbf | Fine-grained Biotite Gneiss (Cambrian/Late Proterozoic) |
| CZbg | Biotite Gneiss and Schist (Cambrian/Late Proterozoic) |
| CZbl | Blacksburg Formation (Cambrian/Late Proterozoic) |
| CZc | Volcanic Metaconglomerate (Cambrian/Late Proterozoic) |
| CZfg | Felsic Mica Gneiss (Cambrian/Late Proterozoic) |
| CZg | Metamorphosed Granitic Rock (Cambrian/Late Proterozoic) |
| CZgms | Garnet-Mica Schist (Cambrian/Late Proterozoic) |
| CZig | Injected Gneiss (Cambrian/Late Proterozoic) |
| CZiv | Intermediate Metavolcanic Rock (Cambrian/Late Proterozoic) |
| CZlg | Lineated Felsic Mica Gneiss (Cambrian/Late Proterozoic): |
| CZpg | Inequigranular Biotite Gneiss (Cambrian/Late Proterozoic) |
| Dsc | Caesars Head Granite Gneiss (Devonian/Silurian) |
| PPg | Granitic Rock (Permian/Pennsylvanian) |
| PPgb | Pee Dee Gabbro (Pennsylvanian) |
| PPmg | Foliated to Massive Granitic Rock (Permian/Pennsylvanian) |
| PzZq | Metamorphosed Quartz Diorite (Paleozoic/Late Proterozoic) |
| Sg | Shelton Granite Gneiss (Silurian) |
| Ybgg | Biotite Granitic Gneiss (Middle Proterozoic) |
| Zg | Metamorphosed Granitic Rock (Late Proterozoic) |
| TRc | Newark Supergroup, Chatham Group; Chatham Group, Undivided (Triassic) |
| TRcs | Newark Supergroup, Chatham Group; Sanford Formation (Triassic) |
| TRd | Newark Supergroup, Dan River Group; Dan River Group, Undivided (Triassic) |

Reasoning Behind the Inclusion of Units on the Map

The inclusion of specific geologic units on this map is based on their broad lithologic descriptions and limited field reconnaissance. Generally, in non-sedimentary rocks, factors such as higher feldspar content and greater degree of metamorphism tend to produce saprolites that yield sandy sediments. Less altered intrusive rocks can supply sandy sediments, but tend to be associated with bedrock or gravel/cobble controlled streams.

# APPENDIX H

## Common Aquatic Fauna




Bar lines indicate relative size

# Stream Insects & Crustaceans

## GROUP ONE TAXA

*Pollution sensitive organisms found in good quality water.*

1 ***Stonefly: Order Plecoptera.*** 1/2" - 1 1/2", 6 legs with hooked tips, antennae, 2 hair-like tails. Smooth (no gills) on lower half of body. (See arrow.)

2 ***Caddisfly: Order Trichoptera.*** Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. May have fluffy gill tufts on underside.

3 ***Water Penny: Order Coleoptera.*** 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs and fluffy gills on the other side. Immature beetle.

4 ***Riffle Beetle: Order Coleoptera.*** 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

5 ***Mayfly: Order Ephemeroptera.*** 1/4" - 1". brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

6 ***Gilled Snail: Class Gastropoda.*** Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

7 ***Dobsonfly (Hellgrammite): Family Corydalidae.*** 3/4" - 4", dark-colored, 6 legs, large pinching jaws, eight pairs feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, 2 tails and 2 pairs of hooks at back end.

## GROUP TWO TAXA

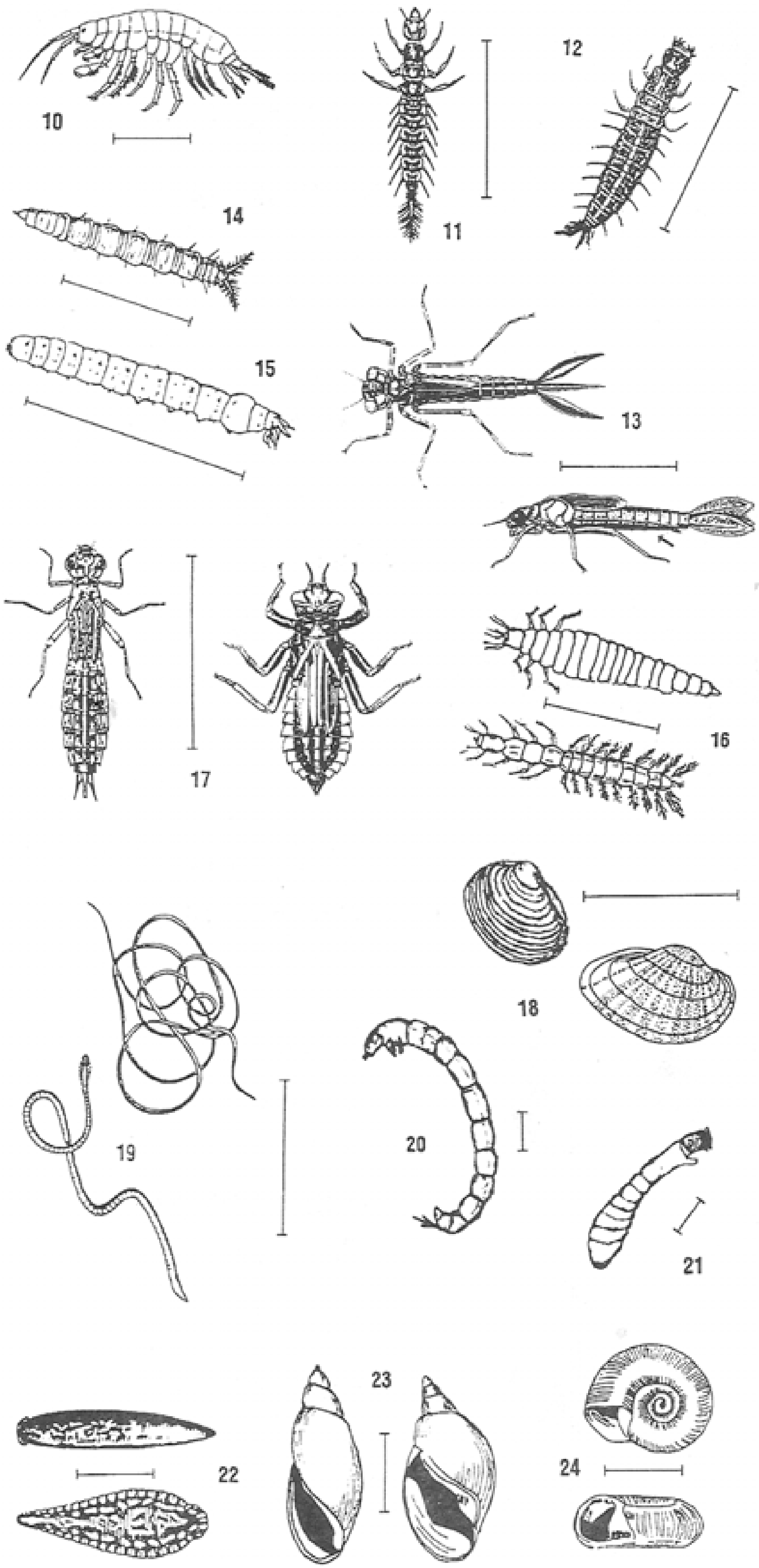
*Somewhat pollution tolerant organisms can be in good or fair quality water.*

8 ***Crayfish: Order Decapoda.*** Up to 6", 2 large claws, 8 legs, resembles small lobster.

9 ***Sowbug: Order Isopoda.*** 1/4" - 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

# Save Our Streams

Izaak Walton League of America
707 Conservation Lane
Gaithersburg, MD 20878-2983
1(800)BUG-IWLA




Bar lines indicate relative size

## GROUP TWO TAXA CONTINUED

**10** ***Scud: Order Amphipoda.*** 1/4", white to grey, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

**11** ***Alderfly Larva: Family Sialidae.*** 1" long. Looks like small hellgrammite but has 1 long, thin, branched tail at back end (no hooks). No gill tufts underneath.

**12** ***Fishfly Larva: Family Corydalidae.*** Up to 1 1/2" long. Looks like small hellgrammite but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.

**13** ***Damselfly: Suborder Zygoptera.*** 1/2" - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body. (See arrow.)

**14** ***Watersnipe Fly Larva: Family Athericidae (Atherix).*** 1/4" - 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

**15** ***Crane Fly: Suborder Nematocera.*** 1/3" - 2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger-like lobes at back end.

**16** ***Beetle Larva: Order Coleoptera.*** 1/4" - 1", light-colored, 6 legs on upper half of body, feelers, antennae.

**17** ***Dragon Fly: Suborder Anisoptera.*** 1/2" - 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

**18** ***Clam: Class Bivalvia.***

## GROUP THREE TAXA

*Pollution tolerant organisms can be in any quality of water.*

**19** ***Aquatic Worm: Class Oligochaeta.*** 1/4" - 2", can be very tiny; thin worm-like body.

**20** ***Midge Fly Larva: Suborder Nematocera.*** Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

**21** ***Blackfly Larva: Family Simulidae.*** Up 1/4", one end of body wider. Black head, suction pad on other end.

**22** ***Leech: Order Hirudinea.*** 1/4" - 2", brown, slimy body, ends with suction pads.

**23** ***Pouch Snail and Pond Snails: Class Gastropoda.*** No operculum. Breathe air. When opening is facing you, shell usually opens on left.

**24** ***Other Snails: Class Gastropoda.*** No operculum. Breathe air. Snail shell coils in one plane.

# APPENDIX I

## North Carolina Non-native Invasive Species

## Appendix I: North Carolina Non-native Invasive Species

This table identifies exotic, invasive plant species that have been identified by state entities (as of the date of this manual) as indicated by an "X" in the three right columns.

- Plants listed under "N.C. Law" fall under North Carolina Department of Agriculture and Consumer Services (NCDA&CS) Noxious Weed Regulations (02 NCAC 48A. 1702, amended effective October 1, 2011). The NCDA&CS considers a "noxious weed" to be "any plant in any stage of development, including parasitic plants whose presence whether direct or indirect, is detrimental to crops or other desirable plants, livestock, land, or other property, or is injurious to the public health" (02 NCAC 48A. 1702, ).
- Plants listed under "NCDOT" are those considered by the N.C. Department of Transportation to be either a "threat to habitat and natural areas" or a "moderate threat to habitat and natural areas" in Invasive Exotic Plants of North Carolina (NCDOT 2008, available on the web at https://connect.ncdot.gov/resources/Environmental/Documents/Invasive%20Exotic%20Plants%20of%20North%20Carolina.pdf).
- Plants listed under "NCEEP" are identified by the N.C. Ecosystem Enhancement Program as invasives of concern or interest. This list is available on the web at http://www.nceep.net/pages/EEP_Mon_Rep_Temp_1.3_01-15-10.pdf (pp. 23 and 24).

| Scientific Name | Common Name | N.C. Law | NC DOT | NC EEP |
|---|---|---|---|---|
| **Vines** | | | | |
| *Ampelopsis brevipedunculata* (Maxim.) Trautv. | porcelain berry, coral berry | - | X | X |
| *Cayratia japonica* Thunb. | bush killer | X | - | X |
| *Celastrus orbiculatus* Thunb. | oriental bittersweet | X | X | X |
| *Dioscorea bulbifera* L. | air potato | - | - | X |
| *Dioscorea oppositifolia* L. | Chinese yam | - | - | X |
| *Euonymus fortunei* (Turcz.) Hand.-Maz. | climbing euonymus | - | X | X |
| *Hedera helix* L. | English ivy | - | X | X |
| *Humulus japonicus* | Japanese hops | - | - | X |
| *Ipomoea aquatica* Forsskal | swamp morning-glory | X | - | X |
| *Ipomoea* spp. | morning glories | | | X |
| *Lonicera japonica* Thunb. | Japanese honeysuckle | - | X | X |
| *Lygodium japonicum* (Thunb. ex Murr.) Sw. | Japanese climbing fern | - | - | X |
| *Mikania cordata* (Burm. f.) B.L. Robins. | heartleaf hempvine | X | - | - |
| *Mikania micrantha* Kunth | bittervine | X | - | - |
| *Persicaria perfoliatum (*L.) Gross | mile-a-minute | X | - | - |
| *Pueraria Montana* var. *lobata* (Lour.) Merr. | kudzu | - | X | X |
| *Tribulus terrestris* L. | puncturevine | X | - | - |
| *Wisteria floribunda* (Willd.) DC. | Japanese wisteria | - | X | X |
| *Wisteria sinensis* (Sims) DC. | Chinese wisteria | - | X | X |

| Scientific Name | Common Name | N.C. Law | NC DOT | NC EEP |
|---|---|---|---|---|
| **Shrubs** | | | | |
| *Berberis thunbergii* DC. | Japanese barberry | - | - | X |
| *Elaeagnus angustifolia* | Russian olive | - | - | X |
| *Elaeagnus pungens* Thunb. | thorny olive | - | X | - |
| *Elaeagnus umbellata* Thunb. | autumn olive | - | X | - |
| *Euonymus alatus* | burning bush | - | - | X |
| *Lespedeza cuneata* (Dum.-Cours.) G. Don | Chinese lespedeza | - | X | X |
| *Lespedeza bicolor* | shrub lespedeza | - | X | X |
| *Ligustrum japonicum* Thunb. | Japanese privet | - | X | X |
| *Ligustrum lucidum* Ait. f. | glossy privet | - | - | X |
| *Ligustrum sinense* Lour. | Chinese privet | - | X | X |
| *Ligustrum vulgare* L. | European privet | - | - | X |
| *Lonicera fragrantissima* Lindl. & Paxton | sweet breath of spring | - | - | X |
| *Lonicera maackii* (Rupr.) Herder | Amur honeysuckle | - | - | X |
| *Lonicera morrowii* Gray | Morrow's honeysuckle | - | - | X |
| *Lonicera tatarica* L. | Tatarian honeysuckle | - | - | X |
| *Lycium ferrocissimum* Miers | African boxthorn | X | - | - |
| *Melastoma malabathricum* L. | Malabar melastome | X | - | - |
| *Mimosa invisa* Martius | giant sensitive plant | X | - | - |
| *Mimosa pigra* L. | catclaw mimosa | X | - | - |
| *Phyllostachys* sp. | bamboo | - | X | X |
| *Polygonum cuspidatum* Sieb. & Zucc. | Japanese knotweed | - | X | X |
| *Rosa multiflora* Thunb. ex Murr. | multiflora rose | - | X | X |
| *Rubus fruticosus* L. | shrubby blackberry | X | - | - |
| *Rubus moluccanus* L. | wild raspberry | X | - | - |
| *Spiraea japonica* L. f. | Japanese spiraea | - | X | X |
| *Vitex rotundifolia* L. f. | beach vitex | X | X | - |
| **Parasitic and Epiphytic Plants** | | | | |
| *Aeginetia* spp. L. | aeginetia | X | - | - |
| *Alectra* spp. Thunb. | alectra | X | - | - |
| *Cuscuta* spp. L. | dodder | X | - | - |
| *Orobanche* spp. L. | broomrape | X | - | - |
| *Striga* spp. Lour. | witchweed | X | - | - |
| **Hardwood Trees** | | | | |
| *Ailanthus altissima* (P. Mill.) Swingle | tree-of-heaven | - | X | X |
| *Albizia julibrissin* Durazz. | mimosa | - | X | X |
| *Elaeagnus angustifolia* L. | Russian olive | - | - | X |
| *Melaleuca quinquenervia* (Cav.) Blake | broad leaf paper bark tree | X | - | - |

| Scientific Name | Common Name | N.C. Law | NC DOT | NC EEP |
|---|---|---|---|---|
| *Melia azedarach* | China berry | - | - | X |
| *Morus alba* | white mulberry | - | - | X |
| *Paulownia tomentosa* | princess tree | - | X | X |
| *Prosopis* spp. L. | mesquite | X | - | - |
| *Pyrus calleryana* | callery pear | - | - | X |
| *Triadica sebifera* (L.) Small | tallow tree | - | - | X |
| | | | | |
| **Grass or Grasslike Plants** | | | | |
| *Arundo donax* | giant reed | - | - | X |
| *Avena sterilis* L. | animated oat | X | - | - |
| *Chrysopogon aciculatus* (Retz.) Trin. | golden false beardgrass | X | - | - |
| *Digitaria scalarum* (Schwein.) | African couchgrass | X | - | - |
| *Digitaria velutina* (Forsk.) Beauv. | velvet fingergrass | X | - | - |
| *Festuca* spp. | fescue | - | - | X |
| *Imperata brasiliensis* Trinius | Brazilian satintail | X | - | - |
| *Imperata cylindrica* (L.) Beauv. | Cogon grass | X | - | X |
| *Ischaemum rugosum* Salisbury | Muraina grass | X | - | - |
| *Leptochloa chinensis* (L.) Nees | Asian sprangletop | X | - | - |
| *Microstegium vimineum* (Trin.) A. Camus | Japanese grass | - | X | X |
| *Miscanthus sinensis* Anderss. | Chinese silvergrass | - | X | X |
| *Nassella trichotoma* Hackel ex Arech. | serrated tussock grass | X | - | - |
| *Oryza longistaminata* A. Chev. & Roehr. | longstamen rice | X | - | - |
| *Oryza punctata* Kotzchy ex Steud. | red rice | X | - | - |
| *Oryza rufipogon* Griffiths | red rice | X | - | - |
| *Paspalum scrobiculatum* L. | kodomillet | X | - | - |
| *Pennisetum clandestinum* Hochst. ex Chiov. | Kikuyu grass | X | - | - |
| *Pennisetum macrourum* Trinius | African feathergrass | X | - | - |
| *Pennisetum pedicellatum* Trinius | Kyasuma grass | X | - | - |
| *Pennisetum polystachyon* (L.) Schultes | mission grass | X | - | - |
| *Rottboellia cochinchinensis* (Lour.) W.D. Clayton | itchgrass | X | - | - |
| *Saccharum spontaneum* L. | wild sugarcane | X | - | - |
| *Sorghum halepense* (L.) Pers. | Johnson grass | - | X | X |
| *Urochloa panicoides* Beauvois | liverseed grass | X | - | - |
| | | | | |
| **Forbs / Herbs** | | | | |
| *Ageratina adenophora* (Spreng.) King & Robins. | crofton weed | X | - | - |
| *Ageratina sessilis* (L) Brown ex Candolle | sessile joyweed | X | - | - |
| *Alliaria petiolata* (Bieb.) Cavara & Grande | garlic mustard | - | X | X |
| *Asphodelus fistulosus* L. | onionweed | X | - | - |
| *Carduus acanthoides* L. | plumeless thistle | X | - | - |

| Scientific Name | Common Name | N.C. Law | NC DOT | NC EEP |
|---|---|---|---|---|
| *Carduus nutans* L. | musk thistle | X | - | - |
| *Carthamus oxyacantha* Bieb. | wild safflower | X | - | - |
| *Cirsium arvense* (L.) Scop. | Canada thistle | X | - | - |
| *Commelina benghalensis* L. | tropical spiderwort | X | - | - |
| *Crassula helmsii* A. Berger | swamp stonecrop | X | - | - |
| *Crupina vulgaris* Cass. | common crupina | X | - | - |
| *Drymaria arenarioides* Humboldt & Bonpland | lightning weed | X | - | - |
| *Emex australis* Steinhall | three-cornered jack | X | - | - |
| *Emex spinosa* (L.) Campdera | devil's thorn | X | - | - |
| *Galega officinalis* L. | goat's rue | X | - | - |
| *Glechoma hederacea* | gill-over-the-ground | - | X | |
| *Heracleum mantegazzianum* Sommier & Levier | giant hogweed | X | - | - |
| *Homeria* spp. | cape tulip | X | - | - |
| *Hygrophila polysperma* (Roxb.) T. Anders. | Miramar weed | X | - | - |
| *Limnophila sessiliflora* (Vahl) Blume | ambulia | X | - | - |
| *Lythrum* spp. (any *Lythrum* spp. not native to NC) | lythrum/loosestrife | X | - | - |
| *Monochoria hastata* (L.) Solms | arrowleaved monochoria | X | - | - |
| *Monochoria vaginalis* (Burm. f.) Kunth | monochoria | X | - | - |
| *Murdannia keisak* | Asian spiderwort | - | X | - |
| *Rorippa sylvestris* (L.) Bess. | Yellow fieldcress | X | - | - |
| *Salsola vermiculata* L. | wormleaf salsola | X | - | - |
| *Senecio inaequidens* DC. | South African ragwort | X | - | - |
| *Senecio madagascariensis* Poir. | Madagascar ragwort | X | - | - |
| *Solanum torvum* Swartz | turkey berry | X | - | - |
| *Solanum viarum* Dunal | tropical soda apple | X | - | X |
| *Spermacoce alata* Aublet | winged false button weed | X | - | - |
| *Tridax procumbens* L. | Coat buttons | X | - | - |
| *Vinca minor* | periwinkle | - | - | X |
| **Cactus** | | | | |
| *Opuntia aurantiaca* Lindley | Jointed prickly pear | X | - | |
| **Aquatic** | | | | |
| *Alternanthera philoxeroides* (Mart.) Griseb. | alligatorweed | X | X | - |
| *Azolla pinnata* R. Brown | pinnate mosquitofern | X | - | - |
| *Caulerpa taxifolia* (Vahl) C. Agardth | Mediterranean clone | X | - | - |
| *Egeria densa* Planch. | Brazilian elodea | X | X | - |
| *Eichhornia azurea* (Swartz) Kunth | anchored water hyacinth | X | - | - |
| *Hydrilla verticillata* (L. f.) Royle | hydrilla | X | X | - |
| *Lagarosiphon* spp. | African elodea | X | - | - |

| Scientific Name | Common Name | N.C. Law | NC DOT | NC EEP |
|---|---|---|---|---|
| *Lagarosiphon major* (Ridley) Moss | oxygen weed | X | - | - |
| *Ludwigia hexapetala* Hook & Arn. | Uruguay water primrose | X | X | |
| *Myriophyllum aquaticum* (Vell.) Verdc. | Parrot feather | X | X | |
| *Myriophyllum spicatum* L. | Eurasian water milfoil | X | - | - |
| *Najas minor* All. | Brittleleaf naiad | X | - | - |
| *Nymphoides cristata* | crested floating heart | X | - | - |
| *Nymphoides indica* | water snowflake | X | - | - |
| *Nymphoides peltata* | yellow floating heart | X | - | - |
| *Ottelia alismoides* (L.) Pers. | duck-lettuce | X | - | - |
| *Phragmites australis (Cav.) Trin. Ex Steud* | common reed | X | X | X |
| *Pistia stratiotes* L. | water lettuce | X | - | - |
| *Sagittaria sagittifolia* L. | arrowhead | X | - | - |
| *Salvinia auriculata* Aublet | giant salvinia | X | - | - |
| *Salvinia biloba* Raddi | giant salvinia | X | - | - |
| *Salvinia herzogii* de la Sota | giant salvinia | X | - | - |
| *Salvinia molesta* D. S. Mitchell | giant salvinia | X | - | - |
| *Solanum tampicense* Dunal | wetland nightshade | X | - | - |
| *Sparganium erectum* L. | branched bur-reed | X | X | - |
| *Stratiotes aloides* L. | crab’s claw, water-aloe | X | - | - |
| *Trapa* spp. | water chestnut | X | - | - |

# APPENDIX J

## Specific Conductance and Benthic Macroinvertebrates

# Explorations of Relationships Between Specific Conductance Values and Benthic Macroinvertebrate Community Bioclassifications in North Carolina

October 3, 2011

Susan Gale
NC Division of Water Quality, Wetlands Program Development Unit

## Introduction

Specific conductance readings-- measures of the ability of water to carry electricity-- are often used by water quality professionals to get a "quick and dirty" feel for water quality issues in freshwater. Specific conductance values increase with concentrations of dissolved ions, which are generally from inorganic compounds such as salts (APHA 2005). Higher dissolved inorganic compounds, and therefore higher specific conductance, are more likely to be found in waters subject to anthropogenic impacts (Megan 2007, Kasangaki 2006).

Unlike other chemical compounds or characteristics of surface water, there is not an associated water quality standard or other guidance as to what ranges of specific conductance may indicate "good" or "poor" water quality. This is understandable, as this measure can be highly variable due to both natural conditions, such as soils or recent precipitation, or anthropogenic impacts, such as point source dischargers or non-point urban impacts. However, having some sort of screening values for specific conductance would be helpful to, for example, water quality professionals working in a new area, or prioritization of sites for further intensive study.

The NC Division of Water Quality (DWQ) has extensive chemical and physical water quality monitoring data from its Ambient Monitoring System (AMS) as well as results from the Biological Assessment Unit (BAU) benthic macroinvertebrate community sampling program. Both of these programs are incredibly data-rich and have been active for at least the last 25 years. The AMS program has the advantage of a large amount of specific conductance readings taken monthly at fixed locations for long periods of time (NC DWQ 2004), during all seasons and under a wide range of flow and precipitation regimes. Aside from an assessment of use support as part of the DWQ 303(d)/305(b) program, though, an overall "rating" of the water quality at each AMS site is not available. This is where the benthic macroinvertebrate data collected by the Biological Assessment Unit (BAU) provide a much needed complement: it contains a biotic index (BI) numerical score as well as a narrative bioclassification (e.g., Poor, Fair, Good-Fair, Good, or Excellent) for each sampling event (NC DWQ 2006). BAU biologists also collect specific conductance readings during their sampling visits, but this generally limits this data set to a single reading at a location once every five years. It would be preferable to use a summary statistic from multiple specific conductance measurements, such as those performed by the AMS program, for comparison to bioclassifications.

It was found that there were a large number of co-located AMS and benthic macroinvertebrate sampling sites, so combining these two data sets allowed determination of whether or not a relationship exists between bioclassification (as an indicator of water quality) and specific conductance, and whether or not there are certain ranges of conductance that may suggest better or worse water quality.

# Methods

Two NC DWQ data sources were used to obtain data for this project: the AMS chemistry data, via the EPA STORET database (US EPA Accessed August 2011); and the benthic macroinvertebrate community data provided as Excel spreadsheets on the BAU website (NC DWQ Accessed August 2011).

The AMS data download included specific conductance data, depth of measurement, and site location information. Sampling site metadata included a Station ID, description, latitude and longitude. This information was used to develop a list of unique Station IDs and corresponding locations, which were then imported into ESRI ArcGIS 9.3.1 to create a shapefile. A similar process using the BAU data set resulted in a shapefile that included all of the BAU sampling sites. The two shapefiles were intersected using a buffer of 500 feet to obtain a list of co-located sample sites, and then intersected with Level III ecoregions (US EPA ORD 2010). The resulting data set was exported for further data clean up and analysis in SAS JMP 8.0 (SAS 2009). The co-located site list was then reviewed using the site descriptions from each program and the GIS shapefiles to ensure that both sampling sites were on the same waterbody and reasonably close together (<500 feet); site pairs not meeting these criteria were deleted.

The final co-located site list was used to extract the corresponding data from the AMS and BAU data sets: surface readings (depth <0.5 m) for specific conductance from the AMS data set; bioclassifications from the BAU database; and date of sampling for all events. Results were reviewed for completeness and reasonable values (for example, very high or low specific conductance values), and records with issues were rectified or deleted.

Due to the extended time range of data collections and ensuing changes in water quality over the course of decades, it was felt that using a summary statistic of conductance over the entire period of record may not accurately reflect water quality conditions at the time of a particular benthos sample, especially since most benthos samples are only repeated every five years. To try to reduce errors from this source, a median specific conductance for each year was calculated for each site using the AMS data, and 90% of the site/year combinations had at least 10 distinct sampling events. The annual median specific conductance was then used for comparison to BAU bioclassifications, based on the year the benthos sampling occurred.

Median annual specific conductance values were graphed and found not to be normally distributed; this disallowed the use of traditional statistical tests for determining differences in distributions by ecoregion or bioclassification. However, $\log_{10}$-transformed data were found to be normally distributed; therefore, analyses requiring the assumption of normality were performed on the $\log_{10}$-transformed data.

Summary statistics and box plots of distributions of median annual specific conductance by bioclassifications were performed for each ecoregion on the $\log_{10}$-transformed data. The Tukey-Kramer honestly significant difference (HSD) test was used to compare distributions of transformed annual median specific conductance. This test was selected as it tends to be conservative when dealing with unequal sample sizes and is also able to reduce compounded errors that would be encountered when other tests (such as the student t-test) are performed on multiple data pairs (SAS 2009).

# Results

## *Description of data set*

The original BAU data set included 6,488 benthic macroinvertebrate sampling events collected between 1982 and 2010, with the great majority occurring between June and September. The original AMS data set included 154,545 surface specific conductance collected during the period of 1968 through 2010; they were spread evenly throughout the year. The sampling frequency and timing (seasonal vs. year-round) of each data set was in accordance with the standard operating procedures of each program.

The final data set built using the co-located site list included 1,070 benthic sampling events at 233 locations (Figure 1) that had corresponding annual median specific conductance from a co-located AMS site; they were collected during the period of 1982-2009. All four Level III ecoregions were represented, and the Southeastern Plains, Piedmont and Blue Ridge seemed to have sample sizes proportionate to their relative areas in NC. The Mid-Atlantic Coastal Plain had few samples; this is likely due to difficulties with finding streams appropriate for sampling using the BAU methods in this area of the state.

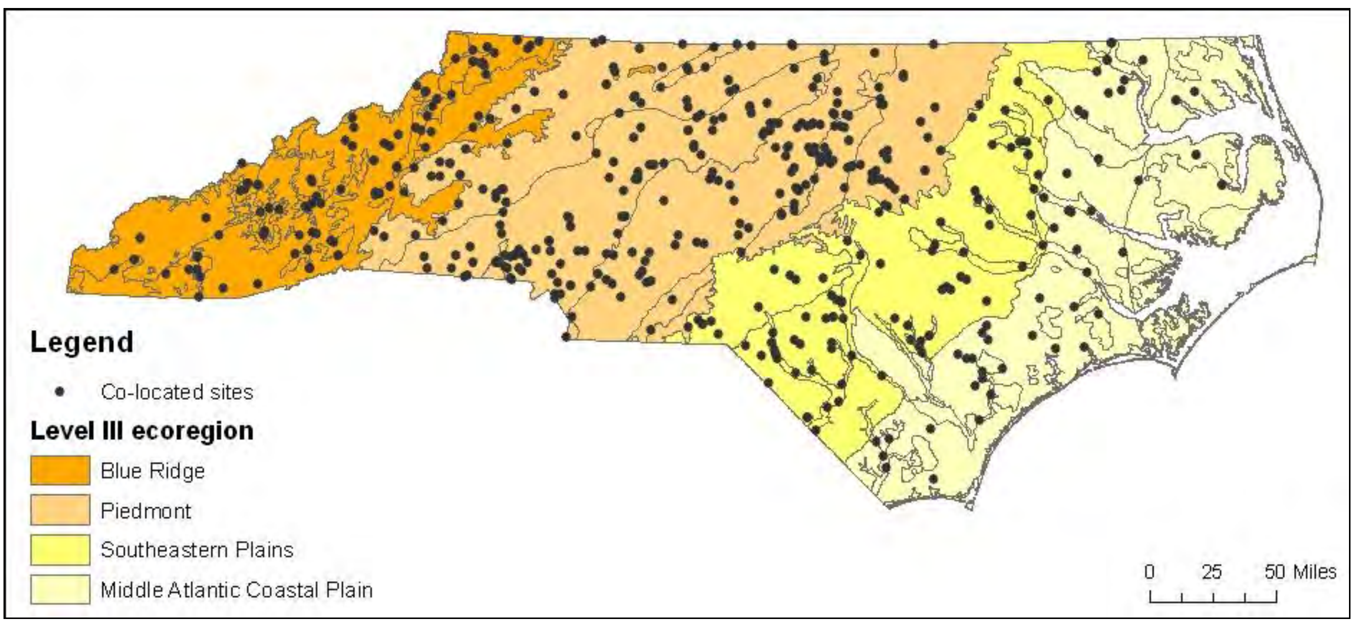



**Figure 1 Co-located BAU and AMS sites and Level III ecoregions**

The majority of the BAU assessment methods resulted in bioclassifications of Poor, Fair, Good-Fair, Good or Excellent (Figure 2, Table 1). The swamp stream assessment methodology used in eastern areas of the state resulted in bioclassifications of Moderate, Natural or Not Rated. There were also a number of sites that were not assigned a bioclassification, indicated as "NA" in the BAU data set. Overall, distributions of bioclassifications were skewed: more samples represent the "higher" end of the water quality spectrum than the lower end.

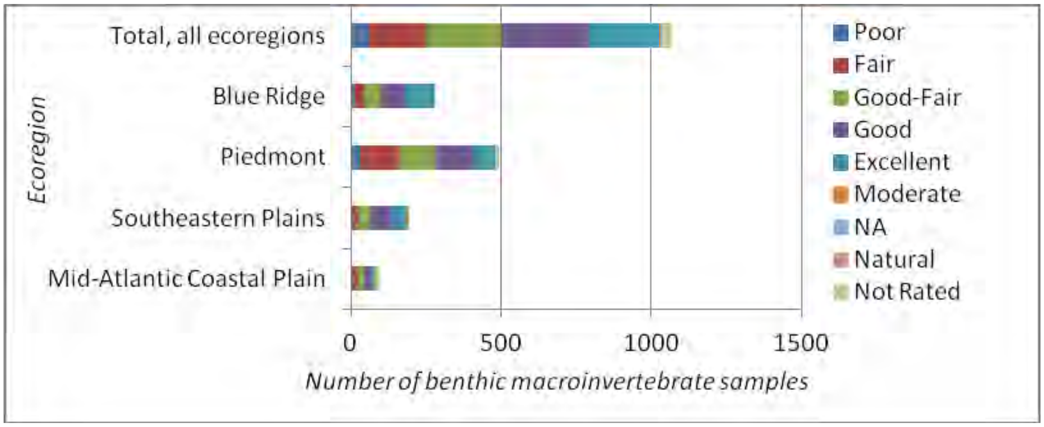



**Figure 2 Number of benthic macroinvertebrate samples by bioclassification by ecoregion**

**Table 1 Number of benthic macroinvertebrate samples by ecoregion and bioclassification**

| | **Bioclassification** | | | | | **Swamp streams** | | **Not rated** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Level III Ecoregion** | Poor | Fair | Good-Fair | Good | Excellent | Moderate | Natural | NA | Not Rated | **Total** |
| Blue Ridge | 14 | 33 | 56 | 78 | 100 | 0 | 0 | 0 | 0 | 281 |
| Piedmont | 35 | 128 | 121 | 124 | 75 | 0 | 0 | 0 | 10 | 493 |
| Southeastern Plains | 3 | 16 | 50 | 65 | 54 | 2 | 0 | 1 | 6 | 197 |
| Mid-Atlantic Coastal Plain | 6 | 16 | 26 | 20 | 7 | 3 | 2 | 0 | 19 | 99 |
| **Total, all ecoregions** | **58** | **193** | **253** | **287** | **236** | **5** | **2** | **1** | **35** | **1070** |

## *Specific conductance distributions statewide and by Level III ecoregion*

Specific conductance varies widely across the state due to natural conditions as well as anthropogenic impacts on water quality. In general, very low values are seen in the mountains and higher values in the piedmont and coastal areas. This implies that values that are "normal" for one ecoregion will not necessarily be appropriate for another. This is supported by the distributions of the annual median specific conductance data used in this project, presented by ecoregion in Figure 3 and Table 2.

Figure 3 uses box plots to represent the distributions of the data for each ecoregion, and this data display method is used throughout this report. For those unfamiliar with them, the ends of the red "boxes" represent the 25th and 75th percentiles of the distribution, with a line representing the median through the middle (SAS 2009). Median values range from 44 µS/cm at 25°C in the mountains (Blue Ridge ecoregion) to more than triple that in the Mid-Atlantic Coastal Plain (138 µS/cm at 25°C).

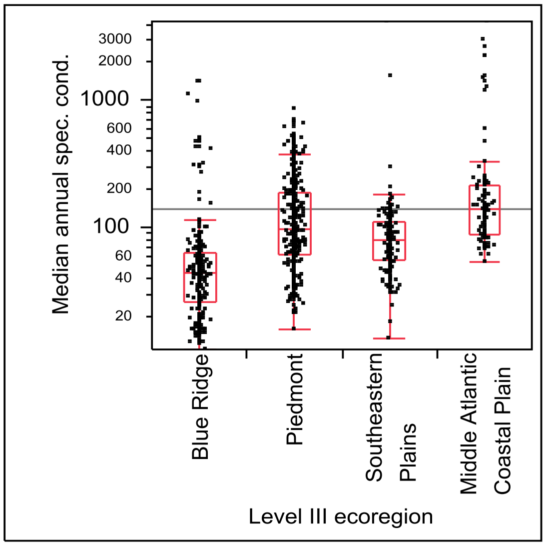



**Figure 3 Distributions of annual median specific conductance (uS/cm at 25°C) by ecoregion. The gray line indicates the grand mean.**

**Table 2 Distributions of specific conductance (uS/cm at 25°C) by ecoregion**

| Level III Ecoregion | *Percentiles* | | | | | | |
|---|---|---|---|---|---|---|---|
| | Min | 10% | 25% | Median | 75% | 90% | Max |
| Blue Ridge | 11 | 16 | 27 | 44 | 64 | 94 | 1420 |
| Piedmont | 16 | 36 | 62 | 97 | 191 | 329 | 870 |
| Southeastern Plains | 14 | 39 | 56 | 80 | 111 | 138 | 4194 |
| Mid-Atlantic Coastal Plain | 53 | 72 | 90 | 138 | 217 | 1200 | 4205 |

**Statewide distributions by bioclassification**

A clear pattern was seen when reviewing the distributions of the untransformed annual median specific conductance for each bioclassification (Figure 4, Table 3), suggesting that the two water quality indicators were indeed correlated or otherwise related.

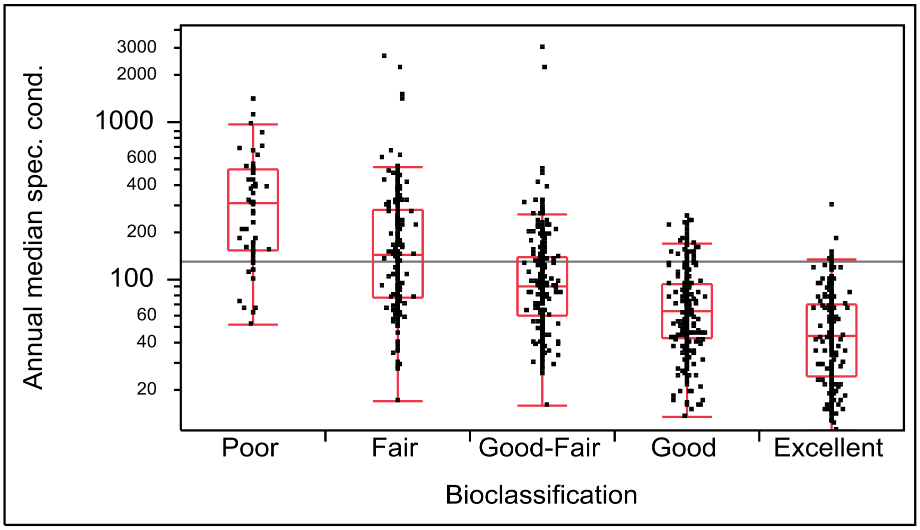



**Figure 4 Median annual specific conductance (uS/cm at 25°C) by bioclassification (all ecoregions). The gray line indicates the grand mean.**

**Table 3 Distributions of specific conductance (uS/cm at 25°C) for all ecoregions by bioclassification**

| | *Percentiles* | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bioclassification** | **Min** | **10%** | **25%** | **Median** | **75%** | **90%** | **Max** |
| Poor | 52 | 99 | 153 | 308 | 503 | 880 | 4205 |
| Fair | 17 | 57 | 78 | 144 | 284 | 442 | 2650 |
| Good-Fair | 16 | 40 | 58.5 | 92 | 139 | 222 | 3038 |
| Good | 14 | 29 | 43 | 63 | 96 | 145 | 255 |
| Excellent | 11 | 16 | 24 | 43.5 | 70 | 96 | 299 |

**Distributions by ecoregion**

Results presented in the previous section used untransformed data to provide a quick reference for the general ranges of field readings seen for different ecoregions and bioclassifications. However, as noted in the methods section, the specific conductance data were not normally distributed, which limited the traditional statistical tests that could be performed. However, when $log_{10}$-transformed, the data were found to be normally distributed and so were appropriate for analyses to determine significant differences between distributions; results presented from this point forward were obtained using $log_{10}$-transformed data.

When reviewing the transformed annual median specific conductance data by ecoregion, a strong relationship appeared to be present between conductance and bioclassification in the Blue Ridge and Piedmont ecoregions. There was a weaker relationship present for the Southeastern Plains. The Mid-Atlantic Coastal Plain did not show any strong relationships, which may have been due to the lower sample sizes for these areas, greater natural variability, the presence of samples from brackish waters, or other, unknown factors.

Results for the level III ***Piedmont*** ecoregion are shown in Figure 5 and Table 4. The $\log_{10}$ annual median specific conductance for each bioclassification decreased when moving from the “lowest” water quality (indicated by a bioclassification of “Poor”) to “best” water quality (as indicated by a bioclassification of “Excellent”). The Tukey-Kramer HSD test (α=0.05) showed statistical differences between all bioclassifications, which is graphically represented by the circles in the right hand of Figure 5: each circle represents a single bioassessment category, and when they do not overlap, they can be considered statistically different. Analysis showed a strong relationship, with almost all bioclassification pair comparisons resulting in a p-value of <0.0001; the remaining pair resulted in a p-value of 0.0011.

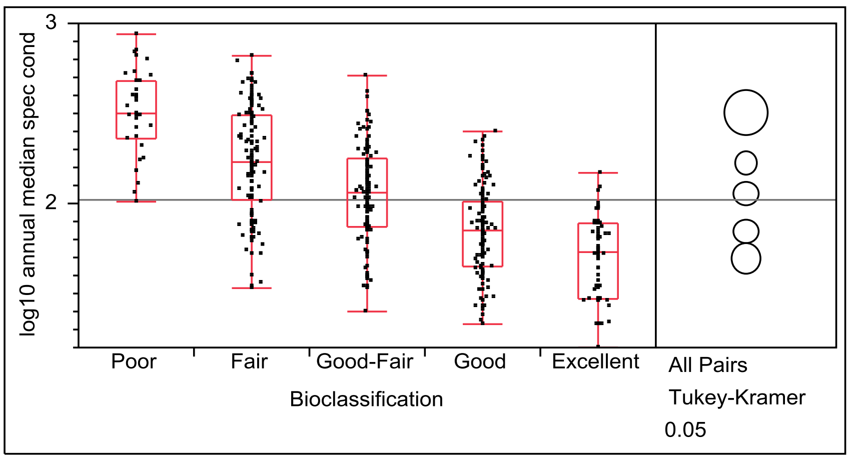



**Figure 5 Piedmont ecoregion, log10 annual median specific conductance distributions by bioclassification**

**Table 4 Piedmont ecoregion, $\log_{10}$ annual median specific conductance distributions by bioclassification**

| | ***Percentiles*** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bioclassification** | **Min** | **10%** | **25%** | **Median** | **75%** | **90%** | **Max** |
| Poor | 2.0086 | 2.152964 | 2.359835 | 2.503791 | 2.680336 | 2.826745 | 2.939519 |
| Fair | 1.531479 | 1.821831 | 2.018043 | 2.225955 | 2.490418 | 2.615976 | 2.822168 |
| Good-Fair | 1.39794 | 1.659346 | 1.872146 | 2.058805 | 2.253364 | 2.412964 | 2.71265 |
| Good | 1.332438 | 1.501407 | 1.653213 | 1.845087 | 2.013855 | 2.204112 | 2.404834 |
| Excellent | 1.20412 | 1.338429 | 1.469822 | 1.732394 | 1.889302 | 1.974966 | 2.173186 |

Similar patterns and results were seen for the Blue Ridge level III ecoregion (Figure 6, Table 5). Bioclassifications were statistically different across all pairs according to the Tukey-Kramer (α=0.05) analysis. Again, the p-values were very low (<0.0001) across the majority of comparisons, and the remaining two were 0.0436 (Fair vs. Good-Fair) and 0.0154 (Good-Fair vs. Good).

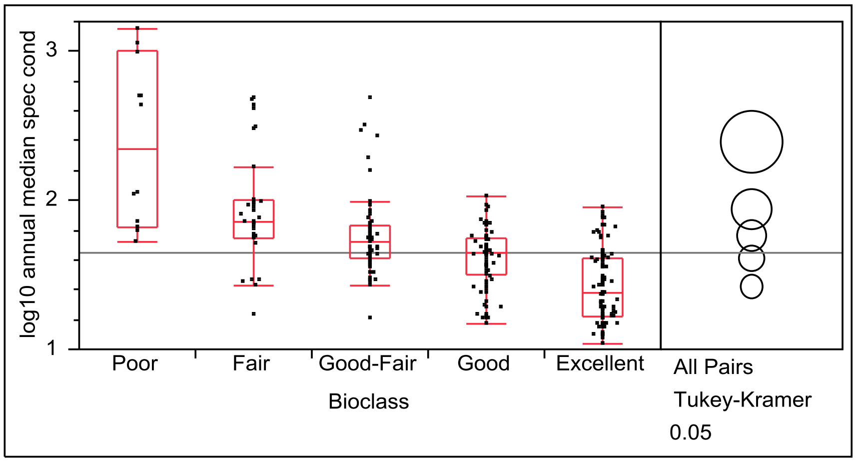



**Figure 6 Blue Ridge annual median specific conductance distributions by bioclassification**

**Table 5 Blue Ridge annual median specific conductance distributions by bioclassification**

| | ***Percentiles*** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bioclassification** | **Min** | **10%** | **25%** | **Median** | **75%** | **90%** | **Max** |
| Poor | 1.716003 | 1.754198 | 1.819544 | 2.347987 | 3.003828 | 3.152288 | 3.152288 |
| Fair | 1.230449 | 1.453254 | 1.746206 | 1.857332 | 1.997818 | 2.629949 | 2.681241 |
| Good-Fair | 1.20412 | 1.474931 | 1.612688 | 1.716003 | 1.835549 | 2.218813 | 2.681241 |
| Good | 1.176091 | 1.273923 | 1.496573 | 1.650786 | 1.740363 | 1.842296 | 2.02735 |
| Excellent | 1.041393 | 1.146128 | 1.217484 | 1.380211 | 1.611452 | 1.791686 | 1.954243 |

The ***Southeastern Plains*** ecoregion (Figure 7, Table 6) did not show the almost textbook results that were seen in the Piedmont and Blue Ridge ecoregions, but there were still significant differences (α=0.05 ) between the Poor and Good, and the Poor and Excellent bioclassifications. Essentially, the worst sites have statistically different specific conductance values than the better end of the water quality spectrum. While not a strong relationship, it suggests that it may be useful to repeat this analysis in the future once additional benthic macroinvertebrate samples have been completed in this ecoregion. In fact, the results for the Southeastern Plains actually showed vast improvements over a similar analysis done previously using an older data set that only covered a period up through early 2007.

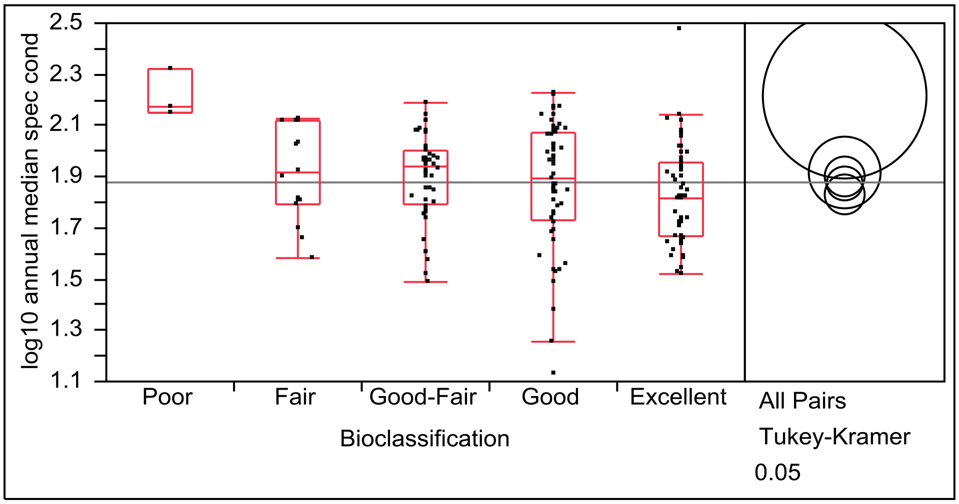



**Figure 7 Southeastern Plains distributions of specific conductance by bioclassification**

**Table 6 Southeastern distributions of specific conductance by bioclassification**

| | ***Percentiles*** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bioclassification** | **Min** | **10%** | **25%** | **Median** | **75%** | **90%** | **Max** |
| Poor | 2.152288 | 2.152288 | 2.152288 | 2.174641 | 2.324282 | 2.324282 | 2.324282 |
| Fair | 1.579784 | 1.637866 | 1.793201 | 1.914973 | 2.120574 | 2.126454 | 2.128722 |
| Good-Fair | 1.491362 | 1.612031 | 1.795838 | 1.941944 | 2.003209 | 2.109856 | 2.19173 |
| Good | 1.130334 | 1.535283 | 1.732319 | 1.892095 | 2.070034 | 2.152144 | 2.224015 |
| Excellent | 1.518514 | 1.591065 | 1.667453 | 1.817893 | 1.958385 | 2.075512 | 2.475671 |

There are some caveats that should be addressed with the Southeastern Plains data set. First, the sample size for the Poor bioclassification was extremely small (n=3), so the results should obviously be used with caution. Second, the BAU swamp stream sampling and assessment protocols are often more appropriate for streams in this ecoregion yet the data used for this analysis was limited to the more "standard" methods of Full Scale, Qual4, and EPT since they included the standard bioclassifications (Poor, Fair, etc.). So, in fact, this analysis only reflects streams that met the criteria for those more traditional assessment methods (Full Scale, Qual4, and EPT) from the ecoregion, i.e., those with visible flow year-round (NC DWQ 2006). The original data set included two sampling events that used the Swamp methodology, both of which received bioclassifications of Moderate.

In the beginning of the results section, the bioassessment categories of "Natural", "Moderate" and "Not Rated" were mentioned but have generally been ignored for much of this document. These categories correspond to the results of swamp stream assessments, with Natural implying few water quality impacts on the benthic community, Moderate implying moderate stress, and those samples that show even higher impacts on the benthic communities are simply Not Rated (NC DWQ 2006). The Not Rated bioclassification is used instead of a rating such as Fair or Poor because it is not yet understood if these less diverse communities are actually due to water quality issues or simply due to natural stressors found in these systems with naturally low flows, pH, and dissolved oxygen.

Given the interesting results found during the initial data analysis, a second analysis was performed. This time, the analysis included the two swamp samples with bioclassifications of Moderate. They were grouped with the more standard bioclassifications, resulting in five amended categories: Poor, Fair, Good-Fair/Moderate, Good, and Excellent. (Natural would have been grouped with Excellent, and Not Rated grouped with Poor if any had been present.) These two additional data points did not have any noticeable effects on the results; Poor/Excellent was still the only category pair showing significant differences from each other.

The ***Middle Atlantic Coastal Plain*** distributions (Figure 8, Table 7) did not show any statistical differences in annual median specific conductance between any bioclassification pairings using Tukey-Kramer HSD (either at α=0.05 or α=0.10). One issue may be the small data set, which may not fully capture the variability within this ecoregion. There were only 99 benthos samples total for this ecoregion, and most bioclassifications had very small sample sizes.

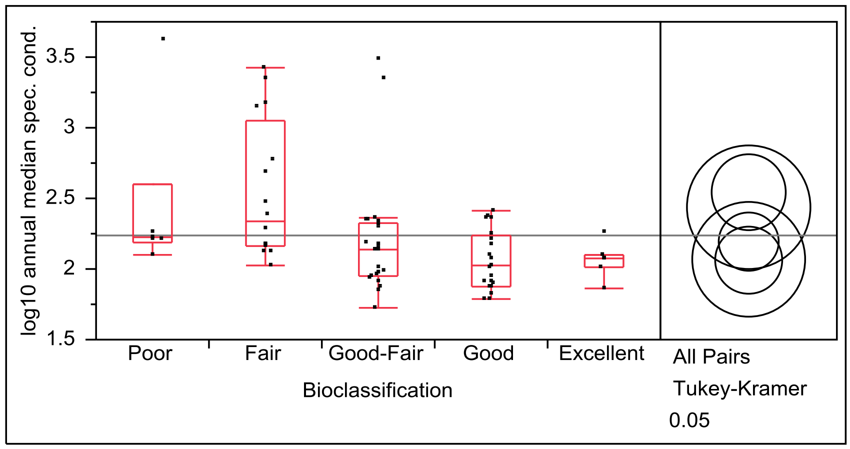



**Figure 8 Middle Atlantic Coastal Plain distributions of specific conductance by bioclassification**

**Table 7 Middle Atlantic Coastal Plain distributions of specific conductance by bioclassification**

| | *Percentiles* | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bioclassification** | **Min** | **10%** | **25%** | **Median** | **75%** | **90%** | **Max** |
| Poor | 2.09691 | 2.09691 | 2.181364 | 2.219982 | 2.600099 | 3.623766 | 3.623766 |
| Fair | 2.02735 | 2.097178 | 2.167675 | 2.340485 | 3.053604 | 3.368048 | 3.423246 |
| Good-Fair | 1.724276 | 1.86994 | 1.955402 | 2.141447 | 2.331163 | 2.657717 | 3.482588 |
| Good | 1.792392 | 1.796083 | 1.877696 | 2.020143 | 2.238176 | 2.374009 | 2.40654 |
| Excellent | 1.863323 | 1.863323 | 2.006466 | 2.079181 | 2.103804 | 2.264818 | 2.264818 |

However, multiple sampling methodologies and bioclassifications were confounding factors for the Mid-Atlantic Coastal Plain. The majority of samples in the Mid-Atlantic Coastal Plain were collected using the more common methods of EPT (n = 61) and Full Scale (n = 4), but the Swamp (n = 9) and Boat (n = 25) methods for 34% of the sampling events. The Boat (or Coastal B) methodology was used on large, non-wadeable rivers; this method resulted in similar bioclassifications as the more common methods and was included in Figure 8 and Table 7, but these waterbodies are likely distinctly different from the wadeable streams just based on size. A repeated analysis excluding the Boat samples did not improve the results of the Tukey-Kramer analysis.

As discussed in the Southeastern Plains section above, Swamp assessments resulted in a different set of bioclassifications: Natural, Moderate Stress, and Not Rated; these were therefore not included in the results shown in Figure 8 and Table 7. A re-analysis using the groupings described in the Southeastern Plains section above (Poor/Not Rated, Fair, Good-Fair/Moderate, Good, and Excellent/Natural) was performed. The specific conductance associated with the Fair bioclassification was found to be statistically different from the Good-Fair/Moderate, Good, and Excellent/Natural categories. The Poor/Not Rated category showed no statistically significant differences from other categories.

An additional concern was that the data were inherently biased, in that they represented streams that are the exception to the rule for this area of the state. Swamp streams (those that have visible flow only during certain seasons) are fairly common in the Coastal Plain, as are streams which simply cannot be assessed with current BAU methods as they simply have no visible flow at any time of the year. The sites included in the analyses are solely from the traditional (Full Scale, EPT) and Boat methods and therefore may not adequately reflect the actual predominant stream types in this region. More information would need to be obtained about the specific sampling sites before refinement of this analysis could occur.

## Uses for benchmark or screening criteria

Though specific conductance is often used by water quality professionals as an indicator of issues or concerns, the values that are generally considered “good” or “bad” are based on each person’s experience, both in terms of time and spatially (many professionals work only in one area). There are no water quality standards for this measurement, and with good reason based on its great variability. However, having some general “benchmark” value to identify the extreme cases—suggesting very high water quality or very low quality water—would be helpful to those new in the field, working with data from an area of NC that they were unfamiliar with, or for trying to prioritize or rank areas for more in-depth studies. It should be stressed again, however, that specific conductance is highly variable even at a single sampling location, and it should only be used as one of several lines of evidence to support future management or assessment activities. If possible, assessments should be made on multiple specific conductance readings over time under varying flow conditions.

Based on the brief analyses given here, it appears that in at least two ecoregions of the state—Piedmont and Blue Ridge—there are sufficient data available showing strong relationships between annual median specific conductance and the bioclassification assigned based on benthic macroinvertebrate community sampling. There is no evidence of any sort of similar relationships between specific conductance and bioclassification for the Mid-Atlantic Coastal Plain. Results from the Southeastern Plains suggest that a relationship exists for the Poor bioclassification, but due to the small sample size the data are insufficient for this purpose.

For both the Piedmont and Blue Ridge ecoregions, it is suggested that the following percentiles could be used to screen for “waters of concern” and “waters of high quality”:

- For waters of concern, use the 25$^{th}$ percentile of the annual median specific conductance for sites receiving a “Poor” bioclassification;
- For waters of high quality, use the 75$^{th}$ percentile of the annual median specific conductance for sites receiving an “Excellent” bioclassification.

As an example of how to determine these values, Figure 9 shows the distributions of median specific conductance by bioclassification for the Piedmont ecoregion. The upper red line is equal to the $25^{th}$ percentile for the "Poor" bioclassification and the lower green line is equal to the $75^{th}$ percentile for the "Excellent" bioclassification.

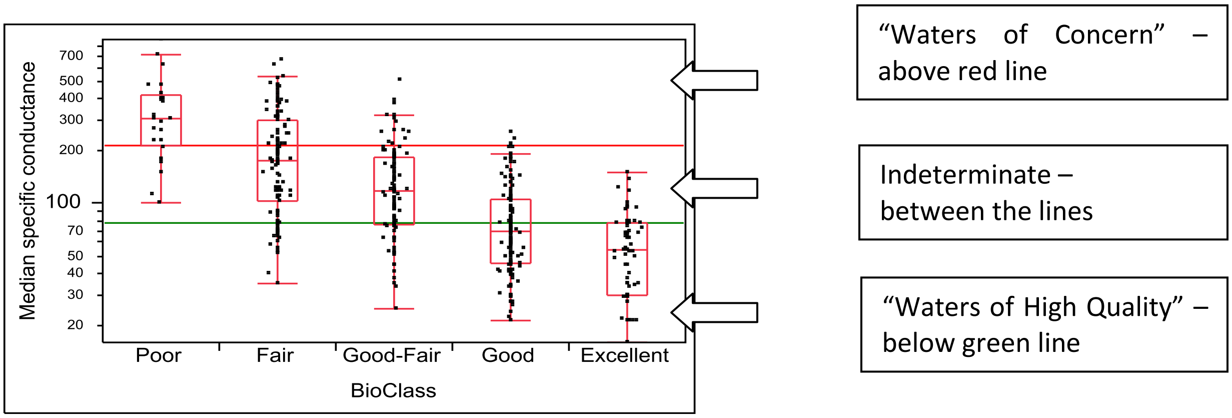



**Figure 9 Piedmont specific conductance distributions showing suggested screening values**

The percentiles by ecoregion were included in the data tables in the previous sections. However, these data were $\log_{10}$- transformed and so are not particularly meaningful when taking measurements in the field; field meters report specific conductance in uS (or mS) per cm at 25°C, not $\log_{10}$(uS/cm). To convert the values back to something useful for field staff, the data can be back-transformed using the following simple equation, where ***x*** is the value corresponding to the $25^{th}$ (or $75^{th}$) percentile:

$$\text{Specific conductance in uS/cm at 25°C} = 10^{x}$$

By referring to the earlier data tables, these guidelines, and back-transformation equation, the screening values can be calculated, and are shown in Table 8.

**Table 8 Suggested screening values for specific conductance in the Piedmont and Blue Ridge ecoregions**

| Ecoregion | Waters of High Quality | Indeterminate Waters | Waters of Concern |
|---|---|---|---|
| Piedmont | <78 uS/cm at 25°C | 78-229 uS/cm at 25°C | >229 uS/cm at 25°C |
| Blue Ridge | <41 uS/cm at 25°C | 41-66 uS/cm at 25°C | >66 uS/cm at 25°C |

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# APPENDIX K

# NC SAM Rating Calculator User Guide

# Appendix K:  NC SAM Rating Calculator User Guide

## K-1.0   Introduction

Stream functional ratings are generated by processing stream assessment data collected on the NC SAM Field Assessment Form through a Boolean logic sequence that defines the ratings for all possible metric value outcomes.  Each of the 29 stream categories has its own unique and rather extensive logic sequence.  While it is possible to generate functional ratings by manually processing stream assessment data, the effort would be time consuming and, due to the complicated nature of the Boolean logic, potentially prone to miscalculation.  To reduce processing time and ensure proper calculation, the Stream Functional Assessment Team (SFAT) directed the development of the NC SAM Rating Calculator.

The NC SAM Rating Calculator is a macro-enabled Microsoft Excel 2007 workbook consisting of a pair of worksheets that resemble the NC SAM Field Assessment Form and Stream Rating Sheet.  The purpose of the Rating Calculator is to automate functional rating calculations. Stream assessment data collected in the field and input into the Rating Calculator is automatically passed through the logic chain of a specified stream category.  The result is a Stream Rating Sheet populated with the functional ratings.

This appendix provides instructions for operating the Rating Calculator.

## K-2.0   Rating Calculator Instructions

### K-2.1   Opening the Rating Calculator

The Rating Calculator is opened like a typical Excel file – by either double-clicking the Rating Calculator file or by using the Open function available in Excel's File menu (File > Open).  Open the Rating Calculator using one of the described methods.

Excel's macro security settings may need to be configured to allow the Rating Calculator to operate.  Instructions for configuring the security settings are provided in the following section.

### K-2.2   Setting Excel's Macro Security

The functionality of the Rating Calculator is provided by a collection of macros (computer programming code) triggered as stream assessment data are entered.  Excel has security provisions regulating the use of macros.  The security settings must be configured to allow the use of macros prior to using the Rating Calculator.  The security settings only need to be configured once as the settings will apply to all Excel workbooks thereafter.  The procedure differs between Excel 2007 and Excel 2010.  Please follow the appropriate instructions below.

#### K-2.2.1   Excel 2007

In Excel 2007, opening the Rating Calculator results in a security warning.  The warning is displayed on the left side of the Excel window, just below the Ribbon (see Figure K-1).  The accompanying text indicates that content within the Rating Calculator workbook – in this case, the Rating Calculator macro – has been disabled.  Enable the Rating Calculator functionality by selecting the Options button (denoted by arrow 1 in Figure K-1). Select the Enable this content option from the Microsoft Office Security Options dialog (see Figure K-1).

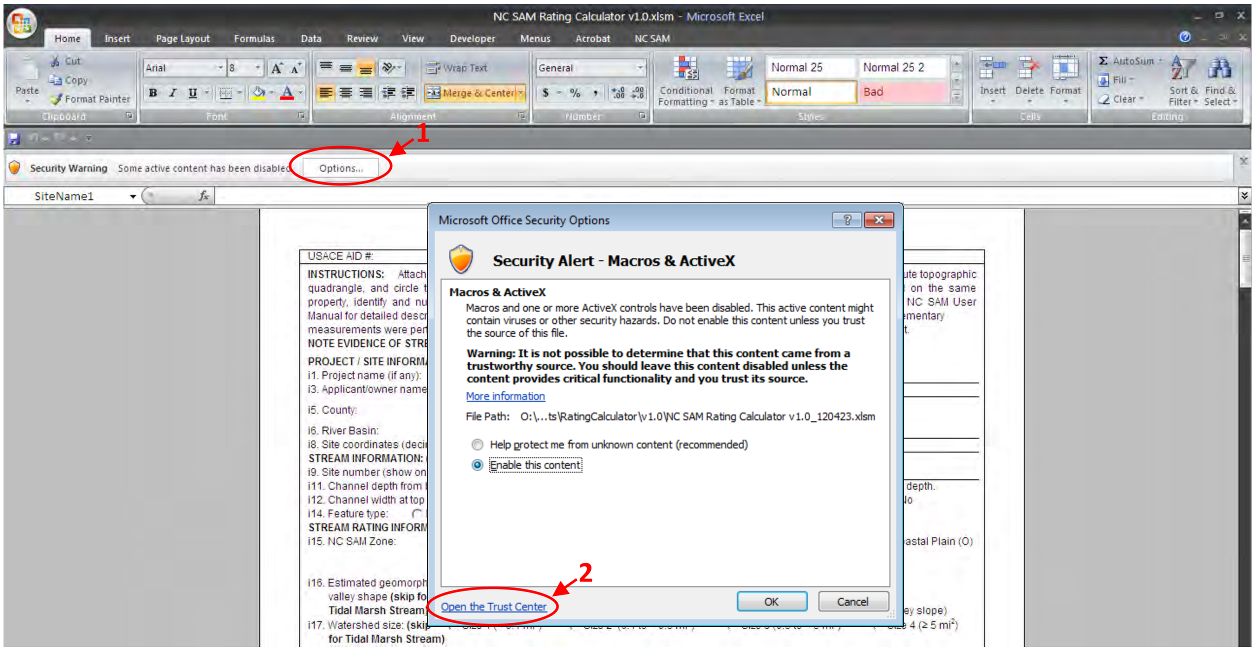


**Figure K-1**. Enable the NC SAM Rating Calculator functionality in Excel 2007.

Next, open the Trust Center dialog by selecting the Open the Trust Center link (denoted by arrow 2) located in the bottom left corner of the Microsoft Office Security Options dialog. This dialog provides access to Excel's security settings.

Select Macro Settings from the option panel on the left margin of the dialog. Two macro settings need to be configured here. First, select the Disable all macros with notification option. Second, place a check in the Trust access to VBA project object model box (see Figure K-2). Close the Trust Center and Microsoft Office Security Options dialogs. Close Excel entirely.

Excel will now permit the Rating Calculator macros to run. Reopen the Rating Calculator to begin use. Dismiss the security warning by clicking the Options button and selecting the Enable this content option from the Microsoft Office Security Options dialog (Figure K-1). This step will need to be repeated each time the Rating Calculator is opened.

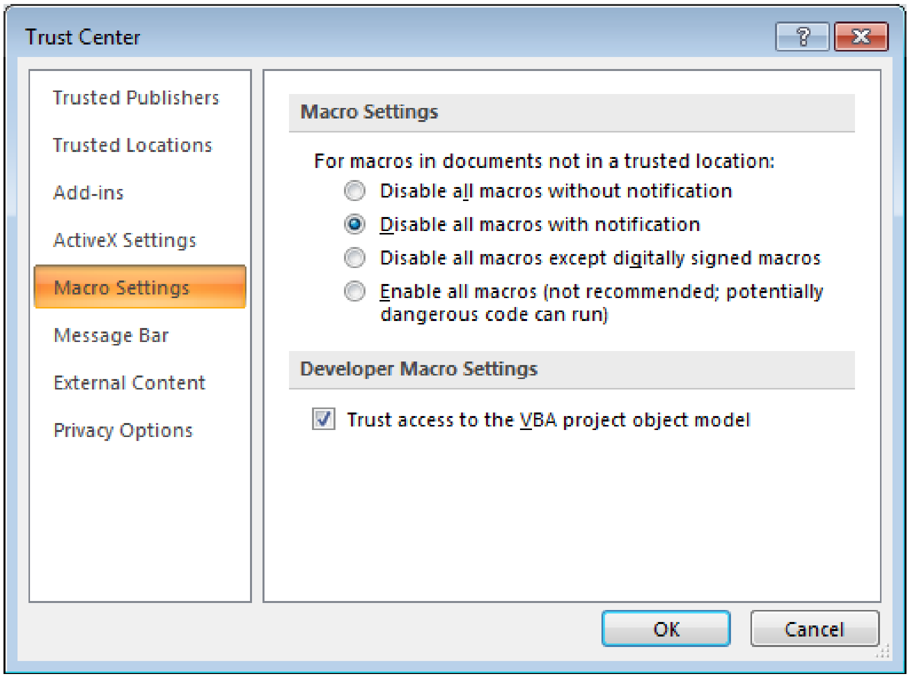


**Figure K-2**. Additional security settings are configured in the Trust Center dialog.

### K-2.2.2 Excel 2010

Depending on the existing security settings, Excel 2010 may issue a security warning when the Rating Calculator is opened (see Figure K-3). If this is case, click the Enable Content to launch the Rating Calculator macros. Excel may also ask if the file should be registered as a trusted document. Select either yes or no. The Rating Calculator functions are not affected by the response. The Rating Calculator is now operational.

If a warning is not issued, open Excel's Trust Center to confirm the security settings. In Excel 2010, the Trust Center is accessed from the Options menu on the File tab (see Figure K-4). Select Options (arrow 1 in the figure) from the panel along the left margin, opening the Excel Options dialog box. Next, click the Trust Center Setting button (arrow 2 in the figure).

The Trust Center dialog box that appears is similar to that of Excel 2007 (see Figure K-2 above). Select Macro Settings from the panel along the left margin. Next, select the Disable all macros with notification option and place a check in the Trust access to VBA project object model box (see Figure K-2). Close the Trust Center and Microsoft Office Security Options dialogs. Close Excel entirely.

The Rating Calculator should now be operational. To use, reopen the Rating Calculator. The security warning mentioned above may appear. If so, dismiss the warning by clicking the Enable Content button.

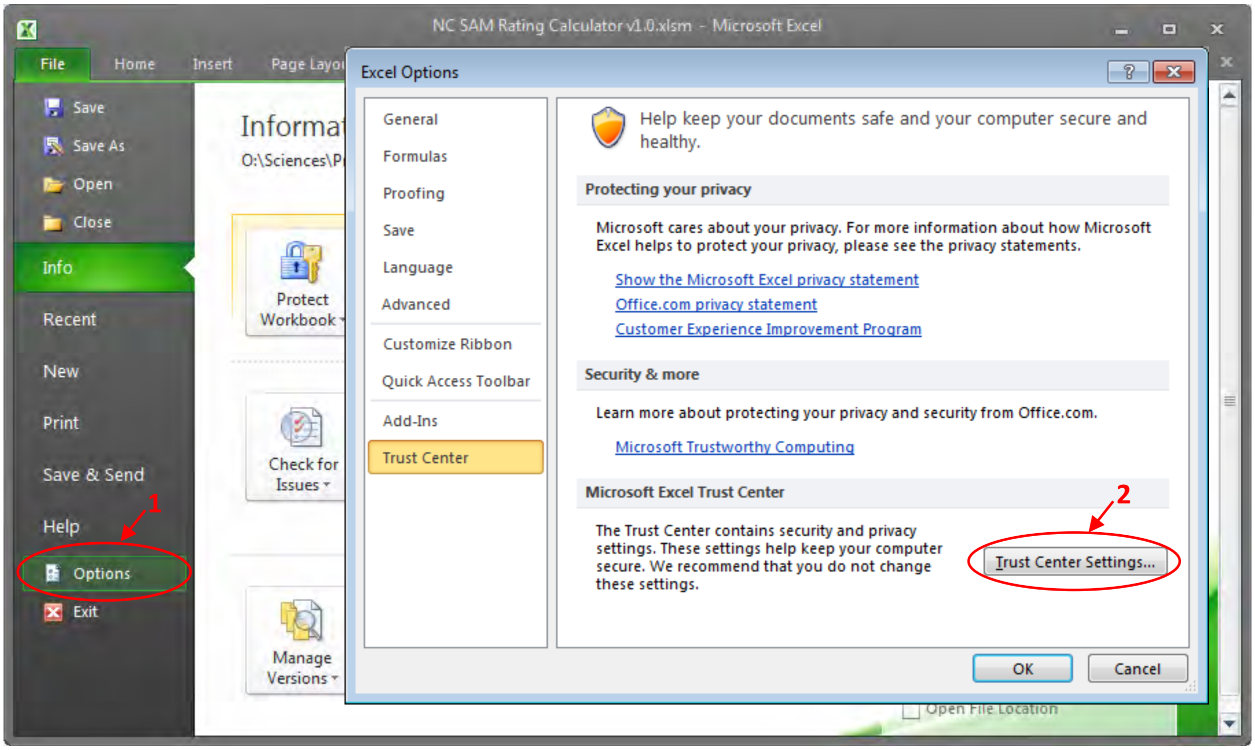


**Figure K-3**. Access the Excel's Trust Center in Excel 2010.

### K-2.3 Rating Calculator Contents

The Rating Calculator has two worksheets: the Form worksheet and the Results worksheet. The Form worksheet replicates the NC SAM Field Assessment Form and the Results worksheet replicates the NC SAM Stream Rating Sheet. Stream assessment data collected in the field are transcribed from the NC SAM Field Assessment Form onto the Form worksheet. The resulting functional ratings are presented on the Results worksheet.

Use the Form and Results tabs located in the bottom left-hand corner of the Rating Calculator screen to toggle between the two worksheets (Figure K-4). Click the Form tab to display the Form worksheet and the Results tab to display the Results worksheet. The operation of both worksheets is described below.

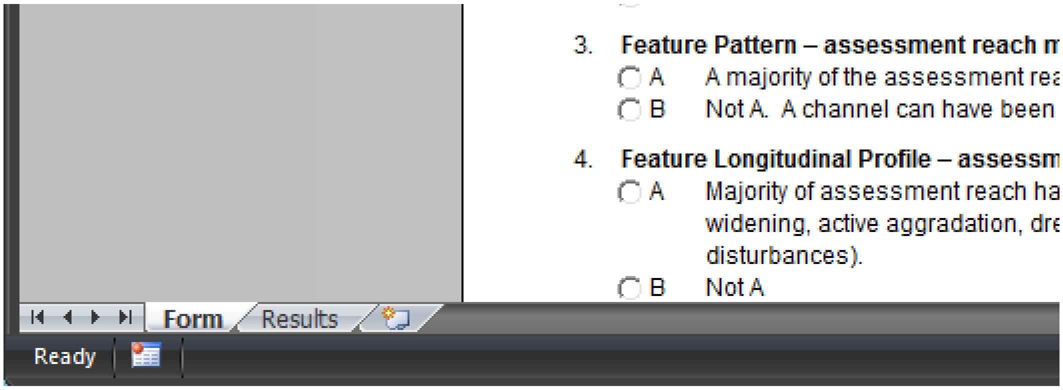


**Figure K-4**. Use the Form and Results tabs to toggle between the respective worksheets.

### K-2.3.1 Form Worksheet

The Form worksheet is displayed when the Rating Calculator opens. The Form worksheet contains all components of the NC SAM Field Assessment Form; each metric as well as the general stream information and notes sections are represented. Several different types of user interfaces are provided for inputting the stream assessment data: text fields, combo boxes, option buttons, and checkboxes.

Text fields provide space for information to be typed in via the keyboard. General project and stream information, such as the project name name, assessor name, and notes are input into text fields (Figure K-5). Information is input into text fields by clicking on a specific text field with the mouse and then typing with the keyboard. Click in the white space on the form to exit the text field.

Two combo boxes are used in the general stream information section of the Form worksheet to specify the assessed the county and river basin. The County combo box lists the 100 counties of North Carolina. The River Basin combo box lists the 17 river basins of North Carolina. The combo boxes are used by clicking the arrow on the right side of the combo box and selecting the appropriate entry from the dropdown list.

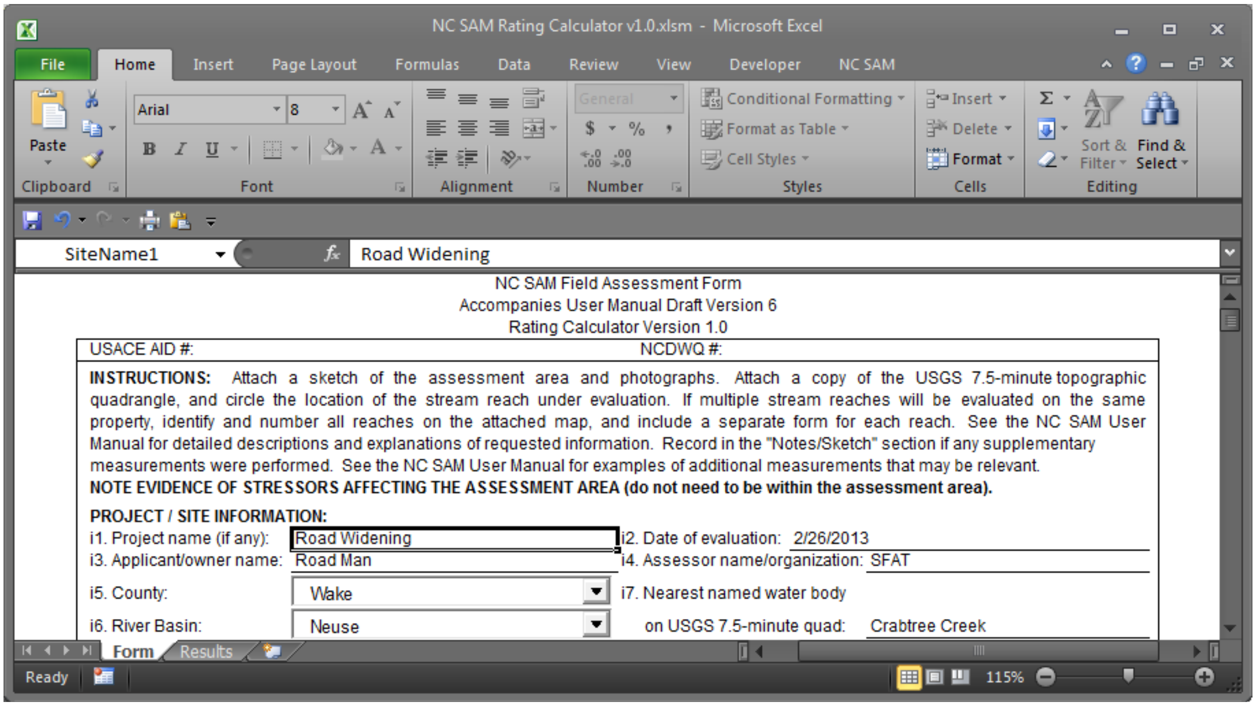


**Figure K-5**. Text field and combo box items on the Form worksheet.

Checkboxes and option buttons are used throughout the Form worksheet to record the selection of metric descriptors, regulatory considerations, and stream categories, among other items (Figure K-6). Checkboxes are used to select inclusive items. For instance, the presence of the water quality stressors listed in Metric 7 (Water Quality Stressors) is documented with checkboxes. The stressors are not necessarily exclusive of each other; multiple stressors may be observed within the assessed stream. Using checkboxes for inclusive scenarios, as is the case for Metric 7, allows multiple items to be selected at once.

Option buttons, in contrast, are used to select mutually exclusive items. Consider Metric 8 (Recent Weather) for example. The three descriptors of Metric 8 are mutually exclusive; the weather condition denoted by descriptor "A" can only occur absent the conditions described by descriptors "B" and "C," and vice versa. As such, only one metric descriptor can be selected for metrics with options buttons. In the event an option button is erroneously selected, it can be deselected with a double-click.

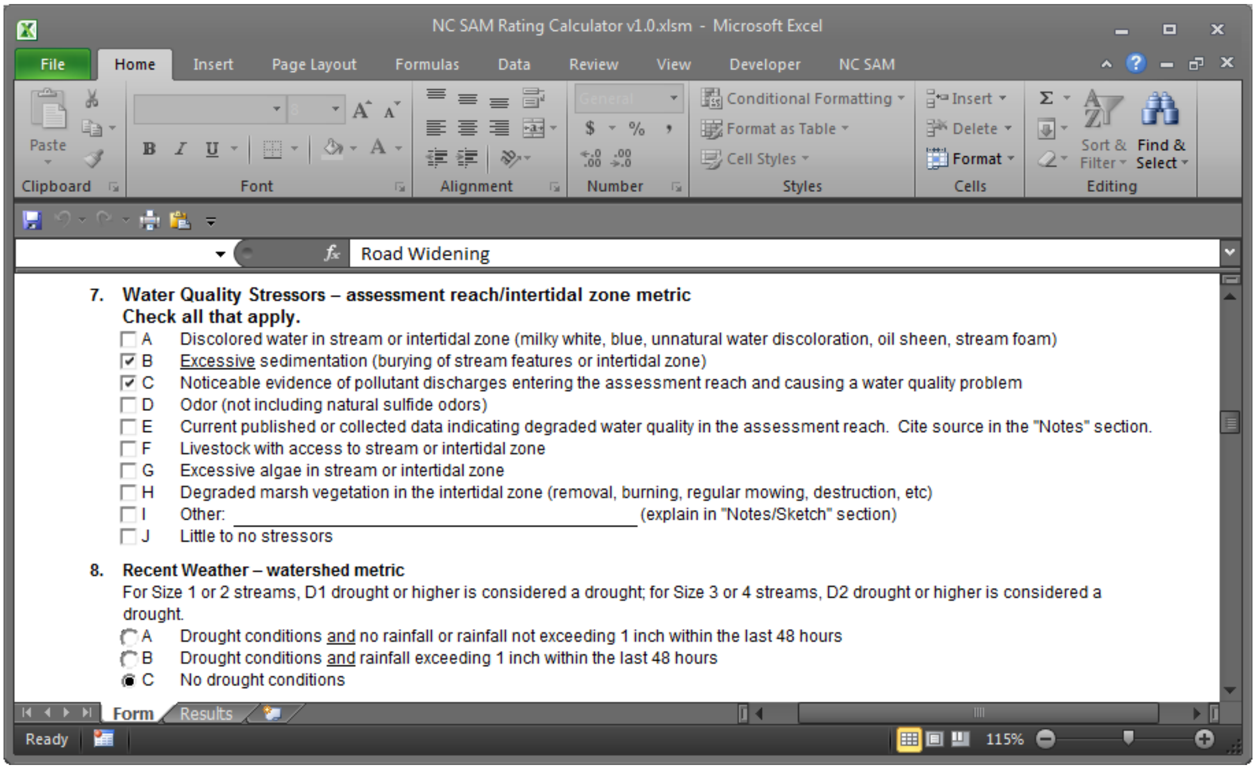


**Figure K-6.** Option buttons are used in Metric 5 for exclusive descriptors and checkboxes in Metric 6 for inclusive descriptors.

### K-2.3.2 Results Worksheet

The Results worksheet, the second worksheet in the Rating Calculator, displays general stream information and the calculated functional ratings as the NC SAM Stream Rating Sheet. The Results worksheet does not allow for user input, but simply displays the functional ratings as calculated. General stream information, such as stream site name and stream category, is automatically transferred from the Form worksheet.

## K-2.4 Generating Functional Ratings

The process of calculating stream functional ratings with the Rating Calculator is relatively simple: complete the NC SAM Field Assessment Form depicted in the Form worksheet by selecting the metric descriptors that apply to the assessed stream. To be thorough, general stream information, such as the project name and date, should be completed as well. As each metric is completed, the Rating Calculator automatically calculates the ratings for corresponding class functions. The calculated functional ratings are output to the Results worksheet. The rating for a particular class function, the Floodplain Access function for instance, is displayed after metric descriptors have been provided for all metrics applicable to the function. An overall stream rating is generated only after metric descriptors have been provided for all metrics applicable to the specified stream category.

The Rating Calculator operates dynamically, meaning stream functional ratings are automatically calculated after each change in the metric descriptors or stream category. For instance, the Rating Calculator could be completed for a Pa2 stream – metric descriptors provided for all necessary metrics and all functional ratings calculated. If a metric descriptor is changed for any metric, the Rating Calculator will automatically recalculate the functional ratings. If it were determined, after ratings calculation, that the stream category should be revised to Pa3, all that would be required to recalculate the functional ratings is to select the Size 3 descriptor from Information 17 in the general stream information section of the Field Assessment Form worksheet.

The feature type (Information 14), NC SAM zone (Information 15), geomorphic valley shape (Information 16), and watershed size (Information 17) (see NC SAM Field Assessment Form, p. vii) are used to determine the stream category and are required information for all stream assessments. Functional ratings cannot be generated until the stream category information is provided. In fact, the Rating Calculator produces a message with instructions to complete the stream category information if metric descriptors are selected beforehand.

### K-2.5 Viewing the Results

The Results worksheet can be viewed at any time while completing the Field Assessment Form on the Form worksheet by selecting the Results tab. The Results worksheet displays ratings for the class functions completed to that point. For instance, if only metrics pertaining to the Channel Stability class function have been completely specified, then only the Channel Stability class function rating will be presented.

As previously stated, the Results worksheet displays general stream information and function ratings without allowing any user input. The general stream information is transferred from the Form worksheet, while function ratings are determined by the imbedded macros. If no general stream information is provided on the Form worksheet, then none will appear on the Results worksheet.

A total of 41 Hydrology, Water Quality, and Habitat class functions are presented on the NC SAM Stream Rating Sheet, and in turn, the Results worksheet. Only a sub-set of the class functions will apply to a given stream category. The class functions pertaining to tidal streams, for instance, do not apply the any other stream categories. “NA” will appear in place of a rating to indicate that the class function is not applicable to the specified stream category (see Figure K-7).

Distinct class function ratings are also reported for streams determined with the use of the NCDWQ Stream Identification Form (NCDWQ 2010) to be intermittent. Two rating columns are provided on the Results worksheet, USACE/All Streams and NCDWQ Intermittent, to accommodate the separate ratings. In the case of perennial streams and Tidal Marsh Streams, no results are presented in the NCDWQ Intermittent column and the entire column is shaded gray to indicate it is disabled (Figure K-7). When the stream is intermittent, the NCDWQ Intermittent column is activated and ratings are presented in both the USACE/All Streams All Streams and NCDWQ Intermittent columns.

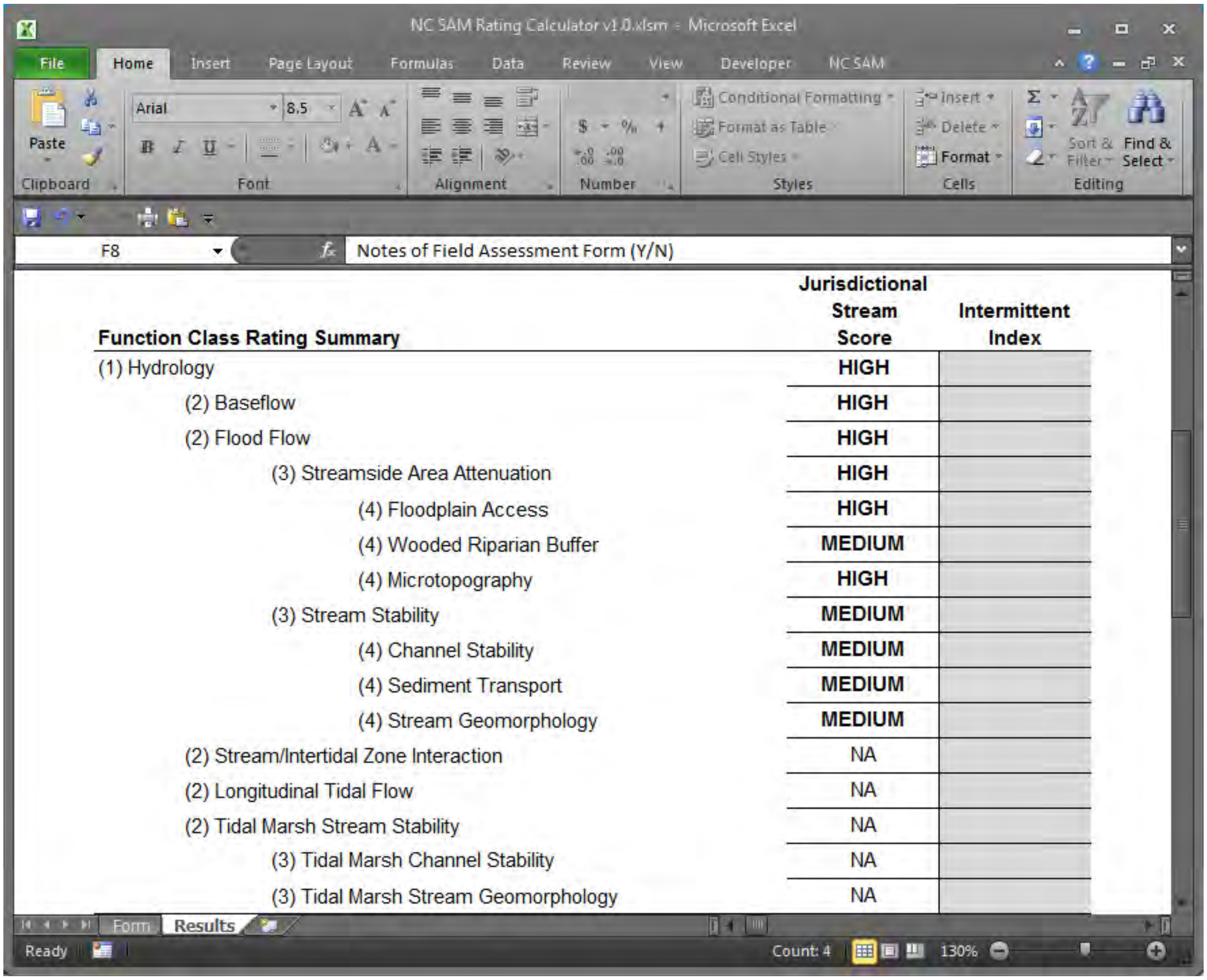


**Figure K-7**. Class functions not applicable to a stream category are indicated by an "NA" on the Results worksheet. The NCDWQ Intermittent column is shaded gray when the assessed stream has not been determined to be intermittent using the NCDWQ Stream Identification Form.

### K-2.6 NC SAM Menu

Beyond the user interfaces described above for the Field Assessment Form worksheet (Section K-2.2.1), the Rating Calculator also includes an NC SAM tab in the Excel's Ribbon (Figure K-8). The NC SAM tab includes two buttons for launching the Rating Calculator's "Clear" and "Write to Word" functions.

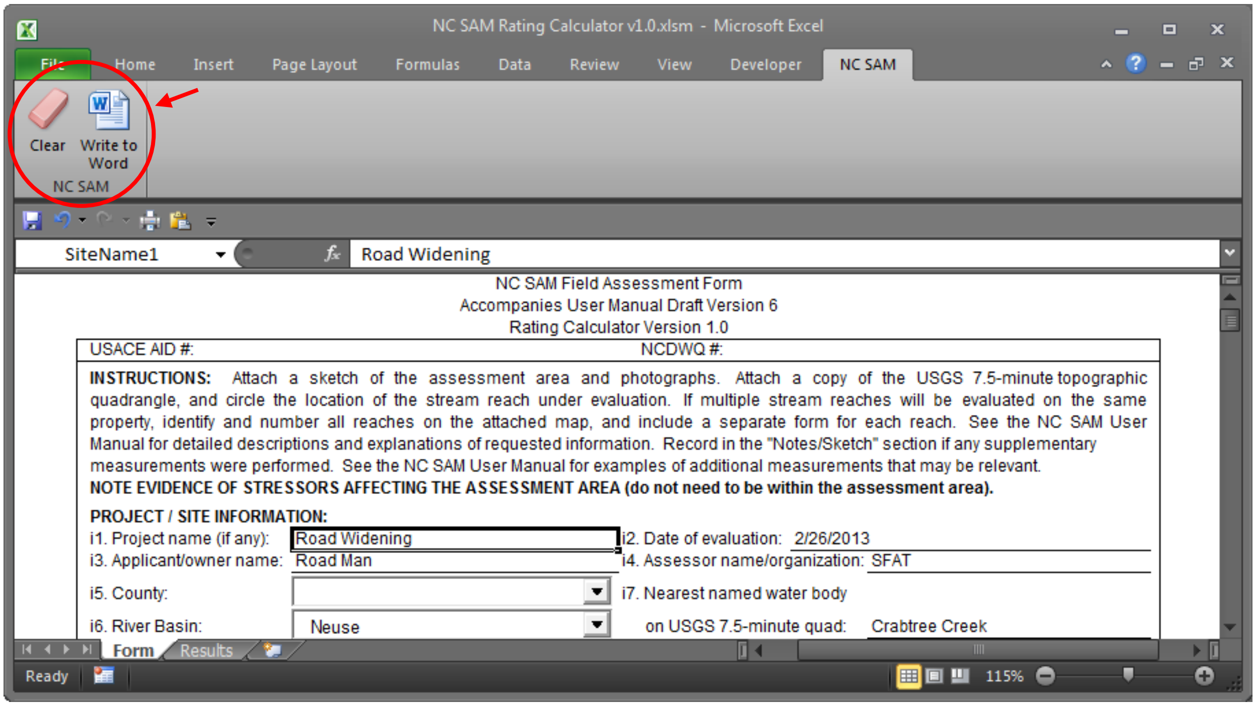

**Figure K-8**. The NC SAM tab is accessed from the Ribbon.

### K-2.6.1 Clear Function

The “Clear” function removes all content from the Form and Results worksheets, including general stream information, metric descriptor selections, and functional ratings. This function allows a new functional rating calculation to be started on clean Form and Results worksheets. To access the Clear function, select Clear from the NC SAM tab (NC SAM > Clear).

### K-2.6.2 Write to Word Function

The “Write to Word” function (NC SAM > Write to Word) compiles the content of the Form and Results worksheets into a single Microsoft Word document. Like the Rating Calculator, the resulting Word document is formatted to include both the NC SAM Field Assessment Form and the NC SAM Stream Rating Sheet. All items from the Form worksheet are transferred to the corresponding locations in the NC SAM Field Assessment Form of the Word document. All items on the Results worksheet are transferred to the corresponding locations in the NC SAM Stream Rating Sheet of the Word document.

The Rating Calculator Excel file is distributed with the StreamTemplate.dotx file. The Write to Word function requires the StreamTemplate.dotx file to operate. The StreamTemplate.dotx file is a Microsoft Word template used by the Write to Word function to reconstruct the formatting of the NC SAM Field Assessment Form and the NC SAM Stream Rating Sheet. While not necessary, it is recommended that the StreamTemplate.dotx file reside in the same directory as the Rating Calculator Excel file. If the StreamTemplate.dotx file is not stored in the same directory, a dialog will appear asking for the location of the file to be specified.

To initiate the Write to Word function, select Write to Word from the NC SAM tab (NC SAM > Write to Word). The Save As dialog appears. Navigate to the desired directory of the new Word document and provide a file name. Click Save. The Write to Word function transfers the contents of the Form and Results worksheets to the newly created Word document.

The Word document created by the Write to Word function is a digital record of the stream assessment. This is in contrast to the Rating Calculator itself, which is designed primarily for data processing and is not intended to be a storage bin for stream assessments. Compared to the Rating Calculator, the created Word document created by the Write to Word function has a smaller file size and the contents are easier to incorporate into reports or other documents.

## K-3.0 Summary

The extensive Boolean logic developed by the SFAT for each of NC SAM stream categories types has been encoded into the NC SAM Rating Calculator. By linking the Boolean logic to an intuitive user interface that resembles the NC SAM Field Assessment Form, the Rating Calculator expedites the conversion of stream assessment data to functional ratings by eliminating the arduous and error-prone task of manual processing. The Rating Calculator can export a completed stream assessment – general stream information, metric description selections, functional ratings, etc. – to a Word Document for storage or integration into reports. In all, the Rating Calculator provides a quick, user-friendly means of processing stream assessment data collected using NC SAM, while at the same time ensuring the integrity of the data processing.

# APPENDIX L

## Glossary of Terms

# Appendix L:  Glossary of Terms

Abundant – Greater than 40 but less than or equal to 70 percent coverage (from NCDWQ Habitat Assessment Field Data Sheet for Piedmont and Mountain Streams, v6 [NCDENR 2006]).

Abut/abuts – For the purposes of NC SAM, this term means "contiguous with" or "touching." This term is used in Metric 21 (Buffer Stressors).  A stressor is considered to be abutting an assessment reach if it extends to the top of bank.

Aggradation – The filling in, over time, of stream beds or floodplains by deposition of sediment eroded and transported from upstream.  Indicators of in-stream aggradation include the presence of large bars with stabilizing woody vegetation and coincident channel widening.  The presence of smaller bars of finer material without stabilizing vegetation is evidence of short-term deposition.

Algae – Benthic algae are photosynthetic organisms that live on substrates in the stream, such as rocks, sticks, leaves, or plants.  These algae can take the form of long, hair-like filaments, a crust-like coating, or as an invisible (but palpable) slimy biofilm growing on appropriate substrates.  Benthic algal abundance is strongly influenced by the amount of sunlight reaching the stream, relative rate of stream discharge, availability of appropriate substrates, and level of nutrient enrichment (NCDWQ 2010).  Algae, in limited coverage, provide a benefit to in-stream habitat.  However, "excessive" algae may remove and degrade in-stream habitat.  Algae is considered to be "excessive" when it is pervasive and readily apparent throughout the reach, thereby interrupting the food chain by smothering habitat and from death and decomposition of algae, resulting in oxygen depletion.

Alluvium – Deposits of unconsolidated or partially consolidated river-laid material in a stream valley (Leopold et al. 1992).

Alluvial valley – An alluvial valley is typically built by a meandering stream with overbank sediment deposits.  The bottom of the valley is dominated by material washed down from the valley (alluvium), with lesser amounts of material washed down from the valley sides (colluviums) along the periphery of the floodplain.

Altered/unaltered – NC SAM considers the term "altered" to mean a change from reference condition resulting from human activity.  NC SAM considers the term "unaltered" to mean unchanged by human activity.

Alternate bars – This term refers to a bedform resulting from unstable flow and characterized by the formation of sediment bars alternating on each stream bank.  Alternate bars are considered to be a precursor to meandering.

Anabranches – The individual channel segments of a of a multi-channel stream system (http://ga.water.usgs.gov/edu/dictionary.html).

Anadromous fish – Fish that spend their adult life at sea, but swim up-river to fresh water spawning grounds to reproduce.  Examples include shad, herring, and striped bass.  This term is often used interchangeably with "diadromous."  The term "diadromous" refers to any fish that migrates between saltwater and freshwater.

Anastomosed channel/stream – Successive division and rejoining of channels with accompanying islands; a type of multi-thread or multi-branched stream. This term implies a relatively stable system. See “braided” channel for comparison.

Aquatic organisms – NC SAM considers this term to refer to animals and plants that live in or on the water. This term includes amphibians, reptiles, fish, adult and larval invertebrates, and submerged or floating aquatic vegetation.

Aquatic macrophytes/vegetation – Plants attached or rooted beneath the mean water surface (both submerged and floating), including aquatic mosses, liverworts, lichens, and various flowering plants, but not including emergent plants.

Artificial substrate – Structures placed in streams that are not part of an ecological restoration project. Artificial substrate may include, but is not limited to rip-rap, bricks, concrete blocks, and treated lumber.

Aspect – A position facing a particular direction; outlook: the southern aspect of a house (http://dictionary.reference.com).

Assessment area – A defined area of stream and abutting land that is subject to functional assessment using the North Carolina Stream Assessment Method (NC SAM). The length of the assessment area is determined by the centerline length of stream. The width of the assessment area extends perpendicular to the stream from the normal wetted perimeter for 300 feet or to the edge of the watershed, whichever is reached first. For the purposes of NC SAM, 300 feet was determined to be the area that provides major benefits to stream function. If the assessment area contains a multi-branched channel, the width of the assessment area extends perpendicular from the outer channels for 300 feet or to the edge of the watershed, whichever is reached first. For Tidal Marsh Streams, the width of the assessment area extends perpendicular to the stream from the normal wetted perimeter for 300 feet or to the edge of the intertidal marsh, whichever is reached first.

Assessment reach – The defined reach of stream subject to functional assessment using the North Carolina Stream Assessment Method (NC SAM); more specifically, the area within the normal wetted perimeter (whether submerged or not) of the defined stream reach subject to the functional assessment. Typically, the length of the assessment reach is determined by 1) the extent of a proposed activity or project, 2) an NC SAM stream category boundary, 3) the confluence of streams of equal NC SAM watershed size, or 4) a change in stream or riparian area character or condition. When practicable, the assessment reach should include at least a portion of a riffle-run section and/or a pool-glide section to completely evaluate a full suite of in-stream bed features (Figure 4, p. 39). When not practicable to include both a riffle-run section and a pool-glide section in the assessment reach, and when a portion of at least one of these bedforms occurs within the assessment reach, a riffle-run section and/or a pool-glide section outside of, but still within sight of the assessment reach may be used in the evaluation. However, it is recommended that the assessor only utilize extra-assessment reach bedforms when in-stream or stream-side conditions are similar to those of the assessment reach; more specifically, do not use extra-assessment reach bedforms located beyond any of the other assessment reach terminus features listed above with the exception of item 1 (project boundary). An assessor should not use extra-assessment reach bedforms if natural bedform is absent from the assessment reach.

Bank – The sloping ground that borders a stream and confines water in the natural channel when the water level, or flow, is normal. Right and left banks are named facing downstream on non-tidal streams and toward the mouth of tidal streams.

Bank erosion – The process in which individual soil particles of a stream bank are carried away. The amount of erosion is affected by the presence and type of vegetation, soil composition of the bank, flow of water in the stream, and runoff from the land (Google's web definition tool).

Bank failure – Structural failure (collapsing or sloughing) of stream banks.

Bankfull/bankfull stage – The point at which water from a stream begins to overflow onto its floodplain, which may not be at the top of the stream bank on entrenched streams. Discharge at bankfull stage is most effective at moving sediment, forming and removing bars, shaping meanders and generally doing work that results in the morphological characteristics of channels (Dunne and Leopold 1978).

Bank height ratio – This variable is a field measurement that determines the degree of channel incision. It is calculated by dividing the maximum bankfull depth into the height of the lowest bank (http://water.epa.gov/scitech/datait/tools/warsss/pla_box07.cfm).

Bank seepage – Groundwater discharge from a stream bank. Physical evidence may include moving water, algae growth, and oxidized iron (orange).

Bank sweating – Groundwater discharge from a stream bank. Physical evidence may include soil surface glistening, algae growth, and oxidized iron (orange).

Baseflow – The sustained low flow of a stream, usually ground-water inflow to the stream channel (USGS Water Basics Glossary).

Best Management Practice (BMP) – A structural or nonstructural management-based practice used singularly or in combination to reduce nonpoint source inputs to receiving waters in order to achieve water quality protection goals (15A NCAC 2B .0202).

Bed/stream bed/aquatic bed – This term refers to the ground forming the bottom of a stream channel.

Bedform – Features that occur below the normal wetted perimeter of a stream such as riffle-pool complexes and step pools (see Figure 4, p. 39).

Bedrock – Native consolidated rock that underlies soils or other unconsolidated material (USGS Water Basics Glossary). Scouring by stream water may expose bedrock within the stream channel. For the purpose of NC SAM, the term "bedrock" refers to rocks partially or wholly within a stream with a median axis length of greater than 4096 millimeters (13.4 feet).

Bivalve – Mollusks that are laterally compressed and possess a shell with two valves, hinged dorsally, that completely enclose the body (Barnes 1980).

Boulder – For the purposes of NC SAM, the term "boulder" refers to rock fragments within a stream with a median axis length between 246 and 4096 millimeters (10 inches and 13.4 feet).

Braided channel/stream – Successive division and rejoining of channels with accompanying islands; type of multi-thread or branched stream. This term implies instability related to non-cohesive bank material and/or a lack of vegetation. Braided channels are typically found in situations characterized by low slope, depositional fans, and/or ground surface disturbance. See “anastomosed” channel for comparison.

Buffer, vegetated and wooded – For the purposes of NC SAM, a “vegetated buffer” is an area dominated by vegetation and abutting a stream. In this case, “vegetation” refers to both herbaceous and woody vegetation, regardless of height. An area dominated by vegetation has greater than 50 percent coverage of vegetation. Vegetated buffer breaks are areas lacking vegetation and greater than 10 feet wide. Vegetated buffer width is measured perpendicular to the stream from the top of bank to the first break. “Wooded buffer” is vegetation dominated (greater than 50 percent coverage) by woody species and abutting a stream. Wooded buffer breaks are areas not dominated by woody vegetation and greater than 10 feet wide. Wooded buffer width is measured perpendicular to the stream from the top of bank to the far side of woody stems along the first break. In terms of function, vegetated buffer provides the Water Quality functions of promotion of infiltration, erosion deterrent, and temperature moderation. Wooded buffer provides the Hydrology functions of energy dissipation of overbank flows from a stream, upland runoff toward a stream, and interception of precipitation, as well as the Habitat functions of temperature moderation and habitat diversity enhancement.

Bulkhead – For the purposes of NC SAM, a bulkhead is a vertical retaining structure of timber, steel, concrete, or other man-made material used for stream bank or shore protection in an unstable setting. Bulkheads typically provide shoreline stabilization by blocking or reflecting wave energy; however, the presence of bulkheads can lead to the destruction of shallow water habitat (http://dcm2.enr.state.nc.us/Handbook/section4.htm). NC SAM considers the presence of a bulkhead to be an indicator of an unstable bank. See also the definition of “retaining wall.”

Canal – See “ditch.”

Canopy – The canopy is the uppermost layer of vegetation in a plant community. In forested areas, mature trees comprise the canopy layer, while the tallest herbaceous species constitute the canopy layer in a marsh (Environmental Laboratory 1987).

Cascade – A small waterfall; one or a series of vertical drops of water. A cascade is considered to be more substantial than a step or series of steps.

Catchment – See watershed.

Causeway – A raised road or path, as across low or wet ground (http://dictionary.com).

Channel – A channel is a natural water-carrying trough cut vertically into low areas of the land surface by erosive action of concentrated flowing water or a ditch or canal excavated to carry the flow of water (15A NCAC 02B .0233 (2)(a)).

Channel hardening – Installation of non-erosive materials (rip-rap, stone, etc.) along the stream banks or within the stream channel. Channel hardening is usually undertaken to repair prior bank erosion and prevent future bank erosion. For the purposes of NC SAM, the presence of channel hardening is considered to be, *ceteris paribus*, an indicator of instability.

Channel instability – The active degradation of channel features. Signs of channel instability include but are not limited to bank collapse, channel widening, bed and bank scouring/erosion, channel down-cutting or incision, aggradation, and bank failure. Artificial hardening (even when it appears to be stable) is considered a sign of channel instability. An exception to this indicator is when artificial hardening has been applied as a standard part of a construction project (such as a sewer line crossing of a stream) and not in reaction to channel degradation.

Chroma – Soil colors are typically measured by comparison with a color chart from the Muncell Book of Color. The arrangement of color chips on these charts is by the dimensions that combine to describe all colors and are known in the Munsell system as "hue," "value," and "chroma." Chroma is the relative purity or strength of the spectral color. Chroma indicates the degree of saturation of neutral gray by the spectral color (Soil Survey Division Staff 1993).

Chute cutoff – An alternate stream channel formed across the mouth of a meander bend. Under normal flow conditions, the meander bend may be abandoned. Often, abandoned meander bends form oxbows.

Clear-cut – A regeneration method of timber harvesting in which all suitable trees within a designated area are removed while leaving ground material in place, along with stumps and usually some woody debris. For the purposes of NC SAM, assessors should consider an area to be clear-cut if a timber harvest has occurred and the regenerating woody vegetation is less than 10 feet tall on average.

Coastal Plain ecoregion – The Coastal Plain is a physiographic province/ecoregion that includes all areas extending eastward from the fall line/fall zone to the ocean. It consists of the areas with surface geology consisting of Cretaceous and younger sedimentary rocks and unconsolidated sediments. The Coastal Plain contains two Level III ecoregions according to Griffith et al. 2003: Middle Atlantic Coastal Plain and Southeastern Plains (Appendix E).

Cobble – For the purpose of NC SAM, the term "cobble" refers to rock fragments within a stream with a diameter of between 64 and 246 millimeters (2.5 and 10 inches).

Co-dominant tributary – If neither of two tributaries clearly exerts more influence over the in-stream and/or streamside area character at and below a confluence, both streams are considered to be co-dominant.

Colluvium – This term refers to material washed onto the floodplain from the valley sides (Leopold et al. 1992).

Colluvial valley – A colluvial valley is typically built by a relatively straight, steep stream with little sediment deposits from overbank flow. The bottom of the valley is dominated by material washed down from the valley sides.

Commercial horticulture – The cultivation of an orchard or nursery, including Christmas tree farms. The primary reason for including horticultural operations is the incidental soil compaction within the streamside area that results from maintenance of these areas. The NCDWQ has found that herbicides and pesticides used in association with horticultural operations are typically not a water quality problem for nearby streams.

Common – Term used by NC SAM that means greater than 10 but less than or equal to 40 percent coverage (from NCDWQ Habitat Assessment Field Data Sheet for Piedmont and Mountain Streams, v6).

Condition metric – A condition metric is any metric that is based on the inherent capacity of a stream to perform functions; a measurement of the extent to which a stream departs from full stream functional integrity. NC SAM uses condition as a surrogate for function because "condition" can be observed while "function" must be inferred or measured over a long period of time.

Conductivity – Conductivity is a measure of a solution's (i.e. water's) ability to carry an electrical current. The measurement is used in fresh water analyses to obtain a rapid estimate of dissolved solids or salts content of a water sample. A pristine mountain stream in North Carolina may have a conductivity measurement as low as 15 microsiemens per centimeter (µS/cm), and natural levels throughout the state are generally less than 100 µS/cm. In estuarine and marine waters, salinity is a more appropriate measurement of conductivity (http://www.enr.state.nc.us/html/c - terms.html). In fresh waters, high conductivity may indicate pollution from such sources as road salting, septic systems, wastewater treatment plants, or urban/agriculture runoff. An assessor should be aware that variations in watershed geology can result in natural fluctuations in conductivity. User Manual Appendix J contains information concerning specific conductance and benthic macroinvertebrates.

Confined animal operations – Facilities associated with production of animal products through the raising of livestock in large numbers in a limited space, resulting in the concentration of on-site animal byproducts.

Crenulation – A crenulation is a linear, topographic feature that is less defined than a channel or valley and may be characterized by "v"-shaped contour lines on topographic mapping. Crenulations are typically smaller-scale, localized features as opposed to larger-scale, landscape-wide features. Also see "reentrant." Field observations and/or detailed mapping are very important in determining the presence or absence of a topographic crenulation. Man-made crenulations are not considered "natural." Wetlands located within a natural topographic crenulation are considered to be riparian wetlands.

Critical habitat – "Critical habitat" for a Threatened or Endangered species means –

(i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of Section 4 of the Endangered Species Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and

(ii) (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of Section 4 of the Endangered Species Act, upon a determination by the Secretary that such areas are essential for the conservation of the species (the Endangered Species Act, http://www.fws.gov/endangered/esa-library/pdf/ESAall.pdf).

Culvert – A drain or covered channel that crosses under a road, railway, sidewalk, etc. (http://dictionary.reference.com).

Dam – A barrier to obstruct the flow of water, especially one of earth, masonry, etc., built across a stream or river (http://dictionary.reference.com).

Decimal degrees (or "deci-degrees") – The expression of a latitude or longitude in degrees only (rather than in minutes and seconds), typically written to six significant figures (example: 35.123456, -078.123456).

Dendritic channels – A multiple channel system in which the channels do not reconnect. Large-scale drainage patterns in most places in North Carolina are dendritic, with lower-order streams flowing into higher-order streams.

Deposition – The settling out of sediment. NC SAM considers this term in a positive light.

Descriptor – A descriptor is one of two or more options to be selected from when evaluating metrics on the Field Assessment Form. Directions on whether one descriptor or multiple descriptors may be selected are provided on an individual basis for each metric.

Detritus – "Detritus" is organic material of various sizes (including silt-size up to leaves, twigs, or bark) lying on the stream bed, including collecting in pools. Detritus, including loose leaves, filling a pool is usually a sign that dissolved oxygen is low because of microbial activity. A coating of silt-sized detritus on the bottom of a very small stream is doing the same thing – reducing dissolved oxygen available to aquatic life. Note: the presence of common detritus or more may suggest that dissolved oxygen is a problem for aquatic life.

Diameter at Breast Height (DBH) – The width of a plant stem as measured at 4.5 feet above the ground surface (Environmental Laboratory 1987).

Discharge – A point-source entry of a liquid into a stream. Discharges include stormwater runoff.

Discolored water – Water in streams characterized as milky white, blue, or any other unnatural color which is an indicator of a potential chemical or biological problem. This term does not refer to turbidity, a measure of the amount of solid particles that are suspended in water.

Distributary – A branch of a river that flows away from the main stream or one of the channels in a multi-thread stream (http://dictionary.reference.com/browse/distributary).

Ditch – A "ditch" or "canal" is a man-made channel other than a modified natural stream constructed for drainage purposes that may be dug through interstream divides, natural topographic crenulations, and in geomorphic floodplains. A ditch or canal may have flows that are perennial, intermittent, or ephemeral and may exhibit hydrological and biological characteristics similar to perennial or intermittent streams (15A NCAC 02B .0233(2)(d)). To be effective, a ditch must have an outlet and must eventually connect to a water body.

Dominant tributary – At the confluence of two or more streams, the dominant tributary is the tributary that clearly exerts the most influence over the in-stream and/or streamside area character at and below the confluence. The other tributary is the subordinate tributary.

Dominates/dominant – For the purposes of NC SAM, this term will have either of two meanings: 1) anything making up greater than 50 percent of a whole, and 2) at a confluence, the "dominant" tributary is the tributary that clearly exerts the most influence over the in-stream and/or streamside area character at and below the confluence.

Down-cutting – A process by which the streambed elevation is lowered, thereby deepening the stream. A consequence of down-cutting is a reduced frequency of overbank flooding.

Dredging – Removal of sediment or organic debris from the bed of a stream channel. For the purposes of NC SAM, "dredging" is considered to be an on-going practice – as opposed to "excavation," which is considered to be a one-time event.

Drought – A prolonged period of less-than-normal precipitation such that the lack of water causes a serious hydrologic imbalance (USGS Water Basics Glossary). For drought classifications, NC SAM will rely on the U.S. Drought Monitor – a synthesis of multiple indices, outlooks, and news accounts that represent a consensus of federal and academic scientists (http://drought.unl.edu/dm/index.html). The Drought Monitor generates maps labeling drought areas in order of intensity (D0 through D4), with D1 being the least intense and D4 being the most intense. D0 represents drought watch areas. Following is a brief description of each drought category. Refer to http://www.ncdrought.org/ for a map of North Carolina drought areas.

- D0 Abnormally dry. Going into drought or coming out of drought: characterized by water deficits and fire risk above average.
- D1 Moderate drought: characterized by some damage to crops; high fire risk; and low water levels in streams, reservoirs, or wells.
- D2 Severe drought: characterized by likely crop losses, very high fire risk, and water shortages are common.
- D3 Extreme drought: characterized by major crop losses, extreme fire risk, and widespread water shortages.
- D4 Exceptional drought: characterized by exceptional and widespread crop losses; exceptional fire risk; and shortages of water in reservoirs, streams, and wells creating water emergencies.

Dry detention basin – This is a man-made depression/basin constructed to temporarily store incoming stormwater, trapping suspended pollutants, and reducing the peak discharge from a site (NCDWQ 2007). These basins are typically dry between storm events. A low-flow outlet slowly releases water retained over a period of days.

Dry season – For the purposes of NC SAM, the term “dry season” uses the definition proposed by the U.S. Army Corps of Engineers in the regional supplements (USACE 2010a and 2010b) to the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory 1987): “the period of the year when soil moisture is normally being depleted and water tables are falling to low levels in response to decreased precipitation and/or increased evapotranspiration. This generally occurs in late spring and summer…” Additional guidance is provided in the aforementioned supplements.

Embeddedness – see “substrate embeddedness.”

Emergent vegetation/emergent plant – An emergent plant is a rooted herbaceous plant that has parts extending above a water surface (Environmental Laboratory 1987).

Entrenchment/incision – A vertical description of the stream. Flood flows in an entrenched or incised stream are contained within the stream banks or adjacent terraces. Flood flows in a stream that is not entrenched or incised are spread out over a floodplain (Harmon and Jennings 1999a)

Entrenchment ratio – The entrenchment ratio is a field measurement of channel incision. Specifically, it is the flood-prone width divided by the bankfull width. The flood-prone width is measured at the elevation of twice the maximum depth at bankfull (Harmon and Jennings 1999b).

Ephemeral (stormwater) flow/stream – An ephemeral stream is a feature that carries only stormwater in direct response to precipitation with water flowing only during and shortly after large precipitation events. An ephemeral stream may or may not have a well-defined channel, the aquatic bed is always above the water table, and stormwater runoff is the primary source of hydrology. An ephemeral stream typically lacks the biological, hydrological, and physical characteristics commonly associated with the continuous or intermittent conveyance of water (15A NCAC 02B .0233(2)(d)).

Erosion – The process whereby materials of the Earth's crust are loosened, dissolved, or worn away and simultaneously moved from one place to another (USGS Water Basics Glossary). For the purpose of NC SAM, erosion is a result of instability in the physical structure of a stream characterized by, but not limited to, bank collapse, channel widening, bed and bank scouring, channel down-cutting or incision, and aggradation.

Essential Fish Habitat (EFH) – Important habitat for federally managed fishery species. EFH is protected in accordance with 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) in an effort to maintain sustainable fisheries. Within the area encompassed by the NMFS Southeast Region, EFH has been identified for hundreds of marine species. Additional information is available at http://sero.nmfs.noaa.gov/hcd/efh.htm.

Example – An "example" is an instance serving for illustration; one of a number of things taken to show the character of the whole (http://dictionary.reference.com). For the purposes of NC SAM, the provision of a list of examples is always intended to be non-exhaustive.

Excavation/mining – Removal of sediment or organic debris from the bed of a stream channel. For the purposes of NC SAM, the terms "excavation" and "mining" are considered to be a one-time event– as opposed to "dredging," which is considered to be an on-going practice.

Excessive sedimentation – NC SAM considers sedimentation that buries channel features (mid-channel bars, filling of pools, streambed aggradation, burying of the whole channel) or floodplain or intertidal features to be excessive.

Extensive – "Extensive" is a relative term used in this assessment to indicate an amount greater than 50 percent. In Metric 6 (Streamside Area Interaction) the assessor is requested to make a determination among "little to no," "moderate," and "extensive" evidence of something. In this case, examples provided within the metric descriptor are intended to assist with the determination.

Exuviae – The cast skins, shells, or other coverings of animals (http://dictionary.reference.com).

Fall line/zone – The fall line or fall zone is a narrow zone encompassing a change in topography that separates the Piedmont and Coastal Plain physiographic provinces. Within this zone, the uplift of the Piedmont and Blue Ridge physiographic provinces has resulted in accelerated erosion, which, in turn, has resulted in a band of rapids and steep-sided valleys (Beyer 1991).

Feature – A formation or object in the landscape or a human-determined boundary. The specific definition is based on the contextual setting (examples: stream, pond, hill, project boundary, riffle, etc.).

Feature pattern – See "pattern."

Feature profile – See "profile."

Few – "Few" is a relative term used in this assessment to indicate an amount less than 25 percent of the total present within the assessment area.

Field Assessment Form – See "NC SAM Field Assessment Form."

Fine sediment – Sediment with a diameter less than 0.06 millimeters, or, more generally, fine sands and smaller particles.

Flashy flows – Water levels that rise quickly and subsequently fall quickly in response to a rainfall event. This term infers higher energy flows than a given reach and/or streamside area are capable of handling without stability degradation. Circumstances that may lead to flashy flows include watershed modifications that increase surface runoff (examples: vegetation reduction or removal and construction of impervious surfaces). Evidence of flashy flows includes, but is not limited to, bed and/or bank destabilization, channel and/or streamside area surface scouring, and damage to streamside vegetation

Flood flow – A relatively high stream flow that overtops the natural or artificial banks of any reach of a stream (USGS Water Basics Glossary).

Floodplain – The geomorphic floodplain is a valley formed in the past by floods which extended to the valley walls. The active floodplain is the land beside a river or stream that receives overbank flooding when discharge exceeds channel capacity. Evidence that a stream is accessing the floodplain include wrack/drift lines, surface scour, recent sediment deposition, water marks on trees, reclining vegetation, etc. Conditions that may adversely affect a stream's access to its floodplain include, but are not limited to, man-made berms and levees, down-cutting, fill or structures within the floodplain (spoil piles, logging roads, causeways, pipelines), and retaining walls. To roughly approximate the active floodplain (or flood prone) area, estimate the maximum stream depth at the bankfull elevation, double that height from the stream bed, and extend an imaginary line horizontally until it intersects the ground surface. The area within these imaginary limits may generally be considered the active floodplain.

Flow – Movement of water within a channel or over land.

Forest – NC SAM uses the term "forest" when considering the ability of a riparian buffer to filter upland runoff. This term implies an ecosystem which includes at least some cover by canopy trees. A forest may range in structure from complex (multiple layers) to simple (consist of a canopy with a relatively open understory). The term forest does not include maintained areas dominated by herbs and with scattered trees.

Gabion – Typically a metal basket filled with stones or earth, used as a retaining wall (http://dictionary.reference.com).

"Gaps associated with natural processes" – Processes not considered to be natural include man-maintained gaps, such as utility line and road corridors and maintained residential/commercial yards lacking appropriate shading.

Geographic Information System (GIS) – A computer system for capturing, storing, checking, integrating, manipulating, analyzing, and displaying data related to positions on the Earth's surface. Typically, a GIS is used for handling maps that may be represented as several different layers where each layer holds data about a particular kind of feature (e.g. roads). Each feature is linked to a position on the graphical image of a map (georeferenced).

Geomorphic valley shape – One of the characteristics used by NC SAM to determine stream categories: 1) broad floodplains characterized by flatter valley slope and more sinuous streams (designated “a” valley shape) and 2) narrow to no floodplains characterized by steeper valley slopes and less sinuous streams (designated “b” valley shape). See NC SAM Field Assessment Form Information 16 (p. vii) and User Manual Section 3.1.2 (p. 26). In general, the Hydrology functions of flood water attenuation and energy dissipation are very different between these two valley shapes.

Glide – For the purposes of NC SAM, the reach of stream immediately downstream of a pool where the stream bed is rising and the water is gaining velocity on its way into a riffle.

Grassed swale – A water quality grassed swale is a shallow open-channel drainage way stabilized with grass or other herbaceous vegetation that is designed to filter pollutants (NCDWQ 2007).

Gravel – For the purpose of NC SAM, the term “gravel” refers to rock fragments within a stream with a median axis length of between 2 and 64 millimeters (0.01 and 2.5 inches).

Groundwater – Groundwater is water occurring beneath the ground surface under saturated conditions (modified from 15A NCAC 02L .0102(11).

Growing season – The time frame within each year in which climatic conditions are favorable for vegetative growth. The growing season begins in a given year when two or more different non-evergreen vascular plant species exhibit one or more of the following indicators of biological activity: a) emergence of herbaceous plants from the ground, b) appearance of new growth from vegetative crowns, c) coleoptile/cotyledon emergence from seed, d) bud burst on woody plants, e) emergence or elongation of leaves of woody plants, and f) emergence or opening of flowers. A one-time observation of biological activity during a single site visit is sufficient. In addition, soil temperatures measured at the 12-inch depth of 41°F or higher indicate the growing season is in progress. The end of the growing season is indicated when woody deciduous species lose their leaves and/or the last herbaceous plants cease flowering and their leaves become dry or brown, generally in the fall due to cold temperatures or reduced moisture availability (modified from USACE 2010a and 2010b).

Habitat – The environment occupied by individuals of a particular species, population, or community (Environmental Laboratory 1987). The provision of aquatic habitat is considered by NC SAM to be one of the three primary (Class 1) functions of streams.

Head-cut – A point of instability in the stream channel marked by an abrupt, near vertical change in streambed elevation. The stream channel downstream of the head-cut often appears incised relative to the upstream channel.

Herb/herbaceous species/herbaceous vegetation – An herb is a non-woody plant, regardless of size (modified from USACE 2010a and 2010b).

High Quality Waters (HQW) – Supplemental classification intended to protect waters which are rated excellent based on biological and physical/chemical characteristics through NCDWQ monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Marine Fisheries

Commission. The following waters are HQW by definition: Water Supply I (WS-I), Water Supply II (WS-II), tidal salt waters used for commercial shell fishing or marketing purposes (Class SA), Outstanding Resource Waters (ORW), Primary Nursery Areas (PNA) or other functional nursery areas designated by the Marine Fisheries, Commission, or waters for which NCDWQ has received a petition for reclassification to either WS-I or WS-II (15A NCAC 02B .0301 and http://portal.ncdenr.org/web/wq/ps/csu/classifications).

Horticulture – See "commercial horticulture."

Hydrograph – A graph showing the variation of water flow in a stream with respect to time (http://water.usgs.gov/water-basics_glossary.html).

Hydrology – The science dealing with the properties, distribution, and circulation of water. Hydrology (the collection, transport, and overbank outflow and return of water) is one of the three NC SAM primary (or Class 1) functions of streams.

Impervious surface – "Impervious surface" means any material that prevents the natural infiltration of water into the soil (NC General Assembly SB 845, 2007 Session Law). Impervious surfaces include but are not limited to concrete, asphalt, roof tops, and gravel.

Impoundment – A flooded area created by damming a stream.

Incision/entrenchment – See "entrenchment/incision."

Indicator – An event, entity, or condition that typically characterizes a prescribed environment or situation; indicators determine or aid in determining whether or not certain stated circumstances exist.

Inner Coastal Plain NC SAM Zone – As part of development of the North Carolina Stream Assessment Method (NC SAM), the Stream Functional Assessment Team divided the state into four regions, based on ecoregion boundaries, called NC SAM Zones: Mountain, Piedmont, Inner Coastal Plain, and Outer Coastal Plain. The Inner Coastal Plain is comprised of the Southeastern Plains level III ecoregion and the Mid-Atlantic Flatwoods, Carolina Flatwoods, and the Mid-Atlantic Floodplains and Low Terraces level IV ecoregions. See User Manual Figure 2 (p. 25) for NC SAM Zone boundaries and Appendix E for North Carolina ecoregions. The Inner Coastal Plain varies from rolling to hilly terrain with sandy soils to lower, flatter terrain with broad, slow-draining flats of finer-textured soils and large, sluggish river systems (Griffith et al. 2002).

Instability, bank – Occurs when running water scours material from channel banks, resulting in undercut banks and an increased probability of bank collapse (modified from http://www.enr.state.nc.us/html/s_-_terms.html).

In-stream groundwater discharge – Stream bank sweating, stream bank seepage, and springs discharging into stream banks.

In-stream habitat – Habitat located within the channel that is inundated under normal stream flow conditions (within the normal wetted perimeter).

In-stream hardening – For the purposes of NC SAM, the armoring of the stream bed and/or a portion of the banks, thereby altering natural in-stream habitat types (see Metric 10a [Natural In-stream Habitat Types]).

Interflow – Interflow is rapid, unsaturated, subsurface water flow

Intermittent flow/stream – An intermittent stream has a well-defined channel that contains water for only part of the year, typically during winter and spring when the aquatic bed is below the water table. The flow may be heavily supplemented by stormwater runoff. An intermittent stream often lacks the biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water (15A NCAC 02B .0233(2)(g)).

Interstream divide/interstream flat – In the Coastal Plain, this term refers to a generally level landscape located between natural stream valleys (outside of floodplains and natural topographic crenulations).

Intertidal zone – The "intertidal zone" is the marsh contiguous with a Tidal Marsh Stream that is subject to regular or occasional flooding by lunar or wind tides. For the purposes of NC SAM, evaluations of the intertidal zone should focus on the portion of the intertidal zone contiguous to and within 300 feet of the assessment reach.

Inundation – A condition in which water from any source temporarily or permanently covers a land surface (Environmental Laboratory 1987). This term is inclusive of flooding and ponding.

Lap tree – A tree (living or dead) that extends laterally from the stream bank into the stream. Lap trees provide wildlife access between the stream and the streamside area.

Leaf pack – A "leaf pack" is a cluster of leaves that has been pushed into a pile by flowing water, usually against a stick, and usually off the bottom (not loose leaves lying on the stream bed). Flowing water keeps dissolved oxygen levels high, so good leaf packs in good streams support intolerant aquatic life. Note: the presence of leaf packs suggests enough flow that dissolved oxygen is not a problem for aquatic life. Leaf packs are an example of in-stream habitat.

Left bank – The left bank of a stream from the perspective of facing downstream (Twain 1883).

Lentic (ecosystem/habitat) – This term refers to standing-water habitats as found in ponds and lakes, which typically differ from lotic ecosystems/habitats (moving-water habitats) in having low to no current, potentially having lower oxygen content, more temperature stratification, and flora and fauna adapted to these characteristics (Smith 1980).

LiDAR – This is an acronym for "Light Detection and Ranging." LiDAR is a device similar to radar in principle and operation but using infrared laser light instead of radio waves and capable of detecting particles and varying physical conditions in the atmosphere (http://dictionary.reference.com). Downward-looking LIDAR instruments fitted to aircraft and satellites are used for surveying and mapping (http://en.wikipedia.org/wiki/LIDAR). LiDAR data are used to generate topographic maps.

Lithology – the description of rocks on the basis of color, structure, mineral composition, and grain size; the physical character of a rock (http://www.isgs.uiuc.edu/glossary.shtml#L).

Little – "Little" is a relative term used in this assessment to indicate an amount less than 10 percent, unless defined otherwise.

Livestock – This term refers to cattle, horses, poultry, and similar animals kept for domestic use (http://dictionary.reference.com).

Log – For the purposes of NC SAM, the size of a "log" varies among stream categories. A log is a linear piece of woody debris large enough that it is not expected to move during a bankfull event. Therefore, a log can be a smaller size on smaller streams and a larger size on larger streams. Conversely, a "stick" is a linear piece of woody debris small enough to move during a bankfull event.

Longitudinal profile – See "profile."

Lotic (ecosystem/habitat) – This term refers to running-water habitats as found in streams and rivers, which typically differ from lentic ecosystems/habitats (standing-water habitats) in having currents much of the time, potentially having higher oxygen content, less temperature stratification, and flora and fauna adapted to these characteristics (Smith 1980).

Macroinvertebrate – Animals without backbones that are larger than 0.5 millimeter (http://www.dnr.state.md.us/streams/pubs/benthic_macroinvertebrates.pdf).

Macrophyte – See "aquatic macrophyte."

Maintained turf – Land use where intensive management, assuming regular application of fertilizers, herbicides, and/or pesticides, occurs as would be expected in a residential or commercial yard, a golf course, or sod farm. This term does not include roadside shoulders, fallow fields, regularly burned areas, or regularly mowed areas where there is no application of fertilizers, herbicides, and/or pesticides. A lawn or other herbaceous assemblage is considered to be "maintained turf" if the assessor has evidence that fertilizers, herbicides, and/or pesticides are regularly applied.

Majority – "A majority of" is a relative term used in this assessment to indicate an amount greater than 50 percent of the total.

Many – "Many" is a relative term used in this assessment to indicate an amount between 25 and 50 percent of the total.

Mature forest – Mature forest has an appropriately stratified vegetative structure comprised of large canopy trees, a sub-canopy of smaller trees and saplings, and an understory.

Meander – A bend in the stream channel.

Metric – A specific inquiry required by NC SAM to evaluate the inherent characteristics of a stream that affect its ability to perform a given function. The NC SAM Field Assessment Form (pp. vii-x in the User Manual) utilizes 25 metrics in its functional assessment.

Metric-Function Class Diagram – A metric-function class diagram is a depiction of how metric ratings are combined to generate functional class ratings and an overall rating for an assessment area. Appendix C provides a set of metric-function class diagrams for all NC SAM stream categories.

Mid Channel Bar – Sediment accumulation in the middle of a stream. Mid-channel bars are not inherently "bad" or always a sign of excessive sedimentation. They can come and go as a part of natural channel processes.

Mining/excavation – Removal of sediment or organic debris from the bed of a stream channel. For the purposes of NC SAM, the terms "mining" and "excavation" are considered to be a one-time event– as opposed to "dredging," which is considered to be an on-going practice.

Moderate – "Moderate" is a relative term used in this assessment. In Metrics 6 and 13 (Streamside Area Interaction and Streamside Area Ground Surface Condition, respectively) the assessor is requested to make a determination among “little to no,” “moderate,” and “extensive/severe.” In each case, examples provided within the metric descriptors are intended to assist with these determinations.

Modified natural stream – A modified natural stream is an on-site channelization or relocation of a stream channel and subsequent relocation of the intermittent or perennial flow as evidenced by topographic alterations in the immediate watershed. A modified natural stream must have the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water (15A NCAC 02B .0233(2)(h)).

Modified vegetation structure – A vegetation community that has had a portion or all of one or more stratum removed (examples: the understory has been removed from a park, or the canopy has been removed or thinned from a forest).

Mosquitofish (*Gambusia affinis* and *Gambusia holbrooki*) – This small fish inhabits sluggish, backwater habitat such as ditches and canals where there is often little dissolved oxygen. It is tolerant of water quality stressors. This species is also referred to as “ditch minnows.”

Mountain NC SAM Zone – As part of development of the North Carolina Stream Assessment Method (NC SAM), the Stream Functional Assessment Team divided the state into four regions, based on ecoregion boundaries, called NC SAM Zones: Mountain, Piedmont, Inner Coastal Plain, and Outer Coastal Plain. This NC SAM Zone occurs within the same footprint as the Blue Ridge level III ecoregion. See User Manual Figure 2 (p. 25) for NC SAM Zone boundaries and Appendix E for North Carolina ecoregions. The Mountain NC SAM Zone varies in character from narrow ridges to hilly plateaus to more massive mountainous areas with high peaks (Griffith et al. 2002).

Mudminnow (eastern mudminnow, *Umbra pygmaea)* – This small fish inhabits sluggish, backwater habitats where there is often little dissolved oxygen. This species is tolerant of water quality stressors.

Natural bed substrate – The stream bed composition is appropriate for the setting. This term does not include man-made materials such as concrete and bricks and natural materials such as rip-rap and gravel when not appropriate for the setting (such as in Coastal Plain streams). Materials used for the purposes of stream restoration (rock and gravel) are considered natural bed substrate when used in the appropriate setting.

Natural gaps – Gaps that form in a forest canopy when trees fall as a result of “natural processes” such as lightning strikes, disease, and storms. Large, widespread canopy gaps, even to the point of canopy loss, due to fire or hurricane damage are considered natural gaps.

Natural sand-bed streams – Natural sand-bed streams will be characterized by predominantly sand-sized particles (fragments with a median axis length of between 0.062 and 2 millimeters) in the streambed. However, riffle sections and natural bars may contain up to 30 percent fine and very fine gravel-sized particles (fragments with a median axis length of larger than 2 millimeters [0.08 inch] but less than 4 millimeters [0.16 inch]). Parent material with a similar grain size distribution should be evident in the banks, streamside areas, and/or the floodplain valley wall. For some natural sand-bed streams, stream banks and floodplain valley walls may contain saprolite. Saprolites associated with natural sand-bed streams will be highly weathered, friable, and break down easily into sand and finer gravel-sized particles. Outside the Coastal

Plain, natural sand-bed streams will usually be associated with "a" valley shapes (User Manual p. 26) and lower stream and stream valley gradients.

NCDWQ Intermittent – One of two column headings for stream ratings on the Stream Assessment Sheet (p. xi). For streams determined with the use of the current NCDWQ Stream Identification Form (NCDWQ 2010) to be intermittent, a second set of class and overall ratings are provided in the "NCDWQ Intermittent column. Ratings presented in this column are generated using alternative Boolean logic, relative to ratings presented in the USACE/All Streams column, to reflect a potential difference in amount of function provided by streams determined with the NCDWQ Stream Identification Form to be intermittent. If the assessed stream was not determined to be intermittent, "NA" (Not Applicable) will appear in the NCDWQ Intermittent column.

NCDWQ Stream Identification Form – A form used as part of the N.C. Division of Water Quality Methodology for Identification of Intermittent and Perennial Streams and Their Origins (NCDWQ 2010). The form allows an assessor to use a numerical system of scoring for making the determination. Scores less than 19.0 indicate ephemeral streams, scores between 19.0 and less than 30.0 indicate intermittent streams, and scores of 30.0 or more indicate perennial streams.

NC SAM Field Assessment Form – The NC SAM Field Assessment Form is included at the beginning of the User Manual (see pp. vii-x). The form contains an introductory box containing 19 informational questions (Information 1-19) followed by 25 metrics (1-25). A discussion of the informational questions is provided in User Manual Section 4.2.1: Introductory Information (p. 41), and a discussion of metrics is provided in User Manual Section 4.2.2: Metrics (p. 47).

NC SAM Rating Calculator – The NC SAM Rating Calculator is a macro-enabled Microsoft Excel 2007 workbook consisting of a pair of worksheets that resemble the NC SAM Field Assessment Form and Stream Rating Sheet. The purpose of the Rating Calculator is to automate functional rating calculations. Stream assessment data collected in the field and input into the Rating Calculator is automatically passed through the logic chain of a specified stream category. The result is a Stream Rating Sheet populated with the functional ratings. The Rating Calculator is discussed in User Manual Section 5.5.2 (p. 172), and instructions for operating the Rating Calculator are provided in Appendix K.

NC SAM Stream Rating Sheet – The result from using the Rating Calculator is a Stream Rating Sheet populated with the functional ratings. The Stream Rating Sheet is comprised of three sections: project information, additional information, and function class rating summary. A blank example of the Stream Rating Sheet is provided as p. xi at the beginning of the User Manual. Discussions of the contents of the Stream Rating Sheet are provided in User Manual Section 5.5.2 (p. 172) and Appendix K.

NC SAM Zone – As part of development of the North Carolina Stream Assessment Method (NC SAM), the Stream Functional Assessment Team divided the state into four regions, based on ecoregion boundaries, called NC SAM Zones: Mountain, Piedmont, Inner Coastal Plain, and Outer Coastal Plain. The Mountain Zone is equivalent to the Blue Ridge level III ecoregion. The Piedmont Zone is equivalent to the Piedmont level III ecoregion. The Inner Coastal Plain Zone is comprised of the Southeastern Plains level III ecoregion and the Mid-Atlantic Flatwoods, Carolina Flatwoods, and the Mid-Atlantic Floodplains and Low Terraces level IV ecoregions.

The Outer Coastal Plain Zone is comprised of the Chesapeake-Pamlico Lowlands and Tidal Marshes and Nonriverine Swamps and Peatlands level IV ecoregions. See User Manual Figure 2 (p. 25) for NC SAM Zone boundaries and Appendix E for North Carolina ecoregions.

Non-native/exotic invasive species – This designation includes species that are not indigenous to a region, are intentionally or accidentally introduced, and are often persisting. See Appendix I for a list of species considered to be non-native invasive species in North Carolina for the purposes of NC SAM. While numerous non-native species occur in North Carolina, the emphasis is on those with the ability to become abundant in natural or disturbed streamside areas and displace or prevent recovery of native species.

Normal flow – The expected stream flow at a particular time of year given typical weather conditions.

Normal wetted perimeter – For the purposes of NC SAM, the portion of the channel (bed and bank) that is below the ordinary high water mark. In Tidal Marsh Streams, the normal wetted perimeter includes the portion of the channel below the vegetation line on the stream banks (if present) – the sub-tidal portion of the channel.

No till – "Tillage" is the plowing of land for weed and pest control and to prepare for seeding. "No till" refers to a reduction in how often or how intensively the soil is tilled (Horowitz et al. 2010). No-till practices allow the soil to retain more organic matter and moisture and reduce the rate of surface water runoff, sediment transport, and fertilizer, herbicide, and pesticide drift to nearby streams.

Nutrient Sensitive Waters (NSW) – NCDWQ classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation (http://portal.ncdenr.org/web/wq/ps/csu/classifications and 15A NCAC 02B .0301).

Obstruction – A structure that impedes stream flow. NC SAM differentiates between obstructions that pass some flow during low-flow periods (man-made structures such as leaky dams, bottom-release dams, and weirs and natural structures such as fallen trees, debris piles, and beaver dams) and obstructions that do not pass flow (man-made structures such as water-tight dams and weirs and natural structures such as bedrock sills, some fallen trees, and some sediment deposits).

Ordinary high water mark – "That line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas" (USACE Regulatory Guidance Letter No. 05-05, dated December 7, 2005).

Organic debris – See "detritus"

Outer Coastal Plain NC SAM Zone – As part of development of the North Carolina Stream Assessment Method (NC SAM), the Stream Functional Assessment Team divided the state into four regions, based on ecoregion boundaries, called NC SAM Zones: Mountain, Piedmont, Inner Coastal Plain, and Outer Coastal Plain. The Outer Coastal Plain is comprised of the Chesapeake-Pamlico Lowlands and Tidal Marshes and Nonriverine Swamps and Peatlands level IV ecoregions. See User Manual Figure 2 (p. 25) for NC SAM Zone boundaries and

Appendix E for North Carolina ecoregions. The Outer Coastal Plain occurs on the lowest marine terrace east of the Suffolk Scarp in northeastern North Carolina and on flat, poorly drained areas containing organic soils along the full extent of the North Carolina coast (Griffith et al. 2002).

Outstanding Resource Waters (ORW) – All outstanding resource waters are a subset of High Quality Waters (HWQ). This supplemental classification is intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance (http://portal.ncdenr.org/web/wq/ps/csu/classifications and 15A NCAC 02B .0301).

Overbank flooding – Any situation in which inundation occurs as a result of the water level of a stream rising above bank level (Environmental Laboratory 1987).

Pasture (land use) – Pasture is considered to be a land use wherein the ground surface is maintained in grasses and herbs to provide forage for livestock. Hay fields, which typically are not plowed and do not support livestock, are included in this category.

Pattern, stream/channel pattern – The sinuosity or meander geometry of a stream (USACE et al. 2003).

Perched culvert – A culvert situated so that the bottom of the inlet end or the outlet end (or both) is located above the elevation of the stream bed.

Perennial flow/stream – A perennial stream has a well-defined channel that contains water year round during a year of normal rainfall with the aquatic bed located below the water table for most of the year. Groundwater is the primary source of water for a perennial stream, but it also carries stormwater/overland runoff. A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water (15A NCAC 02B .0233 (2)(i)).

Piedmont NC SAM Zone - As part of development of the North Carolina Stream Assessment Method (NC SAM), the Stream Functional Assessment Team divided the state into four regions, based on ecoregion boundaries, called NC SAM Zones: Mountain, Piedmont, Inner Coastal Plain, and Outer Coastal Plain. This NC SAM Zone occurs within the same footprint as the Piedmont level III ecoregion. See User Manual Figure 2 (p. 25) for NC SAM Zone boundaries and Appendix E for North Carolina ecoregions. The Piedmont NC SAM Zone is a transition between the Mountains and the Coastal Plain and is a complex of irregularly dissected plains and some hills (Griffith et al. 2002).

Plane bed stream – In geology, upper plane bed refers to the configuration of the bed (or bedform) of a river that is flat and characterized by a unidirectional flow with high rates of sediment transport as both bed load and suspended load, while a lower plane bed refers to the configuration of the bed of a river that is flat and characterized by low rates of sediment transport (American Geological Institute 2005).

Pollutant – According to the NCDWQ, a pollutant is generally, any substance introduced into the environment that adversely affects the usefulness or health of a resource (http://www.enr.state.nc.us/html/p - terms.html). According to the USACE, the following items are considered pollutants: dredged spoil, solid waste, incinerator residue, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials not covered by the Atomic Energy Act, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water (Section 404(b)(1) Guidelines, 40 CFR Section 230.3). NC SAM accepts both definitions.

Pond – Open, still bodies of water, smaller than lakes (less than 20 acres). Ponds are effectively impoundments and may be man-made (farm ponds, small impoundments) or natural (beaver ponds, vernal pools). For the purposes of NC SAM, ponds include wet detention basins but not sediment basins or dry detention basins (see text associated with Metric 16 [Baseflow Contributors]).

Pool – A part of a stream reach with deeper, slower-moving water (relative to the remainder of the stream) with fine bed materials (Gordon et al. 1992). Pools are expected to occur on the outside of meander bends or at the bottom of steps. Pools are relatively flat compared with riffles. Pools are not to be confused with impoundments/ponds.

Pool-glide section – A pool-glide section of stream is characterized by a reach with deeper, slower-moving water, relative to the remainder of the stream, with fine bed materials followed by a reach over a rising bed causing the water to gain velocity as it nears entrance to a riffle. Pool-glide sections are relatively flat in comparison with steps and riffle-run sections.

Predominant/predominantly – Any feature that makes up greater than 70 percent of a whole.

Primary Nursery Area (PNA) – Tidal salt waters which provide essential habitat for the early development of commercially important fish and shellfish and are so designated by the Marine Fisheries Commission. Information concerning the location of Primary Nursery Areas is available in 15A NCAC 03R .0103. The assessor should use best professional judgment when considering if the distance between the assessment area and a designated PNA makes selection of this descriptor appropriate.

Profile, stream/feature profile/feature longitudinal profile – The bed elevations of a channel along its length. “Appropriate” channel profile is somewhat dependent on the landscape location of a stream reach. Streams within steeper valleys may be characterized by a step-pool profile. Streams in flatter valleys may be characterized by alternating riffle-run and pool-glide sections. Riffles are expected to occur on straight sections of streams and are relatively steep in comparison with pools. Pools are expected to occur on the outside of meander bends or at the bottom of steps. Pools are relatively flat compared with riffles.

Promingent – An animal that urinates in a forward direction because of bodily configuration (modified from Aristotle, circa 350 B.C.E., *History of Animals*).

Rare – Present, but with less than 10 percent coverage (from NC DWQ Habitat Assessment Field Data Sheet for Piedmont and Mountain Streams, v6).

Rating Calculator – See “NC SAM Rating Calculator.”

Reach – A section of stream. Depending on how it is used, the term may refer to either a specific (assessment reach) or general (… the reach shown by the photo…) section of stream.

Recent rain – A measurable rainfall (0.1 inch or greater) in the past 48 hours.

Reduced soils – Soils in a reduced, or oxygen-depleted, environment. In the absence of oxygen, certain mineral ions (mainly iron and manganese) within the soil become chemically reduced and are leached from the parent material. Reduced soils may be identified by their dark (low chroma) color. A “reducing environment” is one conducive to the removal of oxygen and chemical reduction of ions in the soils (Environmental Laboratory 1987).

Reference/reference condition – For the purposes of NC SAM, this term refers to a representative example (there may be more than one) of a stream category without indications of recent, substantial human disturbance. NC SAM recognizes that this term includes a range of biotic and abiotic characteristics within each stream category and considers “reference” to be synonymous to “relatively undisturbed.”

Reference interaction – This term is used in Metric 6 (Streamside Area Interaction). For the purposes of this metric, the term “reference” is synonymous with “unaltered.” This term refers to both the hydrological interaction between the stream and the floodplain and the hydrological interaction between the contiguous uplands and the floodplain. This term also refers to the interaction between the streamside area and the stream in terms of transport into the stream of leaves, sticks, and logs that will enhance aquatic habitat. For Tidal Marsh Streams, this term refers to the hydrological interaction between the stream and the intertidal zone marsh as well as the hydrological interaction between contiguous uplands and the intertidal zone marsh.

Refugia – The plural form of “refuge;” a place of shelter, protection, or safety (http://dictionary.reference.com). This term is used by NC SAM to refer to depressions offering habitat for aquatic species during low tide in the intertidal zone.

Retaining wall – For the purposes of NC SAM a retaining wall is a wall for holding in place a mass of earth or the like in a stable setting, such as at the edge of a terrace or excavation (modified from http://dictionary.reference.com). NC SAM does not consider the presence of a retaining wall alone to be an indicator of an unstable bank. See also the definition of “bulkhead.”

Retendent feature(s) – Streamside area microtopographic relief that retains floodwaters and upland runoff.

Retromingent – An animal that urinates in a backward direction because of bodily configuration (http://dictionary.reference.com).

Riffle – A part of a stream reach with shallower, faster-moving water with coarser bed materials (relative to the remainder of the stream) (Gordon et al. 1992). Riffles can be expected to occur on straight sections of streams and are relatively steep in comparison with pools.

Riffle-pool sequence – An alternating succession of riffle and pool stream features. In an undisturbed riffle-pool stream, riffles typically occur in straight sections of streams and pools typically occur on the outside of bends – this is considered to be an appropriate channel profile.

Riffle-run section – A riffle-run section of stream is characterized by a reach of shallower, faster-moving water with coarser bed materials, relative to the remainder of the stream, followed by less turbulent water as it deepens and slows on its way into a pool. Riffle-run sections typically occur on straight reaches and are relatively steep in comparison with pools.

Riffle substrate embeddedness – See “substrate embeddedness.”

Right bank – The right bank of a stream from the perspective of facing downstream (Twain 1883).

Riparian area – NC SAM considers the riparian area to be the area of land abutting the stream channel, extending outward from the top of the bank.

Riparian buffer – See "buffer."

Ripple – A shallow part of a sand-bed stream where water flows swiftly over submerged small "dunes" in the streambed to produce surface agitation (http://water.usgs.gov/wsc/glossary.html#A). NC SAM considers "ripple" to be a Coastal Plain subset of "riffle." Ripples can be expected to occur on straight sections of streams.

Rip-rap – Rock or other aggregate (of any size) that is placed to protect stream banks, bridge abutments, fords, or other erodible sites from stream scour, runoff, or wave action (modified from http://www.enr.state.nc.us/html/r_-_terms.html).

Root mat – A mass of plant roots extending from a stream bank into the water column or along the stream bed. Root mats provide both aquatic habitat and stability to stream beds and banks.

Row crops – "Row crops" refers to a land use wherein the ground surface is maintained for the planting of crops (examples: tobacco, corn, soy beans, cotton, tomatoes) and the land is subject to fertilizers, herbicides, and pesticides. This land use includes areas regularly plowed as well as areas subject to no-till practices. Although no-till fields typically receive lower levels of fertilizers and pesticides and are characterized by less runoff and export to streams than regularly plowed fields, no-till fields typically receive more herbicides than regularly plowed fields and are irregularly plowed. The determination of whether or not a field is used for row crops is based on evidence at the site on the day of the evaluation (some examples include stubble in fields from previous growing season and recently plowed).

RTFM – "Read the flippin' manual" (when spoken, frequently followed by an emphatic "baby").

Run – For the purposes of NC SAM, this term refers to the reach of stream immediately downstream of a riffle where the water is less turbulent as the channel deepens and the water slows on its way into a pool.

Sand – For the purpose of NC SAM, the term "sand" refers to rock fragments within a stream with a median axis length of between 0.062 and 2 millimeters.

Sand bed streams – See "natural sand bed streams."

Sand dipping – The periodic dredging of a river for the purpose of removing sand.

Sapling – Woody plants approximately 20 feet in height and less than 3 inches in diameter at breast height (DBH) (modified from USACE 2010a and 2010b).

Saprolite – Underlying rock that has weathered in place to the degree that it is loose enough to be dug with a spade (Brady 1999).

Scattered trees – This term refers to an altered buffer structure that contains trees but in less density than would be expected to occur in an unaltered situation. A park setting with scattered mature trees is an example of this structure.

Scour – The erosive effect caused by stream flow on surfaces of the stream bed, bank, and streamside area.

Section 10 water – Section 10 waters are those waters subject to Section 10 of the Rivers and Harbors Act of 1899, which include all navigable waters of the United States. "Navigable waters of the United States" is defined in 33 CFR Part 329 as those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which impede or destroy navigable capacity. (Note, however, that "navigable waters" is only a subset of "waters of the United States," which include not only navigable waters of the United States, but also waters with "a significant nexus to navigable waters," both of which are covered under the Clean Water Act.).

Sediment – Solid fragments of inorganic or organic material that come from the weathering of rock and are carried and deposited by wind, water, or ice (http://dictionary.reference.com).

Sediment deposition/sedimentation – The deposition or accumulation of eroded soil material (sediment). See also "excessive sedimentation." Sediment deposition is considered to be recent when characterized by no plant growth since deposition.

Sediment bars – Depositional areas within the stream channel that extend above the water surface during normal flows.

Sediment load – Sediment transported by stream flow.

Sediment transport – The process by which sediment is moved by stream flow.

Seep – Seeps are areas that are semi-permanently to permanently saturated by groundwater discharge. For the purpose of NC SAM, these areas are typically found on sloping hillsides or at the base of floodplain slopes where impervious layers force groundwater to the surface.

Seepage – See "bank seepage."

Severely – A descriptive term used to emphasize the extent to which an event affects an object or the environment – in this case, having enough substance to make an extreme difference. When this term is used in NC SAM, it is typically followed with descriptive examples.

Shrub – Woody plants less than 20 feet in height (modified from USACE 2010).

Silt – For the purposes of NC SAM, the term "silt" refers to mineral particles within a stream with a median axis length of less than 0.062 millimeters.

Sinuosity – This term refers to the ratio of the channel length between two points on a channel to the straight-line distance between the same two points; a measure of meander (http://water.usgs.gov/wsc/glossary.html#A).

Snag – For the purposes of NC SAM, a dead tree or part of a dead tree held fast in the bed or bank of a stream which provides aquatic habitat.

Snagging – The act of removing a tree or part of a tree held fast in the bottom of a river, lake, etc.

Sparse – "Sparse" is a relative term used in this assessment to indicate that the subject is present but with less than 10 percent coverage.

Spring – Place where a concentrated discharge of ground water flows at the ground surface (http://water.usgs.gov/water-basics_glossary.html). Springs typically immediately form a channel or contribute baseflow to an adjacent stream.

Stable – The ability of the stream to retain its channel dimension over a period of time. A stable stream is capable of conveying its stream flow without experiencing channel incision, bank failure, or aggradation.

Stem – The main trunk of a woody plant.

Stem density – The number of woody plant stems over a given area. Woody stems provide energy dissipation of overbank and flows and upland runoff.

Step – A vertical drop in steam channel elevation formed at non-erosive point in the stream channel, often at a boulder, bedrock outcrop, or tree trunk or root. Steps may occur on steep streams.

Step pools/step-pool sequence/step-pool section – A step-pool section of stream is characterized by an alternating succession of step and pool stream features with fast, high-energy water moving over a steep bed of bedrock or boulders. Step-pools typically occur on steeper reaches than riffles.

Stick – For the purposes of NC SAM, the size of a "stick" varies among stream categories. A stick is a linear piece of woody debris small enough to move during a bankfull event. Therefore, a stick can be a smaller size on smaller streams and a larger size on larger streams. Conversely, a "log" is a linear piece of woody debris that is large enough to not move during a bankfull event.

Stone (natural channel design versus rip-rap) – Fragments of aggregated mineral material.

Stormwater – Overland runoff resulting from rainfall events.

Stream – For the purposes of NC SAM, the terms "stream" and "tributary" are synonymous, referring to an open conduit or conveyance of surface water, either naturally or artificially created, that periodically or continuously contains moving water from storm flow, overland flow, discharged ground water, or a combination of the aforementioned. Both of these terms (stream and tributary) imply federal and/or state jurisdictional status.

Stream bank – See "bank."

Stream bed – See "bed."

Stream category – Through professional experience, office discussions, and field trials, the Stream Functional Assessment Team has divided North Carolina streams into 29 general categories for the purposes of the North Carolina Stream Assessment Method (NC SAM). Twenty-eight of these categories are based on geographic position, valley slope, and watershed size, and are organized as depicted by Table 1. The 29$^{th}$ stream category is Tidal Marsh Stream.

Stream channel – A defined linear depression that confines a stream. A stream channel is composed of sloping sides (stream banks) and a ground surface (streambed).

Stream profile – See "profile."

Stream Rating Sheet – See "NC SAM Stream Rating Sheet."

Streamside area – NC SAM considers the streamside area to be the area of land contiguous with the assessment reach, extending perpendicular to elevation contour lines to a distance of 300 feet or to the edge of the natural topographic high point, whichever is reached first. For multi-thread channels, the streamside area is the area of land contiguous with the outermost channels, extending perpendicular to elevation contour lines to a distance of 300 feet or to the edge of the natural topographic high point, whichever is reached first. For the purposes of NC SAM, 300 feet has been determined to be the extent of area for consideration of major benefits to stream function. The assessor should include areas in the streamside area that artificially drain away from the assessment reach. Examples of such alterations include curb-and-gutter roads and parking lots, ditches, berms, stormwater diversion, and grading. Therefore, in order to capture alterations from reference, the streamside area may extend outside of the current watershed of the assessment reach. For Tidal Marsh Streams, streamside area is equivalent to the marsh intertidal zone (consisting of either of two NC WAM wetland types: Salt/Brackish Marsh or Tidal Freshwater Marsh) extending from the normal wetted perimeter of the channel, perpendicular to the tidal stream to the edge of marsh or to a distance of 300 feet, whichever is reached first.

Streamside habitat – For the purposes of NC SAM, streamside habitat refers to the portion of the streamside area that influences or enhances stream habitat.

Stressors - A typically anthropogenic activity that affects one or more stream functions by altering the stream from reference condition. The response of a stream to a stressor depends on stream size, landscape, and severity of the stressor. Examples of stressors may include nutrient enrichment/eutrophication, organic loading and reduced dissolved oxygen, contaminant toxicity, acidification, salinization, sedimentation/burial, turbidity, vegetation removal/alteration, thermal alteration, and impoundment (modified from Adamus and Brandt 1990). Stressors are anticipated to always degrade the condition of a stream. NC SAM considers on-site evidence of stressors to include discolored water, excessive sedimentation, water quality problems resulting from pollutant discharges, odor, livestock with access to the stream, excessive algae, and degraded vegetation.

Submerged aquatic vegetation – For the purposes of NC SAM, Metric 10b (Natural In-Stream Habitat Types), the term “submerged aquatic vegetation” follows the definition used by the North Carolina Coastal Resources Commission (CRC): “Beds of submerged aquatic vegetation (SAV) are those habitats in public trust and estuarine waters vegetated with one or more species of submergent vegetation. These vegetation beds occur in both sub-tidal and intertidal zones and may occur in isolated patches or cover extensive areas” (15A NCAC 07H .0208 [6]). Example species of submerged vegetation include eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*), and widgeon grass (*Ruppia maritima*). SAV beds are defined by the presence of above-ground/bed leaves or the below-ground rhizomes and propagules together with the sediment on which the plants grow.

Subordinate tributary – At the confluence of two streams, the dominant tributary is the tributary that clearly exerts the most influence over the in-stream and/or streamside area character at and below the confluence. The other tributary is the subordinate tributary.

Substantial/Substantially – This is a descriptive term used to emphasize the extent to which an event affects an object or the environment – in this case, having at least enough substance to make a difference. When this term is used in NC SAM, it is typically followed with descriptive examples.

Substrate – The composition of the assessment reach below the ordinary high water mark/normal high water mark. The surface beneath a stream in which organisms grow or to which organisms are attached (modified from http://water.usgs.gov/wsc/glossary.html#A).

Substrate embeddedness – The degree to which fine sediment surrounds the coarse sediments of the streambed surface. "Riffle substrate embeddedness" refers to the degree of substrate embeddedness only within assessment area riffles.

Surface runoff – That part of the runoff which travels over the soil surface to the nearest stream channel. It is also defined as that part of the runoff of a drainage basin that has not passed beneath the surface since precipitation. (http://water.usgs.gov/wsc/glossary).

Swamp stream – "Swamp streams" occur within the Coastal Plain NC SAM zones (both the Inner Coastal Plain and the Outer Coastal Plain), are wadeable at some point in the year (not too big), regularly use their large floodplains, may exhibit either an intermittent or perennial flow regime, and normally have no visible flow during a part of the year. This low-flow period usually occurs during summer months, but flowing water should be present in swamp streams during the winter months. Other typical characteristics of swamp streams include low dissolved oxygen, low pH (high acidity), and aquatic life populations with low species diversity. Swamp streams include both multi-thread and single-thread channels. For the purposes of NC SAM, swamp streams are characterized by stable channels; unstable channels are not candidates for swamp streams. An excavated channel (such as a ditch or canal) within a natural topographic crenulation is not a swamp stream if it is deep enough so that groundwater flows all year and/or it does not regularly use its relatively large floodplain. Ditches and canals on interstream divides are not candidates for swamp streams.

Tannic water – Water stained to a tea color through the leaching of tannic acids from leaves. For the purposes of NC SAM, tannic water is not a Water Quality stressor.

Taxa – Taxa is the plural form of taxon, a taxonomic category or group, such as a phylum, order, family, genus, or species (http://dictionary.reference.com).

Thalweg – Literally means "valley way" and is the deepest point of a cross section. It is the low-flow channel of the stream (Harmon and Jennings 1999a).

Tide/tidal gate – A gate through which water flows when the tide is in one direction and that closes automatically when the tide is in the opposite direction (http://dictionary.reference.com).

Tidal Marsh Stream – For the purposes of NC SAM, a Tidal Marsh Stream is a stream subject to lunar and/or wind tides that is bounded by a tidal marsh. Tidal marshes include NC Wetland Assessment Method (NC WAM) general wetland types Salt/Brackish Marsh and Tidal Freshwater Marsh (WFAT 2010).

Tidal waters – A situation in which the water level periodically fluctuates due to the action of lunar and solar forces upon the rotating earth (Environmental Laboratory 1987). For the purposes of NC SAM, "lunar tides" refer to water table fluctuations due to the action of lunar and solar gravity, and "wind tides" refer to water table fluctuations due to the action of wind on the water surface.

Tillage – The plowing of land for weed and pest control and to prepare for seeding (Horowitz et al. 2010).

Transverse bar – A transverse bar is a slightly submerged sand bar extending perpendicular to the shoreline.

Tree – Trees are woody plants approximately 20 feet or more in height and 3 inches or more in diameter at breast height (DBH) (modified from USACE 2010a and 2010b).

Tributary – For the purposes of NC SAM, the terms "tributary" and "stream" are synonymous, referring to an open conduit or conveyance of surface water, either naturally or artificially created, that periodically or continuously contains moving water from storm flow, overland flow, discharged ground water, or a combination of the aforementioned. Both of these terms (stream and tributary) imply federal and/or state jurisdictional status. The term "tributary may also be used to refer to one stream that flows into another, such as "an unnamed tributary to…". Also see "co-dominant tributary," "dominant tributary," and "subordinate tributary."

Trout waters – For the purposes of NC SAM, this term refers to an NCDWQ supplemental classification intended to protect freshwaters for natural trout propagation and the survival of stocked trout (15A NCAC 02B .0301). To receive a Trout waters (Tr) classification, the proposed open water must have conditions that will sustain and allow for trout propagation and survival of stocked trout on a year-round basis (15A NCAC 02B .0202). Unnamed tributaries that drain to Tr waters are also (by definition) trout waters. Find NCDWQ Trout water mapping at http://portal.ncdenr.org/web/wq/ps/csu/maps under the heading "GIS Downloads" in the bullet entitled "Named and Unnamed Water Bodies (w/ classifications)." Mountain waters that support trout and are open to public fishing are designated "Public Mountain Trout Waters" by the NCWRC; this is a different definition than that used by the NCDWQ (http://www.ncwildlife.org/Portals/0/Regs/Documents/2011-12/2011-12_MountainTrout.pdf).

Turbidity – The amount of solid particles that are suspended in water and that cause light rays shining through the water to scatter. Thus, turbidity makes the water cloudy or even opaque in extreme cases. Turbidity is measured in nephelometric turbidity units (NTU) (http://ga.water.usgs.gov/edu/dictionary.html).

Turf (maintained) – See "maintained turf."

Unaltered/altered – See "altered/unaltered."

Undercut bank – An area of bank adjacent to the mean water level of a stream where energy from moving water has scoured a shelf in the bank. Undercut banks are typically considered to be stable fixtures which provide aquatic habitat, as opposed to eroding banks which are unstable and degrade aquatic habitats.

Understory – Strata within a mature forest below the canopy and sub-canopy. The understory may consist of saplings, shrubs, and/or herbs.

Unstable – The ability of the stream to retain its channel dimension over a period of time. An unstable stream is not capable of conveying its flow without experiencing channel incision, bank failure, or aggradation.

Urban stream – As a rule of thumb, an urban stream is characterized by greater than 24 percent impervious surface in the upstream watershed and/or is subject, on a regular basis, to flashy flows following precipitation events. Based on site conditions, an assessor can invoke best professional judgment to classify a stream as urban or not, regardless of watershed impervious surface or flashiness.

USACE/All Streams – One of two column headings for stream ratings on the Stream Assessment Sheet (p. xi). For all assessed streams, the different levels of class and overall ratings are provided in the "USACE/All Streams" column.

Valley width/channel width ratio – This variable is a field measurement that determines the degree of channel confinement, an indicator of how much a channel can move within its valley before it is stopped by a hill slope, terrace, or other hard point. It is calculated by dividing the valley width (measured from toe of hill slope on each side of the stream) by the channel width (http://www.ecy.wa.gov/programs/sea/sma/cma/page5.html).

Vegetated buffer – See "buffer."

Visible watershed – The portion of the assessment reach's watershed visible from the assessment reach (for example, about 300 feet).

Voids – The empty space between streambed materials.

Wasting threat – A bank that is being undercut by erosive hydrological forces. In this situation, the bank is unstable and could collapse at any time, potentially introducing turbidity in the water column and excessive sedimentation.

Wastewater discharge – The release of used water from homes, industries, and businesses (http://water.usgs.gov/water-basics_glossary.html). Stormwater discharges are not considered here to be wastewater. Wastewater discharges are considered to be constant while stormwater discharges are episodic.

Water quality – A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to the suitability of water for a particular purpose (http://www.enr.state.nc.us/html/w_-_terms.html). Water Quality is one of the three NC SAM primary (Class 1) stream functions.

Watershed – The NCDWQ (and NC SAM) considers the watershed to be the entire land area contributing surface drainage to a specific point (15A NCAC .02B .0200). The USACE uses the term "catchment" to refer to this same concept. For the purposes of NC SAM, the "watershed" of an assessment area includes the area draining to the lowest point of the assessment reach. Watershed size can be determined with the use of topographic mapping, which identifies geographical barriers that separate watersheds.

Water storage capacity – In Metric 13 (Streamside Area Ground Surface Condition), this term refers to both ground surface microtopography and soil interstitial capacity with respect to the ability to store water from overbank events, precipitation, and upland runoff.

Water table – Water table is the surface of the saturated zone below which all interconnected voids are filled with water and at which the pressure is atmospheric (15A NCAC 02L .0102(27)).

Weir – A dam placed across a river or canal to raise or divert the water, as for a millrace, or to regulate or measure the flow (http://dictionary.reference.com).

Wet detention basin – This is a man-made depression/basin that includes a permanent pool of water for removing pollutants and additional capacity above the permanent pool for detaining stormwater runoff. Water in the permanent pool mixes with and dilutes the initial runoff from storm events and allows for quiescent settling. These basins fill with stormwater and release most of the mixed flow over a period of a few days, slowly returning the basin to its normal depth (NCDWQ 2007).

Wetland – “Wetlands" are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (33 CFR 328.3(b)). The term “wetlands,” as used by NC SAM, refer to areas that meet the criteria set forth by the USACE in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987) and the Regional Supplements (USACE 2010a and 2010b).

Wetted perimeter, normal – See “normal wetted perimeter.”

Widening – The expansion of the stream channel along the minor horizontal axis (side-to-side).

Wooded riparian buffer – The term “wooded” refers to trees and shrubs (not woody vines). A wooded riparian buffer is an area of vegetation with greater than 50 percent coverage by woody plants adjacent to a water body that reduces runoff and non-point source pollution and attenuates flood flows by decreasing water flow velocity. See “buffer.”

Wrack lines – Debris carried by flood flow that collects behind obstructions (trees and shrubs) in the streamside area and intertidal zone.