Appendix 3A. Habitat assessment algorithms.

GCUTypePoolPct: Relative proportion of the total length of all geomorphic channel units (GCUs) that are comprised of pools, in percent

Derivation:

1. Ignore GCU's where GCU length is not reported
2. Ignore GCU's where GCU length = 0
3. Calculate GCUTypePoolPct as:
4. GCUTypePoolPct = SUM(lengths of all pool geomorphic channel units) / GCULengthSum) * 100

Remarks: Calculation is **based on sum of individual GCU measurements (GCULengthSum), NOT on total curvilinear reach length** (RchLength). This because there are significant number of cases where sum of individual GCU's <> total reach length. Since this is relative proportion of measured GCU's that are pools, calculation is based on GCU length measurements.

GCUTypeRiffPct: Relative proportion of the total length of all geomorphic channel units that are comprised of riffles, in percent.

Derivation:

1. Ignore GCU's where GCU length is not reported
2. Ignore GCU's where GCU length = 0
3. Calculate GCUTypeRiffPct as:
4. GCUTypeRiffPct = SUM(lengths of all riffle geomorphic channel units) / GCULengthSum) * 100

Remarks: Calculation is **based on sum of individual GCU measurements (GCULengthSum), NOT on total curvilinear reach length** (RchLength). This because there are significant number of cases where sum of individual GCU's <> total reach length. Since this is relative proportion of measured GCU's that are pools, calculation is based on GCU length measurements.

GCUTypeRunPct: Relative proportion of the total length of all geomorphic channel units that are comprised of runs, in percent.

Derivation:

1. Ignore GCU's where GCU length is not reported
2. Ignore GCU's where GCU length = 0
3. Calculate GCUTypeRunPct as:
4. GCUTypeRunPct = SUM(lengths of all run geomorphic channel units) / GCULengthSum) * 100

Remarks: Calculation is **based on sum of individual GCU measurements (GCULengthSum), NOT on total curvilinear reach length** (RchLength). This because there are significant number of cases where sum of individual GCU's <> total reach length. Since this is relative proportion of measured GCU's that are pools, calculation is based on GCU length measurements.

GCUTypePoolRiff: Ratio of the proportion of pool geomorphic units to the proportion of riffle geomophic channel units.

Derivation:

GCUTypePoolRiff = GCUTypePoolPct / GCUTypeRiffPct

WidthWet (N, Min, Max, Avg)

Variables:

1. WidthWetN = number of observations of wetted channel width
2. WidthWetMin = minimum wetted channel width, in meters
3. WidthWetMax = maximum wetted channel width, in meters
4. WidthWetAvg = mean wetted channel width, in meters

Derivation:

1. Ignore transects where wetted channel width was not recorded.
2. Ignore transects where wetted channel width = 0.

Then, for each reach characterization sample:

1. count the number of transects with wetted channel width > 0 (WidthWetN)
2. determine miniumum wetted channel width (WidthWetMin)
3. determine maximum wetted channel width (WidthWetMax)
4. calculate mean wetted channel width as:

   WidthWetAvg = SUM(WidthWet) / WidthWetN

Depth (N, Min, Max, Avg, Cv)

Variable Definitions:

1. DepthN = number of transect point wetted-channel depth observations
2. DepthMin = minimum wetted channel depth, in meters
3. DepthMax = maximum wetted channel depth, in meters
4. DepthAvg = mean wetted channel depth, in meters
5. DepthCv = coefficient of variation of wetted channel depth, in percent

Derivation:

1. Ignore transect points where depth was not recorded.
2. Use all other transect point depth measurements (**including depths = 0**)

Then, for each reach characterization sample, where Depth = depth from surface to bottom in meters.

1. count the number of transect points with a depth measurement (DepthN)
2. determine miniumum depth (DepthMin)
3. determine maximum depth (DepthMax)
4. calculate mean depth (DepthAvg) as:
5. DepthAvg = SUM(Depth) / DepthN
6. calculate standard deviation of depth (Stdev) as:
7. Stdev = square root [sum((Depth-DepthAvg)^2) / DepthN - 1]
8.
9. where:
10. Depth = Depth at transect point i
11. DepthAvg = mean depth for reach
12. DepthN = number of depth measurements
13. calculate coefficient of variation (DepthCv) as:
14. Stdev / DepthAvg * 100

Remarks:

1. Calculations are based on all depth measurements, **including depths = zero.**
2. **If mean depth in reach = 0 then DepthCv is not calculated.** The algorithm does not attempt to re-scale values to avoid zero mean.

WidthDepth (N, Min, Max, Avg)

Base variable = WidthDepth = wetted channel width-depth ratio **for each transect**

Variable Definitions:

1. WidthDepthN = number of transects where wetted channel width-depth ratio can be calculated
2. WidthDepthMin = minimum wetted channel width-depth ratio
3. WidthDepthMax = maximum wetted channel width-depth ratio
4. WidthDepthAvg = mean wetted channel width-depth ratio

Derivation:

1. ignore transects where wetted channel width is missing or = 0
2. ignore transects where average depth along transect = 0
3. calculate the wetted channel width-depth ratio **for each transect** as:
4. WidthDepthTran = WidthWet at transect / average depth at transect
5. count the number of transects where width-depth ratio can be calculated (WidthDepthN)
6. determine the minimum width-depth ratio in the reach (WidthDepthMin)
7. determine the maximum width-depth ratio in the reach (WidthDepthMax)
8. calculate the mean width-depth ratio for reach as:
9. WidthDepthAvg = SUM(WidthDepth at each transect) / (WidthDepthN)

BFWidth (N, Min, Max, Avg)

Base variable = bankfull width = BFWidth = ChnWidthBnkFull

Variable Definitions:

1. BFWidthN = number of transects where bankfull width was measured
2. BFWidthMin = minimum bankfull width, in meters
3. BFWidthMax = maximmum bankfull width, in meters
4. BFWidthAvg = minimum bankfull widith, in meters

Derivation:

1. Ignore transects with missing bankfull width measurement
2. Ignore transects where bankfull width = 0
3. Ignore transects where bankfull width is not explicitly reported (see remarks below).
4. count the number of transects having bankful width measurement (BFWidthN)
5. determine the minimum bankful width in the reach (BFWidthMin)
6. determine the maximum bankful width in the reach (BFWidthMax)
7. calculate the mean bankful width for reach as:
8. BFWidthAvg = SUM(BFWidth at each transect) / (BFWidthN)

Remarks:

1. Algorithm does not verify that bankfull channel width is >= wetted channel width
2. **Algorithm only uses explicitly declared bankfull width values** - no attempt is made to calculate it using channel feature attributes such as bar width, shelf width, island width, or bank width. This means that it is not determined for many of the cycle I reach habitat samples that were collected using the original NAWQA habitat protocols.

BFDepth (N, Min, Max, Avg)

Base variable = bankfull depth = **bank height** = LBHIGH, RBHIGH = BankHeightRB, BankHeightLB

Variable Definitions:

1. BFDepthN = number of transects where mean bankfull depth can be calculated for reach characterization sample
2. BFDepthMin = minimum bankfull depth, in meters
3. BFDepthMax = maximum bankfull depth, in meters
4. BFDepthAvg = mean bankfull depth, in meters

Derivation:

1. ignore bank height measurements = 0
2. ignore transects that do not have any bank height measurements
3. for each transect, calculate the average bank height at transect as:
4. BFDepthTran = LBHIGH + RBHIGH / N
5.
6. where:
7. LBHIGH = left bank height at transect, in meters
8. RBHIGH = right bank height at transect, in meters
9. N = number of bank height measurements at transect

BFDepthTran is used as the bankfull depth at the transect. When 2 bank height measurements are available this averages the two readings (N = 2). When only one bank height measurement is available (N=1) then the calculation yields that measurement

.

10. count the number of transects having bankfull depth (bank height) data > 0 (BFDepthN).
11. determine the minimum bankfull depth in the reach (BFDepthMin)
12. determine the maximum bankfull depth in the reach (BFDepthMax)
13. calculate the average bankfull depth for reach as:
14. BFDepthAvg = SUM(BFDepth at each transect) / (BFDepthN)

Remarks:

1. Bank height measurements are notoriously problematic. They depend on accurately identifying the top of the bank and measuring the vertical distance from the deepest part of the channel to that surface. The top of the bank is often difficult to identify.
2. BFDepth for each transect is used in calculation of BFWidthDepth statistics

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BFWidthDepth (N, Min, Max, Avg)

Base variables are bankfull width (BFWidth) and bankfull depth (BFDepth) at each transect

Variable Definitions:

1. BFWidthDepthN = number of transects where bankfull width-depth ratio can be calculated for reach characterization sample.
2. BFWidthDepthMin = minimum bankfull width-depth ratio, dimensionless
3. BFWidthDepthMax = maximum bankfull width-depth ratio, dimensionless
4. BFWidthDepthAvg = mean bankfull width-depth ratio, dimensionless

Derivation:

1. Ignore transects with missing bankfull width
2. Ignore transects where bankfull width = 0
3. Ignore transects where bankfull depth can not be calculated (see BFDepth)
4. For each remaining transect, determine the bankfull width-depth ratio as BFWidth at transect / BFDepth at transect
5. count the number of transects where bankfull width-depth ratio could be calculated (BFWidthDepthN)
6. determine the minimum bankfull width-depth ratio (BFWidthDepthMin) for reach characterization sample.
7. determine the maximum bankfull width-depth ratio (BFWidthDepthMax) for reach characterization sample.
8. determine the mean bankfull width-depth ratio (BFWidthDepthAvg) for reach characterization sample as:
9. BFWidthDepthAvg = SUM(bankfull width-depth ratio at each transect) / BFWidthDepthN

Remarks:

1. See remarks for BFWidth and BFDepth

Veloc (N, Min, Max, Avg, Cv)

Base variable is streamflow velocity in feet per second (as NWIS parameter code 00055). **Velocity in feet per second is converted to meters per second for output.**

Variable Definitions:

1. VelocN = number of transect point streamflow velocity measurements in reach
2. VelocMin = minimum streamflow velocity, in meters per second
3. VelocMax = minimum streamflow velocity, in meters per second
4. VelocAvg = maximum streamflow velocity, in meters per second
5. VelocCv = coefficient of variation of streamflow velocity, in percent

Derivation:

1. use all transect points having non-missing velocity measurements
2. **convert velocity from feet per second to meters per second as:**
3. velocity in meters per second = velocity in feet per second * 0.3048
4. count the number of streamflow velocity measurements (VelocN)
5. determine the minimum streamflow velocity (VelocMin) for reach characterization sample.
6. determine the maximum streamflow velocity (VelocMax) for reach characterization sample.
7. determine the mean streamflow velocity (VelocAvg) for reach characterization sample as:
8. VelocAvg = VelocAvg = SUM(Veloc) / VelocN
9. calculate the standard deviation (Stdev) of streamflow velocity as:
10. Stdev = square root [sum((Veloc-VelocAvg)^2) / VelocN - 1]
11.
12. where:
13. Veloc= streamflow velocity at transect point i in meters per second
14. VelocAvg = mean streamflow velocity in reach in meters per second
15. VelocN = number of streamflow velocity measurements
16. calculate the coefficient of variation of streamflow velocity as:

    VelocCv = Stdev / VelocAvg * 100

Remarks:

1. all velocity measurements are used, including values = 0 and all negative values
2. **If mean streamflow velocity in reach = 0 then VelocCv is not calculated.** The algorithm does not attempt to re-scale values to avoid zero mean.

DomSub (N, category counts (e.g. DomSubSACnt), and category percentages (e.g DomSubSAPct))

Base variable is the dominant substrate category code (DOMSUB) for transect points.

Substrate Category Codes:

Code	Description
1	Smooth bedrock/concrete/hardpan
2	Silt/clay/marl/muck/organic detritus
3	Sand (> 0.062 - 2 mm)
4	Fine/medium gravel (>2 - 16 mm)
5	Coarse gravel (>16 - 32 mm)
6	Very coarse gravel (>32 - 64 mm)
7	Small cobble (>64 - 128 mm)
8	Large cobble (>128 - 256 mm)
9	Small boulder (>256 - 512 mm)
10	Large boulder, irregular bedrock, irregular hardpan, irregular artificial surface (>512 mm)
AR	Artificial or man-made - substrates such as rock baskets, trash, or concrete
BO	Boulder - rounded stones > 256 mm in diameter or large slabs more than 256 mm in length
BR	Bedrock - solid rock forming a continuous surface
CL	Ambiguous code that indicates clay **or** cobble
DE	Detritus - unconsolidated organic material including sticks, wood, and other partially or undecayed coarse plant material
GV	Gravel - mixture of rounded course material from 2 - 64 mm in diameter
HP	Hardpan - particles less than 0.004 mm in diameter; usually clay, forming a dense, gummy surface that is difficult to penetrate
SA	Sand - materials 0.06 - 2 mm in diameter; gritty texture when rubbed between fingers
SI	Silt - generally fine material 0.004 - 0.06 mm in diameter; feels "greasy" when rubbed between fingers
CO	Cobble - stones from 64-256 mm in diameter

Variable Definitions:

1. DomSubN = DomSubN substrate number of transect points where the dominant substrate particle size was recorded

2. DomSub1Cnt = number of transect points where the dominant substrate consists of Smooth bedrock/concrete/hardpan
3. DomSub1Pct = relative proportion (percent occurrence) of transect points where the dominant substrate consists of Smooth bedrock/concrete/hardpan
4. DomSub2Cnt = number of transect points where the dominant substrate consists of Silt/clay/marl/muck/organic detritus
5. DomSub2Pct = relative proportion (percent occurrence) of transect points where the dominant substrate consists of Silt/clay/marl/muck/organic detritus
6. DomSub3Cnt = number of transect points where the dominant substrate consists of Sand (> 0.062 - 2 mm)
7. DomSub3Pct substrate relative proportion (percent occurrence) of transect points where the dominant substrate consists of Sand (> 0.062 - 2 mm)
8. DomSub4Cnt substrate number of transect points where the dominant substrate consists of Fine/medium gravel (>2 - 16 mm)

9. DomSub4Pct substrate relative proportion (percent occurrence) of transect points where the dominant substrate consists of Fine/medium gravel (>2 - 16 mm)
10. DomSub5Cnt substrate number of transect points where the dominant substrate consists of Coarse gravel (>16 - 32 mm)
11. DomSub5Pct substrate relative proportion (percent occurrence) of transect points where the dominant substrate consists of Coarse gravel (>16 - 32 mm)
12. DomSub6Cnt substrate number of transect points where the dominant substrate consists of Very coarse gravel (>32 - 64 mm)
13. DomSub6Pct substrate relative proportion (percent occurrence) of transect points where the dominant substrate consists of Very coarse gravel (>32 - 64 mm)
14. DomSub7Cnt substrate number of transect points where the dominant substrate consists of Small cobble (>64 - 128 mm)
15. DomSub7Pct substrate relative proportion (percent occurrence) of transect points where the dominant substrate consists of Small cobble (>64 - 128 mm)
16. DomSub8Cnt substrate number of transect points where the dominant substrate consists of Large cobble (>128 - 256 mm)
17. DomSub8Pct substrate relative proportion (percent occurrence) of transect points where the dominant substrate consists of Large cobble (>128 - 256 mm)
18. DomSub9Cnt substrate number of transect points where the dominant substrate consists of Small boulder (>256 - 512 mm)
19. DomSub9Pct substrate relative proportion (percent occurrence) of transect points where the dominant substrate consists of Small boulder (>256 - 512 mm)
20. DomSub10Cnt substrate number of transect points where the dominant substrate consists of Large boulder, irregular bedrock, irregular hardpan, irregular artificial surface (>512 mm)
21. DomSub10Pct substrate relative proportion (percent occurrence) of transect points where the dominant substrate consists of Large boulder, irregular bedrock, irregular hardpan, irregular artificial surface (>512 mm)
22. DomSubARCnt substrate number of transect points where the dominant substrate is artificial or man-made (pre-1997 code)
23. DomSubARPct substrate relative proportion (percent occurrence) where the dominant substrate is artificial or man-made (pre-1997 code)
24. DomSubBOCnt substrate number of transect points where the dominant substrate is boulder (pre-1997 code)
25. DomSubBOPct substrate relative proportion (percent occurrence) where the dominant substrate is boulder (pre-1997 code)
26. DomSubBRCnt substrate number of transect points where the dominant substrate is bedrock (pre-1997 code)
27. DomSubBRPct substrate relative proportion (percent occurrence) where the dominant substrate is bedrock (pre-1997 code)
28. DomSubCLCnt substrate number of transect points where the dominant substrate is cobble (pre-1997 code)
29. DomSubCLPct substrate relative proportion (percent occurrence) where the dominant substrate is cobble (pre-1997 code)
30. DomSubDECnt substrate number of transect points where the dominant substrate is detritus (pre-1997 code)
31. DomSubDEPct substrate relative proportion (percent occurrence) where the dominant substrate is detritus (pre-1997 code)
32. DomSubGVCnt substrate number of transect points where the dominant substrate is gravel (pre-1997 code)
33. DomSubGVPct substrate relative proportion (percent occurrence) where the dominant substrate is gravel (pre-1997 code)
34. DomSubHPCnt substrate number of transect points where the dominant substrate is hardpan (pre-1997 code)

35. DomSubHPPct substrate relative proportion (percent occurrence) where the dominant substrate is hardpan (pre-1997 code)
36. DomSubMACnt substrate number of transect points where the dominant substrate is marl (pre-1997 code)
37. DomSubMAPct substrate relative proportion (percent occurrence) where the dominant substrate is marl (pre-1997 code)
38. DomSubMUCnt substrate number of transect points where the dominant substrate is muck (pre-1997 code)
39. DomSubMUPct substrate relative proportion (percent occurrence) where the dominant substrate is muck (pre-1997 code)
40. DomSubSACnt substrate number of transect points where the dominant substrate is sand (pre-1997 code)
41. DomSubSAPct substrate relative proportion (percent occurrence) where the dominant substrate is sand (pre-1997 code)
42. DomSubSICnt substrate number of transect points where the dominant substrate is silt or clay (pre-1997 code)
43. DomSubSIPct substrate relative proportion (percent occurrence) where the dominant substrate is silt or clay (pre-1997 code)
44. DomSubCOCnt substrate number of transect points where the dominant substrate is cobble (pre-1997 code)
45. DomSubCOPct substrate relative proportion (percent occurrence) where the dominant substrate is cobble (pre-1997 code)
46. DomSubIvlCnt substrate number of transect points where the dominant substrate is recorded using an invalid code
47. DomSubIvlPct substrate relative proportion (percent occurrence) where the dominant substrate is recorded using an invalid code

Derivation:

1. Ignore transect points where dominant substrate was not characterized
2. count the number of transect points where dominant substrate **was** categorized (DomSubN)
3. count the number of transect points classified according to each substrate category (DomSub*Cnt, where * is the substrate category code).

   if a substrate category was not observed in the reach and DomSubN > 0 then set DomSub*Cnt for that category = 0

4. calculate the percentage of characterized points falling into each category as:
5. DomSub*Pct = DomSub*Cnt / DomSubN * 100
6.
7. where:
8. * = the substrate category code

Remarks:

1. DomSubIvlCnt and DomSubIvlPct report the number of instances and percent of invalid substrate codes stored for the reach characterization sample. If these are > 0 see the raw data to determine whether you can safely map them to another code.
2. DomSubCLCnt is the number of transect points having the CL substrate code. This code is subject to uncertainty as to whether it indicates cobble or clay substrate. As the problem is resolved these observations will be migrated to either SI or CO. The existence of substrate observations with the CL code indicates that this issue has not been fully resolved for the sample in question.

SiltCov (N, Cnt, Pct)

Base variable is the transect point silt cover flag that indicates whether a layer of silt was observed at the transect point.

Variable Definitions:

1. SiltCovN siltcov number of transect points where an observation of whether silt layer covers the streambed was made
2. SiltCovCnt siltcov number of transect points where silt layer on the streambed was observed
3. SiltCovPct siltcov percent occurrence of transect points where silt layer was observed on streambed

Derivation

1. count number of observations of transect point silt cover for reach characterization sample (SiltCovN)
2. count number of observations where silt cover was observed (SiltCovCnt)
3. calculate percentage of observations where silt cover was observed (SiltCovPct) as:
4. SiltCovPct = SiltCovCnt / SiltCovN * 100

MphyMalgCvr (N, Min, Max, Avg)

Base variable is percent of streambed within 10 cm diameter circle covered with macroalgae or macrophytes > 3 cm long. The observations are made at selected transect points.

HDAS Variable Definitions:

1. MphyMalgCvrN = number of observations of percent macrophyte/macroalgae cover in reach characterization sample
2. MphyMalgCvrMin = minimum percent macrophyte/macrolagae cover
3. MphyMalgCvrMax = maximum percent macrophyte/macroalgae cover
4. MphyMalgCvrAvg = average percent macrophyte/macroalgae cover

Derivation:

1. ignore transect points where observation was not made
2. count number of observations of percent macroalgae/macrophyte cover for reach characterization sample (MphyMalgCvrN)
3. determine minimum value of percent macroalgae/macrophyte cover (MphyMalgCvrMin)
4. determine maximum value of percent macroalgae/macrophyte cover (MphyMalgCvrMax)
5. calculate mean value of percent macroalgae/macrophyte cover (MphyMalgCvrAvg) as:
6. MphyMalgCvrAvg = SUM(MphyMalgCvr for each observation) / MphyMalgCvrN * 100

EmbedPct (N, Min, Max, Avg)

Base variable is percent substrate embeddedness at transect points (EmbedPct)

Variable Definitions:

1. EmbedPctN = number of pct embeddedness observations
2. EmbedPctMin = minimum pct embeddedness
3. EmbedPctMax = minimum percent embeddedness
4. EmbedPctAvg = mean percent embeddedness

Derivation:

1. ignore transect points where percent embeddedness was not characterized
2. count number of transect points where percent embeddedness was characterized (EmbedPctN)
3. determine minimum value of percent embeddedness (EmbedPctMin)
4. determine maximum value of percent embeddedness (EmbedPctMax)
5. calculate mean percent embeddedness as:
6. EmbedPctAvg = (SUM(EmbedPct for each transect point) / EmbedPctN) * 100

Remarks:

1. **Data for percent embeddedness suffer from ambiguity about what value was recorded for streams that do not have any large particles (e.g. sand-bottomed streams).** Competing conventions include (1) entering 0 for all points, and (2) entering 100 for all points. The original habitat protocol (USGS Open-File Report 93-408) specifies that 0 should be entered when no gravel, cobble, or boulder particles are present. The revised habitat protocol (USGS Open-File Report 98-4052) specifies that, "If the dominant substrate is sand or finer, record the embeddeddness as 100 percent". **HDAS does not attempt to reconcile any differences in interpretation.**

HabCvrPt (TotN, AnyCnt, AnyPct, category counts (e.g. HabCvrPtWDCnt), and category percentages (e.g. HabCvrPtWDPct))

Base variables are the habitat cover feature category codes recorded for transect points. More than one feature code may be assigned to a point (e.g. point 1 has AM, BO and UB features)

Habitat Cover Feature Codes:

Habitat Cover Feature Code	Description
AM	Aquatic macrophytes (emergent, submergent, and floating)
BO	Boulders
MS	Manmade structure
OV	Overhanging vegetation (terrestrial)
UB	Undercut banks
WD	Natural woody debris pile
TB	Too turbid to determine (**note - NOT used for HDAS calculations - treated as an uncharacterized point)**

HDAS Variable Definitions:

1. HabCvrPtTotN = number of **transect points** where an observation of habitat cover features was made

2. HabCvrPtTranN = number of **transects** with data for instream cover features

3. HabCvrPtAnyCnt = number of transect points where **at least one habitat cover feature** was found
4. HabCvrPtAnyPct = proportion of transect points having **at least one habitat cover feature**

5. HabCvrPtAMCnt = number of transect points having **aquatic macrophyte** instream habitat cover feature
6. HabCvrPtAMPct = percent occurence of **aquatic macrophyte** habitat cover feature for reach

7. HabCvrPtBOCnt = number of transect points having **boulder** habitat cover feature
8. HabCvrPtBOPct = percent occurence of **boulder** habitat cover feature for reach

9. HabCvrPtMSCnt = number of transect points having **manmade structure** habitat cover feature
10. HabCvrPtMSPct = percent occurence of **manmade structure** habitat cover feature for reach

11. HabCvrPtOVCnt = number of transect points having **overhanging vegetation** habitat cover feature
12. HabCvrPtOVPct = percent occurence of points having **overhanging vegetation** habitat cover feature for reach

13. HabCvrPtUBCnt = number of transect points having **undercut bank** habitat cover feature
14. HabCvrPtUBPct = percent occurence of points having **undercut bank** habitat cover feature for reach

15. HabCvrPtWDCnt = number of transect points having **woody debris** instream habitat cover feature
16. HabCvrPtWDPct = percent occurence of **woody debris** instream habitat cover feature for reach

Derivation:

1. count the number of **transect points** where presence/absence of cover features was noted. This does not mean that cover was actually present, only that the point was "examined".

   = HabCvrPtTotN

2. count the number of **transects** having transect points where presence/absence of cover features was noted.

   = HabCvrPtTranN ; this is used as a variable for calculating undercut bank statistics.

3. count the number of transect points where at least one of the cover features was observed

   = HabCvrPtAnyCnt

4. calculate percentage of transect points having at least one habitat cover feature (HabCvrPtAnyPct) as:
5. HabCvrPtAnyPct = HabCvrPtAnyCnt / HabCvrPtTotN * 100
6. count the number transect points classified according to each of the habitat cover feature types

   = HabCvrPt*Cnt

   where:
   * is the habitat feature code

7. calculate the percentage of characterized points falling into each habitat feature type - **excluding undercut banks (see number 7 below)** as:
8. HabCvrPt*Pct = HabCvrPt*Cnt / HabCvrPtTotN * 100
9.
10. where:
11. * = the habitat feature codes AM, BO, MS, OV, WD
12. calculate the percentage of points characterized as having **undercut banks** as:
13. HabCvrPtUBPct = (HabCvrPtUBCnt / (HabCvrPtTranN * 2)) * 100

    This approach recognizes that undercut banks can only occur at two of the points along a transect (left and right bank). It assumes that if presence/absence of any features were characterized along a transect then presence/absence of undercut bank was also characterized - for both banks.

14. if a transect point was characterized, but a particular habitat feature was not observed at the point, then set then set HabCvrPt*Cnt for that particular feature = 0

Remarks:

1. **HDAS assumes that if presence/absence of any features were characterized along a transect then presence/absence of undercut bank was also characterized at both ends of the transect.**

   Percent undercut bank (HabCvrPtUBPct) is calculated using the assumption that undercut banks can only be found at edge-of-water transect points. **The assumption** is that **both** banks were examined for undercuts on a transect when **any** habitat cover features were characterized along a transect. This is how the program determines how many possible occurrences of undercutting there are (the denominator for the percent calculation). In contrast, HDAS assumes that the other cover features (i.e. wood) could occur at **all** of the points where habitat cover was characterized.

CanClosrBnk (N, Min, Max, Avg)

Base data are canopy closure **observations (densiometer readings) taken at the left and right banks** of transects (LBSHAD, RBSHAD). A different set of variables (CanClosrChnl*) summarizes the data for canopy closure observations taken from the middle of the wetted channel. The two sets are separated because mid-channel readings were introduced during NAWQA cycle II by the NEET topical team. The bank measurement set of statistics will allow direct comparison to ealier reach characterization samples.

Variable Definitions:

1. CanClosrBnkN = number of observations of canopy closure taken at left and right bank (LBSHAD, RBSHAD).
2. CanClosrBnkMin = minimum percent canopy closure, bank measurements.
3. CanClosrBnkMax = maximum percent canopy closure, bank measurements.
4. CanClosrBnkAvg = mean percent canopy closure, bank readings.

Derivation:

1. count the number of canopy closure observations taken at left or right bank (CanClosrBnkN)
2. calculate the percent canopy closure for each observation taken at left or right bank as:

3. percent canopy closure for observation = densiometer reading / 17 * 100
4.
5. where each densiometer reading can have a maximum value of 17
6. determine the minimum percent canopy closure for observations taken at left or right bank (CanClosrBnkMin)
7. determine the maximum percent canopy closure for observations taken at left or right bank (CanClosrBnkMax)
8. calculate the mean percent canopy closure for bank observations as:
9. CanClosrBnkAvg =
10. SUM(percent canopy closure for each observation) / CanClosrBnkN * 100

CanClosrChnl (N, Min, Max, Avg)

Base data are canopy closure **observations (densiometer readings) taken at mid-channel** of transects (USSHAD, DSSHAD). A different set of variables (CanClosrBnk*) summarizes the data for canopy closure observations taken at the left and right banks. The two sets are separated because mid-channel readings were introduced during NAWQA cycle II by the NEET topical team. The bank-readings set will allow comparison to previous reach characterization samples.

Variable Definitions:

1. CanClosrChnlN = number of mid-channel canopy closure observations
2. CanClosrChnlMin = minimum percent canopy closure, mid-channel measurements
3. CanClosrChnlMax = maximum percent canopy closure, mid-channel measurements
4. CanClosrChnlAvg = mean percent canopy closure, mid-channel readings

Derivation:

1. count the number of canopy closure observations taken at mid-channel (CanClosrChnlN)
2. calculate the percent canopy closure for each observation taken at mid-channel as:
3. percent canopy closure for observation = densiometer reading / 17 * 100
4.
5. where each densiometer observation has a maximum value of 17
6. determine the minimum percent canopy closure for observations taken at mid-channel (CanClosrChnlMin)
7. determine the maximum percent canopy closure for observations taken at mid-channel (CanClosrChnlMax)
8. calculate the mean percent canopy closure for mid-channel observations as:
9. CanClosrChnlAvg =
10. SUM(percent canopy closure for each observation) / CanClosrChnlN * 100

OCanAngle (N, Min, Max, Avg, Cv)

Base variables for calculations are (1) user-declared **open** canopy angle (CanAngle) for transects, and (2) left and right bank **closed** canopy angles (LCANANG, RCANANG) for transects. The declared value for open canopy angle is preferred over the value calculated using left and right closed canopy angles (see figure below from revised habitat protocols - USGS Open-File Report 98-4052) .

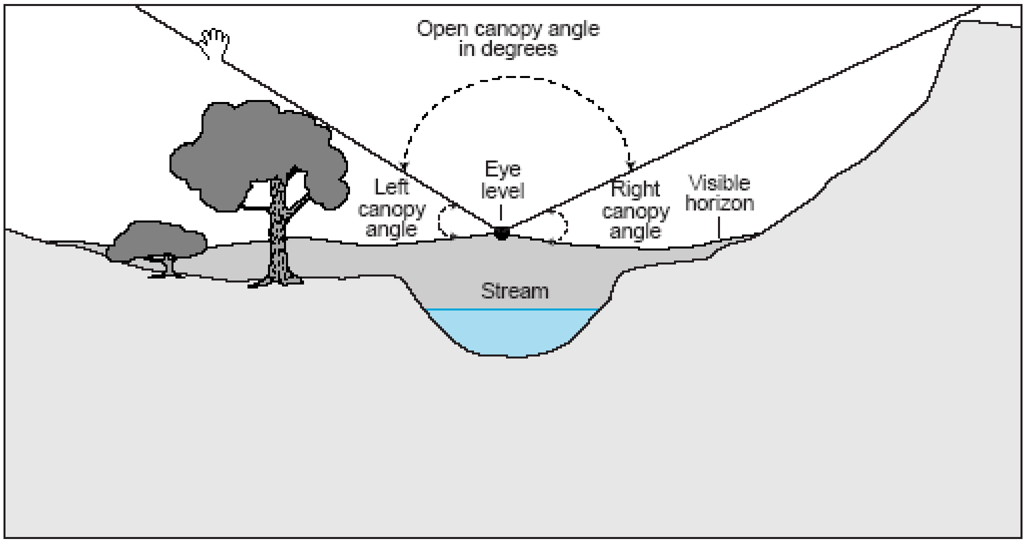

Figure 9. Measurement of open canopy angle (modified from Platts and others, 1983).

Variable Definitions:

1. OCanAngleN = number of transects where LB and RB open canopy angle measurements were taken or total canopy angle was explicitly declared
2. OCanAngleMin = minimum open canopy angle
3. OCanAngleMax = maximum open canopy angle
4. OCanAngleAvg = mean open canopy angle
5. OCanAngleCv = coefficient of variation of open canopy angle

Derivation:

The approach is to determine the open canopy angle for each transect, and then use the transect level data to derive the reach-level summary statistics.

1. Ignore transects that (1) do not have explicitly declared open canopy angle (CanAngle is missing), or (2) do not have readings for **both** left and right canopy angles.

   For each transect:

2. If the open canopy angle was explicitly declared then use it.
3. If not, then calculate the open canopy angle using left and right bank canopy angle measurements.
4. when:
5. 180 - right bank canopy angle + left bank canopy angle > 180 then OCanangle = 180
6.
7. when:
8. 180 - right bank canopy angle + left bank canopy angle < 0 then OCanangle = 0
9.
10. else:
11. OCanangle = 180 - right bank canopy angle + left bank canopy angle

Remarks:

1. No adjustment is made to account for the elevation (eye level) from which the measurement was made. Eye level data are rarely entered.

BankVegCov (N, Min, Max, Avg)

Base variable is estimated percent vegetative cover at left and right banks of transects (BankVegCovLB, BankVegCovRB)

Variable Definitions:

1. BankVegCovN = number of observations of percent bank vegetative cover
2. BankVegCovMin = minimum percent bank vegetative cover
3. BankVegCovMax = maximum percent bank vegetative cover
4. BankVegCovAvg = mean percent bank vegetative cover

Derivation:

1. count number of observations of bank vegetative cover in reach (BankVegCovN)
2. determine minimum bank vegetative cover (BankVegCovMin)
3. determine maximum bank vegetative cover (BankVegCovMax)
4. calculate mean bank vegetative cover as:
5. BankVegCovAvg =
6. SUM(left and right bank vegetative cover estimates) / BankVegCovN * 100

BankEros (N, Cnt, Pct)

Base variable is the presence/absence of erosion at left and right banks of transects (BankErosFlagLB, BankErosFlagRB)

Variable Definitions:

1. BankErosN bank erosion number of observations of whether bank erosion is occurring
2. BankErosCnt bank erosion number of occurrences of bank erosion
3. BankErosPct bank erosion percent occurrence of bank erosion

Derivation:

1. count number of observations of presence/absence of bank erosion (BankErosN)
2. count number of observations where bank erosion was present (BankErosCnt)
3. calculate percent of observations where bank erosion was present as:
4. BankErosPct = BankErosCnt / BankErosN * 100

RchVol: reach wetted channel volume, in cubic meters

Base variables are the reach length (RchLength), mean wetted channel width (WidthWetAvg), and mean depth (DepthAvg)

Derivation: RchVol = reach length * mean width of wetted channel * mean depth

= RchLength * WidthWetAvg * DepthAvg

RchArea: reach wetted-channel surface area, in square meters

Base variables are the reach length (RchLength), mean wetted channel width (WidthWetAvg).

Derivation: RchArea = reach length * mean wetted channel width

= RchLength * WidthWetAvg

WetPerim (N, Min, Max, Avg)

Base variables are the wetted channel width at each transect and mean depth at each transect.

Variable Definitions:

1. WetPerimN = number of transects where wetted channel perimeter can be calculated
2. WetPerimMin = minimum wetted channel perimeter, in meters
3. WetPerimMax = maximum wetted channel perimeter (m)
4. WetPerimAvg = mean perimeter of wetted channel (m)

Derivation:

Approach is to calculate the wetted perimeter for each transect and then calculate summary statistics for reach using the transect level values.

1. ignore transect point depths that = 0
2. ignore transect wetted channel widths that = 0
3. ignore transects that don't have data for **both** wetted channel width **and** wetted channel depth
4. calculate average depth for each transect
5. calculate wetted perimeter **for each transect** as:
6. WetPerimTran = (wetted channel width at transect) + 2(average depth at transect)
7. count number of transects for where wetted perimeter could be calculated (WetPerimN)
8. determine minimum transect level wetted perimeter (WetPerimMin)
9. determine maximum transect level wetted perimeter (WetPerimMax)
10. calculate mean wetted perimeter as:
11. WetPerimAvg = SUM(wetted perimeters for individual transects) / WetPerimN

WetXArea (N, Min, Max, Avg)

Base variables are wetted channel width at transects and average depth for each transect.

Variable Definitions:

1. WetXAreaN = number of transects where wetted cross sectional area of channel can be calculated

2. WetXAreaMin = minimum wetted cross sectional area of channel, in square meters
3. WetXAreaMax = maximum wetted cross sectional area of channel, in square meters
4. WetXAreaAvg = mean cross-sectional are of wetted channel, in square meters

Derivation:

1. count number of transects where wetted cross sectional area can be calculated (**WetXAreaN**). To be eligible a transect must have a non-zero wetted channel width and at least one non-zero depth measurement.
2. calculate cross sectional area of each transect (WetXAreaTran) as:

   WetXAreaTran = wetted channel width at transect * average depth at transect

3. determine minimum cross sectional area of reach (WetXAreaMin) using transect cross sections
4. determine maximum cross sectional area of reach (WetXAreaMax) using transect cross sections
5. calculate average cross sectional area of the reach (WetXAreaAvg) using transect cross sections as:
6. SUM(WetXAreaTran)/ WetXAreaN * 100
7.
8. where:
9. WetXAreaTran = the cross sections of individual transects

WetShape (N, Min, Max, Avg)

Base variables are wetted channel width at transect, mean depth at transect, maximum depth at transect

1. WetShapeN = number of transects where wetted channel shape can be calculated
2. WetShapeMin = minimum wetted channel shape
3. WetShapeMax = maximum wetted channel shape
4. WetShapeAvg = mean wetted channel shape

Derivation: Calculations are based on calculating wet shape for each transect and then summarizing for the reach.

1. ignore transects with wetted channel width = 0
2. ignore transects where average depth = 0
3. ignore transects where maximum depth = 0
4. calculate wet shape for each transect (where possible) as:
5. WetShapeTran = (d/dmax) -- exponent
6. (w/d)
7.
8. where:
9. w = wetted channel width at transect
10. d = mean depth at transect
11. dmax = maximum depth at transect
12. count number of transects where wet shape could be calculated (WetShapeN)
13. determine minimum transect level wet shape (WetShapeMin)
14. determine maximum transect level wet shape (WetShapeMax)
15. calculate average reach level wet shape (WetShapeAvg) as:
16. WetShapeAvg = SUM(WetShapeTran) / WetShapeN
17.
18. where:

19. WetShapeTran = each of the individual transect level wet shape values

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HydRadAvg: The average hydraulic radius of the wetted channel

Base variables are average wetted cross sectional area (WetXAreaAvg) and average wetted channel perimeter (WetPerimAvg)

Derivation: HydRadAvg = WetXAreaAvg / WetPerimAvg

where:
WetXAreaAvg = the average wetted cross sectional area
WetPerimAvg = the average wetted perimeter

Froude Number: Froude number is a dimensionless mathematical expression used to describe a flow field. It gives the ratio of intertial forces to gravitational forces.

Base variables for HDAS calculations are average streamflow velocity in reach (VelocAvg), average depth in reach (DepthAvg), and the acceleration due to gravity (9.807 meters per second squared).

Variable Definition:

1. Froude = Froude number, dimensionless

Derivation:

1. ignore reaches having average velocity = 0 (avoid divide by zero errors)
2. ignore reaches having average depth = 0 (avoid divide by zero errors)
3. calculate Froude number as:
4. Froude = (VelocAvg) / (SQRT(DepthAvg * g))

where:
5. VelocAvg = average streamflow velocity, meters per second
5. DepthAvg = average depth, meters
g = gravitational acceleration constant = 9.807 meters per second per second

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FlowStbl index (N, Min, Max, Avg)

The flow stability index represents a ratio of the maximum wetted channel depth to the bankfull channel depth.

Base variables are the maximum depth at each transect and the bankfull depth for each transect (BFDepthTran)

Variable Definitions:

1. FlowStblN= number of transects for which flow stability index can be calculated
2. FlowStblMin = minimum flow stability index
3. FlowStblMax = maximum flow stability index
4. FlowStblAvg = mean flow stability index

Derivation:

1. determine maximum depth at each transect (DepthTranMax)
2. calculate flow stability index **for each transect** as:
3. FlowStblTran = DepthTranMax / BFDepthTran
4.
5. where:
6. DepthTranMax = maximum water depth recorded for transect
7. BFDepthTran = average bankfull depth at transect
8. count number of transects with flow stability data (FlowStblN)
9. determine minimum flow stability index for reach (FlowStblMin)
10. determine maximum flow stability index for reach (FlowStblMax)
11. calculate average flow stability as:
12. FlowStblAvg = SUM(FlowStblTran) / FlowStblN