Abandoned Mine Drainage Stream Monitoring

FIELD BINDER

Based on Conference Field Binder from the proceedings of the Abandoned Mine Reclamation Conference - June 12, 2004 Indiana, PA; Updated November 2, 2011 (v2) and March 7, 2021 (v3)

CONTENTS

Section 1A: Stream Quality & Quantity Field Sampling Datasheets (Updated 1/2021)

Station Information (adapted from PA DEP Bureau of Water Standards Form 3800-FM-WSFR0086 Rev. 12/2008)

Date-Time-Initials: ___________-________-________ Station ID: ________________________

Location (ex. Latitude/Longitude, directions, landmarks...): ____

____

County: ____________________ Municipality: __________________________ Topo Quad: ______________________

Watershed (HUC8): ________________ Stream (HUC12): __________________ Tributary (HUC14): ________________

Waterbody Class*: ________ Ch. 93 Use¥: ___________ Weather - Current: __________ - Past Week:______________

*Riverine, Lacustrine, Palustrine or Non-classified manmade ¥Warm Water Fish, Trout Stock Fish, Cold Water Fish, Migratory Fish, High Quality, or Exceptional Value.

Reminder to take (3) photos (of site, upstream & downstream with people for scale) & sketch site (in-stream attributes like riffles, fallen trees, pools, etc.)

Physical Conditions (circle one or more): (adapted from WV SOS Level 1 Survey 18373 Rev. 11/2009 and EPA Rapid Bioassessment 841-B-99-002)

Water Clarity: *clear, murky, milky, muddy, other*

Water Color: *none, brown, black, green, gray /white, orange/red*

Streambed Color: *brown, black, green, white/gray, orange/red*

Surface Foam/Oil: *none, slight, moderate, high*

Water Odor: *none, fishy, musky, sewage, chemical, rotten egg*

Algae Abundance: *none, scattered, moderate, heavy*

Algae Growth Habit: *even coating, hairy, matted, floating*

Algae Color: *light green, dark green, brown, other*

Field Chemistry Result/Unit — Result/Unit — Describe Type Result/Unit

Temperature: _______________

Dissolved Oxygen: ___________

pH: ________________________

Total Alkalinity: _____________

Conductivity: _______________

Turbidity: __________________

Metals: _____________________

Nutrients:___________________

Redox (ORP): _______________

Additional tests (describe and record results): ____

____

Flow Calculation (adapted from WV SOS Level one Survey Datasheet 18373 Rev. 11/2009) Channel Width/Pipe Diameter(ft):_____________

Method Used (circle one): *flow meter, float, pipe, velocity head rod (VHR)*

Tape distance (ft)	Depth (ft)	X Velocity (ft/sec) or	Float (sec)	or VHR (Rise-in.)	= Discharge (CFS)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Totals/Averages					

VHR Values Chart

Rise	Velocity	Rise	Velocity
¼"	1.2 f/s	3 ¼"	4.2 f/s
½"	1.6 f/s	3 ½"	4.3 f/s
¾"	2.0 f/s	3 ¾"	4.5 f/s
1"	2.3 f/s	4"	4.6 f/s
1 ¼"	2.6 f/s	4 ¼"	4.8 f/s
1 ½"	2.8 f/s	4 ½"	4.9 f/s
1 ¾"	3.1 f/s	4 ¾"	5.0 f/s
2"	3.3 f/s	5"	5.2 f/s
2 ¼"	3.5 f/s	5 ¼"	5.3 f/s
2 ½"	3.7 f/s	5 ½"	5.4 f/s
2 ¾"	3.8 f/s	5 ¾"	5.5 f/s
3"	4.0 f/s	6"	5.7 f/s

Basic Calculation: Discharge (CFS)= Width (ft) x Depth(ft) x Velocity (ft/sec.)

If you use the "float method" record your float distance here _____ (ft) and multiply by the time (recorded above) to get velocity.

If you use the "VHR method" record the rise in inches and select velocity in the chart to the right. 1 CFS = 448.83 gpm = 1.858 MGD

Habitat Visual Assessment (adapted from PA DEP BWS Form 3800-FM-WSFR0402 Rev. 10/2008 and EPA Rapid Bioassessment 841-B-99-002)

Particle Size Descriptors: Silt (slick feel), Sand (grainy feel), Gravel (> pea), Cobble (> tennis ball), Boulder (> basketball), and Bedrock (> car).

Habitat Parameter Part 1	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Instream Cover (Fish)	Greater than 50% mix of boulder, cobble, sub-merged logs, undercut banks, or other stable habitat.	30-50% mix of boulder, cobble, or other stable habitat; adequate habitat.	10-30% mix of boulder, cobble, or other stable habitat; habitat avail-ability less than desirable.	Less than 10% mix of boulder, cobble, or other stable habitat; lack of habitat is obvious.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
2. Epifaunal Substrate	Well developed riffle and run, riffle is as wide as stream and length extends two times the width of stream; abundance of cobble.	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than two times the stream width; gravel or large boulders and bed-rock prevalent; some cobble present.	Riffles or run virtually nonexistent; large boulders and bedrock prevalent; cobble lacking.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment (silt=slick or sand=grainy feel).	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
4. Velocity/Depth Regimes	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score lower than if missing other regimes).	Dominated by 1 velocity/depth regime (usually slow-deep).
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
5. Channel Alteration	No channelization or dredging present.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	New embankments present on both banks; and 40-80% of stream reach channelized and disrupted.	Banks shored gabion or cement; over 80% of the stream reach channelized and disrupted.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
6. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from coarse gravel; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, coarse sand on old and new bars; 30-50% of the bottom affected; sediment deposits at obstruction, constriction, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**

Total Part 1 _____

Habitat Parameter	**Category**

Part 2	Optimal	Suboptimal	Marginal	Poor
7. Frequency of Riffles	Occurrence of riffles relatively frequent; distance between riffles divided by the width of the stream equals 5 to 7; variety of habitat.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream equals 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is between ratio >25.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
8. Channel Flow Status	Water reaches base of both lower banks and minimal amount of channel substrate is exposed.	Water fills > 75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
9. Condition of Banks	Banks stable; no evidence of erosion or bank failure.	Moderately stable; infrequent, small areas of erosion mostly healed over.	Moderately unstable; up to 60% of banks in reach have areas of erosion.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; on side slopes,60-100% of bank has erosional scars.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
10. Bank Vegetative Protection	More than 90% of the streambank surface covered by vegetation.	70-90% of the stream-bank surface covered by vegetation.	50-70% of the stream-bank surfaces covered by vegetation.	Less than 50% of the streambank surface covered by vegetation.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
11. Grazing or Other Disruptive Pressure	Vegetative disruption, through grazing or mowing, minimal or not evident; almost all plants allowed to grow naturally.	Disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	Disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Disruption of vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
12. Riparian Vegetative Zone Width	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE ______	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**

Total Part 2 _____

Total Score _______ If < 140 for forested, cold water & high gradient (<120 for warm water low gradient), then generally impaired

Impairment Thresholds

#3 Embeddedness + #6 Sediment Deposition: ________ If < 24 (<20 for warm water low gradient), then impaired by sediment

#9 Condition of Banks + #10 Bank Vegetation: ________ If < 24 (<20 for warm water low gradient), then impaired by bank erosion

Land Use

Residential: _______% Commercial: _______% Industrial: ______%

Cropland: _________% Pasture: ________% Abd. Mining: ______%

Old Fields: ________% Forest: ________% Other: ____________%

(circle one)

Canopy cover: open partly shaded mostly shaded fully shaded

Dominant bank veg. species 1st: __________________________

2nd: ___________________ 3rd: __________________________

Habitat comments: ____

Aquatic life observed or collected (other than Macro-invertebrate tally):____________________________________

____

Section 1A: Stream Quality & Quantity Field Sampling Datasheets (Updated 1/2021)

Benthic Macro-invertebrates (adapted from WV SOS Level One Survey Datasheet 18373)

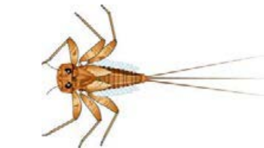
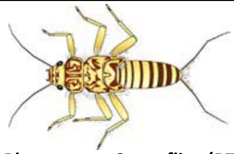
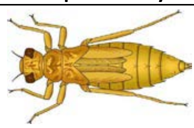
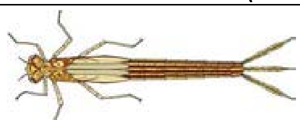
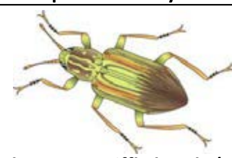
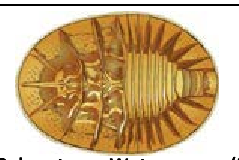
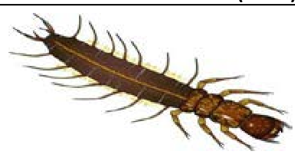
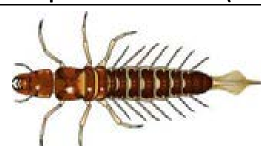
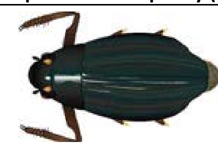
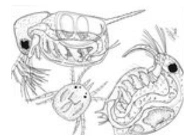
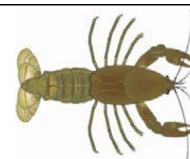
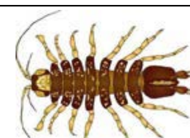
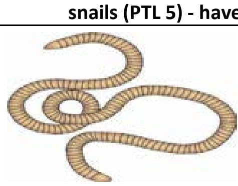
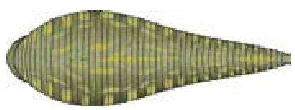
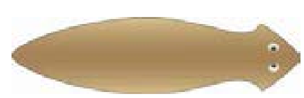
after name indicates Pollution Tolerance Level (PTL): Low (1) to High (10). Use the dot dash tally method. >

1 2 3 4 5 6 7 8 9 10

Record: **Abundance** - (A) > 50, (C) 5 – 50 and (R) < 5 and **# of kinds -** indicates groups where multiple kinds (families) are possible

Sampling Method Used? (circle one): Std. Kick Screen, D-Frame Net, Surber Sampler, Other

(Illustrations by **Cacapon Institute**)

 **Ephemeroptera - Mayflies (PTL 3)**	**# of kinds**	 **Plecoptera - Stoneflies (PTL 2)**	**# of kinds**	 **Trichoptera -Caddisflies (PTL 3) - rock or stick case builders**	**# of kinds**
 **Odonata Anisoptera - Dragonflies (PTL 4)**	**# of kinds**	 **Trichoptera - Caddisflies (PTL 5) – net-spinners "hairy abdomen"**		 **Trichoptera - Caddisflies (PTL 4) - free living**	**# of kinds**
 **Odonata Zygoptera - Damselflies (PTL 7)**	**# of kinds**	 **Coleoptera - Riffle beetle (PTL 4)**		 **Coleoptera - Water penny (PTL 3)**	
 **Megaloptera - Dobsonfly (PTL 3)**		 **Megaloptera - Alderfly (PTL 6)**		 **Heteroptera – True bugs (PTL 7)**	**# of kinds**
 **Diptera Chronomidae - Rat-Tailed Maggots & Midges (PTL 8)**		 **Diptera - Crane fly (PTL 4)**		 **Cladocera -Water fleas (PTL 6)**	
 **Diptera - Watersnipe fly (PTL 3)**		 **Diptera - Other flies, Mosquito larvae, Black fly (PTL 6)**	**# of kinds**	 **Decapoda - Crayfish (PTL 5)**	**# of kinds**
 **Bivalva Veneroida - Clams (PTL 6)**	**# of kinds**	 **Mytiloida - Mussel (PTL 4)**		 **Amphipoda – Scud / Side-swimmer (PTL 5)**	
 **Gastorpada - Gilled or Operculate snails (PTL 5) - have lid**	**# of kinds**	 **Gastropada – Lunged or Non-operculate snails (PTL 7) - no lid**	**# of kinds**	 **Isopoda - Aquatic sowbug (PTL 7)**	
 **Oligacheta -Aquatic worm (PTL 10)**		 **Hirudinea - Leech (PTL 10)**		 **Planaridae - Flatworm (PTL 7)**	

Totals: # Macros: _______ # EPT: _______ %EPT: _______ # of Taxa (kinds): _______ Date: _________ Station ID: ____________

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

M - Marine

Subsystem: 1 - Subtidal

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	RF – Reef
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud	1 Algal 3 Rooted Vascular	1 Coral 3 Worm

Subsystem: 2 - Intertidal

Class	AB – Aquatic Bed	RF – Reef	RS – Rocky Shore	US – Unconsolidated Shore
Subclass	1 Algal 3 Rooted Vascular	1 Coral 3 Worm	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic

E - Estuarine

Subsystem: 1 - Subtidal

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	RF – Reef
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 3 Rooted Vascular 4 Floating Vascular	2 Mollusk 3 Worm

Subsystem: 2 - Intertidal

Class	AB – Aquatic Bed	RF – Reef	SB – Streambed	RS – Rocky Shore	US – Unconsolidated Shore	EM – Emergent	SS – Scrub-Shrub	FO – Forested
Subclass	1 Algal 3 Rooted Vascular 4 Floating Vascular	2 Mollusk 3 Worm	1 Bedrock 2 Rubble 3 Cobble-Gravel 4 Sand 5 Mud 6 Organic	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Persistent 2 Non-persistent 5 *Phragmites australis*	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen

R - Riverine

Subsystem: 1 - Tidal; 2 – Lower Perennial; 3 – Upper Perennial; 4* - Intermittent; 5* – Unknown Perennial

Class	RB** – Rock Bottom	UB – Unconsolidated Bottom	SB** – Streambed	AB – Aquatic Bed	RS – Rocky Shore	US – Unconsolidated Shore	EM – Emergent
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble 3 Cobble-Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent

* **Intermittent** is limited to the **Streambed** Class;
Unknown Perennial is limited to **Unconsolidated Bottom** Class code **R5UB** only

** **Rock Bottom** is not permitted for the **Lower Perennial** Subsystem;
Streambed is limited to **Tidal** and **Intermittent** Subsystems

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

February, 2011

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

System: L - Lacustrine

Subsystem: 1 - Limnetic

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed
Subclass	1 Bedrock	1 Cobble-Gravel	1 Algal
	2 Rubble	2 Sand	2 Aquatic Moss
		3 Mud	3 Rooted Vascular
		4 Organic	4 Floating Vascular

Subsystem: 2 - Littoral

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	RS – Rocky Shore	US – Unconsolidated Shore	EM – Emergent
Subclass	1 Bedrock	1 Cobble-Gravel	1 Algal	1 Bedrock	1 Cobble-Gravel	2 Nonpersistent
	2 Rubble	2 Sand	2 Aquatic Moss	2 Rubble	2 Sand	
		3 Mud	3 Rooted Vascular		3 Mud	
		4 Organic	4 Floating Vascular		4 Organic	
					5 Vegetated	

System: P - Palustrine

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	US – Unconsolidated Shore	ML – Moss-Lichen	EM – Emergent	SS – Scrub-Shrub	FO – Forested
Subclass	1 Bedrock	1 Cobble-Gravel	1 Algal	1 Cobble-Gravel	1 Moss	1 Persistent	1 Broad-Leaved Deciduous	1 Broad-Leaved Deciduous
	2 Rubble	2 Sand	2 Aquatic Moss	2 Sand	2 Lichen	2 Nonpersistent	2 Needle-Leaved Deciduous	2 Needle-Leaved Deciduous
		3 Mud	3 Rooted Vascular	3 Mud		5 *Phragmites australis*	3 Broad-Leaved Evergreen	3 Broad-Leaved Evergreen
		4 Organic	4 Floating Vascular	4 Organic			4 Needle-Leaved Evergreen	4 Needle-Leaved Evergreen
				5 Vegetated			5 Dead	5 Dead
							6 Deciduous	6 Deciduous
							7 Evergreen	7 Evergreen

MODIFIERS

In order to more adequately describe the wetland and deepwater habitats, one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

Water Regime			Special Modifiers	Water Chemistry			Soil
Nontidal	**Saltwater Tidal**	**Freshwater Tidal**		**Coastal Halinity**	**Inland Salinity**	**pH Modifiers for all Fresh Water**	
A Temporarily Flooded	L Subtidal	S Temporarily Flooded-Tidal	b Beaver	1 Hyperhaline	7 Hypersaline	a Acid	g Organic
B Saturated	M Irregularly Exposed	R Seasonally Flooded-Tidal	d Partly Drained/Ditched	2 Euhaline	8 Eusaline	t Circumneutral	n Mineral
C Seasonally Flooded	N Regularly Flooded	T Semipermanently Flooded-Tidal	f Farmed	3 Mixohaline (Brackish)	9 Mixosaline	i Alkaline	
E Seasonally Flooded/ Saturated	P Irregularly Flooded	V Permanently Flooded-Tidal	h Diked/Impounded	4 Polyhaline	0 Fresh		
F Semipermanently Flooded			r Artificial	5 Mesohaline			
G Intermittently Exposed			s Spoil	6 Oligohaline			
H Permanently Flooded			x Excavated	0 Fresh			
J Intermittently Flooded							
K Artificially Flooded							

Section 1B: AMD PASSIVE TREATMENT SYSTEM O&M INSPECTION

Inspection Date: ____/____/______ Project Name:______________________________
Inspected by:______________________________ Municipality:______________________________
Organization:______________________________ County: ______________________________ State: ______
Time Start: __________ End: __________ Project Coordinates: ____° _____' _____" Lat, ____° _____' _____" Long
Receiving Stream: ____________________ Sub-watershed: ______________ Watershed: ____________________

Weather (circle one): Snow, Heavy Rain, Rain, Light Rain, Overcast, Fair/Sunny **Ambient Temp**(°F): ________
Is maintenance required? Yes/No If yes, provide explanation: ______________________________
____

INSPECTION SUMMARY

A. Site Vegetation (Uplands and Associated Slopes)
Overall condition of vegetation on site: 0 1 2 3 4 5 (0=poor, 5=excellent, circle one) (See instructions.)
Is any reseeding required? Yes/No If yes, describe area size and identify location:
____
____

B. Site Access and Parking
Is the access road passable for operation and monitoring? Yes/No Does vegetation hinder monitoring? Yes/No
Does the access road need maintenance? Yes/No
Describe maintenance performed and remaining (Identify location): ______________________________
____
____

C. Vandalism and "Housekeeping"
Is there litter around or in the passive system? Yes/No If yes, was the litter picked up? Yes/No
Is there litter that may be considered hazardous or dangerous that requires special disposal? Yes/No
Is there evidence of vandalism to the passive system? Yes/No
Additional comments: ______________________________

D. Ditches, Channels, Spillways

Channel Identification	Erosion Rills (Y/N)	Debris Present (Y/N)	Maintenance Performed (Y/N)	Comments
In				
Out				

Produced by SRI for Datashed.org 2007, Modified by EPCAMR 2011 and 2021

Section 1B: AMD PASSIVE TREATMENT SYSTEM O&M INSPECTION

Inspection Date: _____/_____/________ Project Name:____

E. Passive Treatment System Components

Component ID	Erosion Rills (Y/N)	Berms Stable (Y/N)	Vegetation Successful (Y/N)	Siltation Significant (Y/N)	Water Level Change (Y/N)	Valves Operable (Y/N)	Maintenance Performed and/or Remaining
Intake							
Outlet							

Is the intake system functioning properly? Yes/No Does it need cleaning? Yes/No Was it cleaned? Yes/No?
Is any flowing over the spill dam? Yes/No Is the dam in good condition? Yes/No Does the dam need repair? Yes/No
Are any of the pipes broken? Yes/No Are the pipes or components free of metals buildup? Yes/No
If no, what _____% blocked ? Was the piping flushed (If possible)? Yes/No Additional Comments: ________________
Other maintenance conducted or needed (erosion, ponds overflowing, etc):____

____

____

____

F. Wildlife Utilization

Animals sighted or tracks observed: ____
Invasive plants observed: ____
Describe any damage caused to by wildlife (especially muskrats) and required maintenance: ________________________

____

G. Field Water Monitoring and Sample Collection - For passive components sample effluent. Loading requires a flow for calculation.

Field monitored? Yes/No Sent to Lab? Yes/No If yes, include sample IDs in comments.

Sampling Point ID	Flow (gal/min)	pH (SU)	Temp. (°F)	ORP (mV)	Alkalinity (mg/L)	Diss. O^2 (mg/L)	Iron (mg/L)	Comments and/or Sample IDs
In								
Out								

GENERAL O&M SITE INSPECTION INSTRUCTIONS

The following general instructions are meant to provide a one page supplement to the O&M manual for inspectors to take in the field and be used as a guide in conjunction with the individualized inspection sheets.

For each Passive System Component do the following if applicable:

1. Enter effluent pH, temperature, alkalinity, flow and other field data as applicable in water monitoring section.
2. If water samples were collected for lab analysis, enter bottle numbers in water monitoring section.
3. Check the outlet spillway for stability, erosion rills, debris, and significant siltation.
4. If present, check the effluent pipe condition. Is the pipe in good condition? Is the pipe crushed, broken, leaking, or plugged?
5. Was the pipe cleaned out? Does the pipe need to be cleaned out?
6. Is all water going through the effluent pipe or over the appropriate spillway?
7. Check all valves to insure full operation and no leaking? Do any valves need to be replaced?
8. If an inline water control structure is present: Were (Do) any stoplogs (need to be) added or removed? Were stoplogs cleaned and greased?
9. Is the access deck to the inline control structure in good condition? Is the deck damaged or rotting? Does the deck need repaired or replaced?
10. If present, check the condition of the emergency spillway for erosion rills, debris, and significant siltation.
11. Check the berm of the pond for slumping, erosion rills, tension cracks, vegetation. Is there evidence of water overtopping the berm?
12. Is there evidence of damage by wildlife such as muskrats burrowing into berms? Is there a need to conduct trapping?
13. Does sludge need to be removed? (If water is overtopping the berm or is about to over top the berm, sludge may need to be removed.)
14. Note any maintenance that was conducted. Note any maintenance that is needed and mark on schematic.

Anoxic Limestone Drains (ALDs)
1. Are there significant slumping or "subsidence-like" features where the ALD is located?
2. Is there water seeping out from the ALD indicating the ALD may be plugging?

Collection Channels, Diversion Channels, Open Limestone Channels (OLCs), Oxidation & Precipitation Channels (OPCs)
1. Check the channel for stability, erosion rills, debris/obstructions, and significant siltation. Does the channel need to be cleaned out?
2. Is there any evidence that water has overtopped the channel? Does the channel need to be repaired or replaced?

Culverts
1. Check to see if the culvert is crushed, plugged, damaged? Does the culvert need to be cleaned out, repaired, or replaced?
2. Is the culvert able to handle all of the water? Is there evidence of water flowing over or around the culvert?

Diversion Well
1. Does limestone or other treatment media need to be added? Does limestone or other treatment media need to be ordered & delivered?
2. Is the inlet clear of debris?

Forebays, Ponds, Settling Basins/Settling Ponds
1. Does the pond appear to be short-circuiting? Determine with use of a dye-test or by water quality data. If so, a baffle may need to be installed.
2. Is the baffle functioning properly? Is the baffle in the proper position? Does the baffle need to be weighted down? Does the baffle need reset?

Horizontal Flow Limestone Beds (HFLBs), Manganese Oxidizing Beds (MOBs), Sloped Limestone Beds (SLBs)
1. Is the water flowing above the top of the stone indicating the treatment media or piping may be plugging? Does the media need to be stirred?
2. Is there excessive vegetation growing in the treatment media that needs to be removed?

Vertical Flow Ponds (VFPs), Vertical Flow Wetlands (VFWs), Successive Alkalinity Producing Systems (SAPS)
1. Does the water level appear to be increasing in the pond?
2. Was the component flushed? Does the component need to be flushed or backflushed?
3. Does the treatment media need to be stirred and/or mixed?

Weirs & Flumes
1. Does the weir or flume need to be cleaned out? Clean the debris, sediment, and sludge and allow to equilibrate before measuring flow.
2. Check to make sure the weir or flume is stable and is level both horizontally and vertically. Does the weir or flume need to be reset?
3. Does the weir or flume need to be repaired or replaced?

Wetlands
1. Does the wetland appear to be short-circuiting or channelizing? If so, were haybales placed? Do haybales need to be placed?
2. Is the wetland well vegetated with wetland plants? If not what is the cause (water level to high, muskrats, water quality, etc)?
3. Are there invasive species in the wetlands?

NAACC North Atlantic Aquatic Connectivity Collaborative

AQUATIC CONNECTIVITY
Stream Crossing Survey
DATA FORM

DATABASE ENTRY BY ____ ENTRY DATE ____

DATA ENTRY REVIEWED BY ____ REVIEW DATE ____

CROSSING DATA

Crossing Code____ **Local ID** (Optional)____

Date Observed (00/00/0000)____ **Lead Observer**____

Town/County____ **Stream**____

Road____ **Type** ☐ MULTILANE ☐ PAVED ☐ UNPAVED ☐ DRIVEWAY ☐ TRAIL ☐ RAILROAD

GPS Coordinates (Decimal degrees) ☐☐.☐☐☐☐☐ °N Latitude — ☐☐.☐☐☐☐☐ °W Longitude

Location Description

Crossing Type ☐ BRIDGE ☐ CULVERT ☐ MULTIPLE CULVERT ☐ FORD ☐ NO CROSSING ☐ REMOVED CROSSING ☐ BURIED STREAM ☐ INACCESSIBLE ☐ PARTIALLY INACCESSIBLE ☐ NO UPSTREAM CHANNEL ☐ BRIDGE ADEQUATE

Number of Culverts/ Bridge Cells ____

Photo IDs INLET____ OUTLET____ UPSTREAM____ DOWNSTREAM____ OTHER____

Flow Condition ☐ NO FLOW ☐ TYPICAL-LOW ☐ MODERATE ☐ HIGH

Crossing Condition ☐ OK ☐ POOR ☐ NEW ☐ UNKNOWN

Tidal Site ☐ YES ☐ NO ☐ UNKNOWN

Alignment ☐ FLOW-ALIGNED ☐ SKEWED (>45°)

Road Fill Height (Top of culvert to road surface; bridge = 0)____

Bankfull Width (Optional)____ **Confidence** ☐ HIGH ☐ LOW/ESTIMATED

Constriction ☐ SEVERE ☐ MODERATE ☐ SPANS ONLY BANKFULL/ ACTIVE CHANNEL ☐ SPANS FULL CHANNEL & BANKS

Tailwater Scour Pool ☐ NONE ☐ SMALL ☐ LARGE

Crossing Comments

STRUCTURE 1

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Outlet Armoring ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**____.____ **B. Height**____.____ **C. Substrate/Water Width**____.____ **D. Water Depth**____.____

Outlet Drop to Water Surface____.____ **Outlet Drop to Stream Bottom**____.____ **E. Abutment Height** (Type 7 bridges only)____.____

L. Structure Length (Overall length from inlet to outlet)____.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**____.____ **B. Height**____.____ **C. Substrate/Water Width**____.____ **D. Water Depth**____.____

ADDITIONAL CONDITIONS

Slope % (Optional)____ **Slope Confidence** ☐ HIGH ☐ LOW

Internal Structures ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER____

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**____

Comments

5/26/16

STRUCTURE 2

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED **Outlet Armoring** NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

Outlet Drop to Water Surface__________.___ **Outlet Drop to Stream Bottom**__________.___ **E. Abutment Height** (Type 7 bridges only)______________.___

L. Structure Length (Overall length from inlet to outlet)_____________.____

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

ADDITIONAL CONDITIONS

Slope % (Optional)________ **Slope Confidence** HIGH LOW | **Internal Structures** NONE BAFFLES/WEIRS SUPPORTS OTHER________

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

Structure Substrate Type (Pick one) NONE SILT SAND GRAVEL COBBLE BOULDER BEDROCK UNKNOWN

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

Dry Passage through Structure? YES NO UNKNOWN **Height above Dry Passage**___________

Comments

STRUCTURE 3

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED **Outlet Armoring** NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

Outlet Drop to Water Surface__________.___ **Outlet Drop to Stream Bottom**__________.___ **E. Abutment Height** (Type 7 bridges only)______________.___

L. Structure Length (Overall length from inlet to outlet)_____________.____

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

ADDITIONAL CONDITIONS

Slope % (Optional)________ **Slope Confidence** HIGH LOW | **Internal Structures** NONE BAFFLES/WEIRS SUPPORTS OTHER________

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

Structure Substrate Type (Pick one) NONE SILT SAND GRAVEL COBBLE BOULDER BEDROCK UNKNOWN

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

Dry Passage through Structure? YES NO UNKNOWN **Height above Dry Passage**___________

Comments

STRUCTURE 4

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

Outlet Drop to Water Surface________.___ **Outlet Drop to Stream Bottom**________.___ **E. Abutment Height** (Type 7 bridges only)________.___

L. Structure Length (Overall length from inlet to outlet)________.___

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

ADDITIONAL CONDITIONS

Slope % (Optional)________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**________

Comments

STRUCTURE 5

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

Outlet Drop to Water Surface________.___ **Outlet Drop to Stream Bottom**________.___ **E. Abutment Height** (Type 7 bridges only)________.___

L. Structure Length (Overall length from inlet to outlet)________.___

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

ADDITIONAL CONDITIONS

Slope % (Optional)________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**________

Comments

STRUCTURE 6

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

Outlet Drop to Water Surface_________.____ **Outlet Drop to Stream Bottom**_________.____ **E. Abutment Height** (Type 7 bridges only)_________.____

L. Structure Length (Overall length from inlet to outlet)_________.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions A. Width_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

ADDITIONAL CONDITIONS

Slope % (Optional)_________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER_________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**_________

Comments

STRUCTURE 7

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

Outlet Drop to Water Surface_________.____ **Outlet Drop to Stream Bottom**_________.____ **E. Abutment Height** (Type 7 bridges only)_________.____

L. Structure Length (Overall length from inlet to outlet)_________.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions A. Width_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

ADDITIONAL CONDITIONS

Slope % (Optional)_________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER_________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**_________

Comments

Structure Shape & Dimensions

1) Select the Structure Shape number from the diagrams below and record it on the form for Inlet and Outlet Shape.

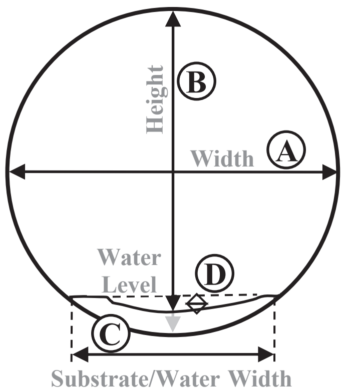
2) Record on the form in the approriate blanks dimensions **A**, **B**, **C** and **D** as shown in the diagrams;
C captures the width of water or substrate, whichever is wider; for dry culverts without substrate, C = 0.
D is the depth of water -- be sure to measure inside the structure; for dry culverts, D = 0.

3) Record Structure Length (**L**). (Record abutment height (**E**) only for Type 7 Structures.)

4) For multiple culverts, also record the Inlet and Outlet shape and dimensions for each additional culvert.

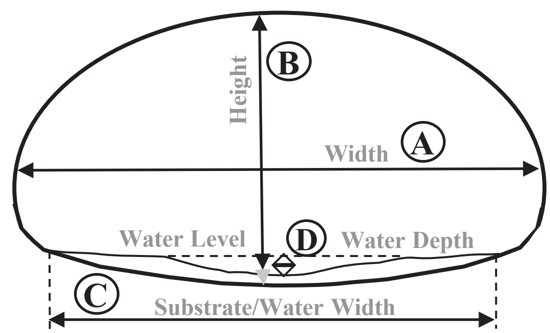
NOTE: Culverts 1, 2 & 4 may or may not have substrate in them, so height measurements (B) are taken from the level of the "stream bed", whether that bed is composed of substrate or just the inside bottom surface of a culvert (grey arrows below show measuring to bottom, black arrows show measuring to substrate).

1



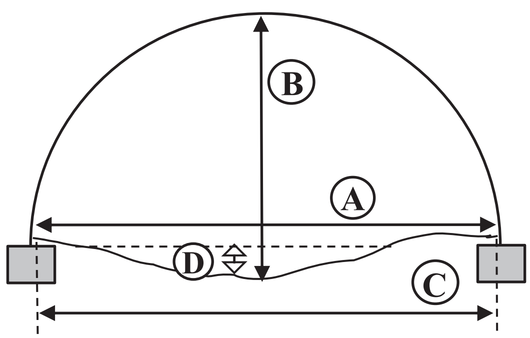
Round Culvert

2



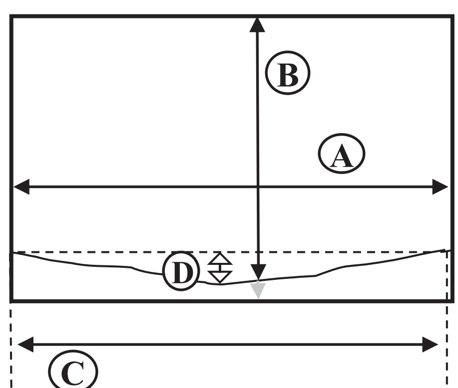
Pipe Arch/Elliptical Culvert

3



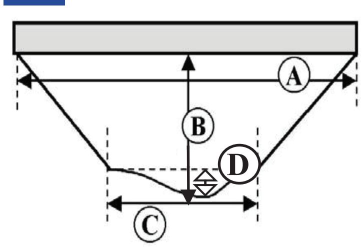
Open Bottom Arch Bridge/Culvert

4



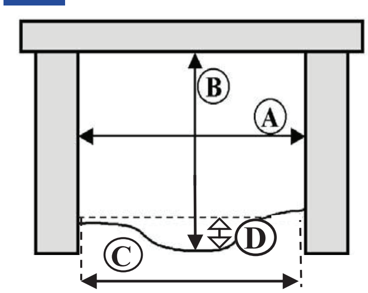
Box Culvert

5



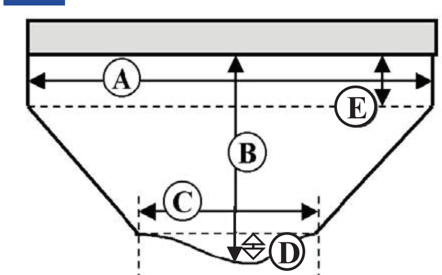
Bridge with Side Slopes

6



Box/Bridge with Abutments

7



Bridge with Abutments and Side Slopes

Introduction

Chemical characterization of a waterbody is driven by the need to identify the sources/causes of impairment and possible treatment (if needed). In combination with other detailed field observations (ex. ambient temperature, weather conditions, and flow) the measurement of several water quality parameters can indicate stream health at that moment in time. At a minimum, pH, dissolved oxygen, conductivity, and temperature are measured in the field with handheld meters calibrated according to manufacturer's specifications. These parameters are considered volatile because they need to be sampled within 15 minutes of sample collection to be accurate.

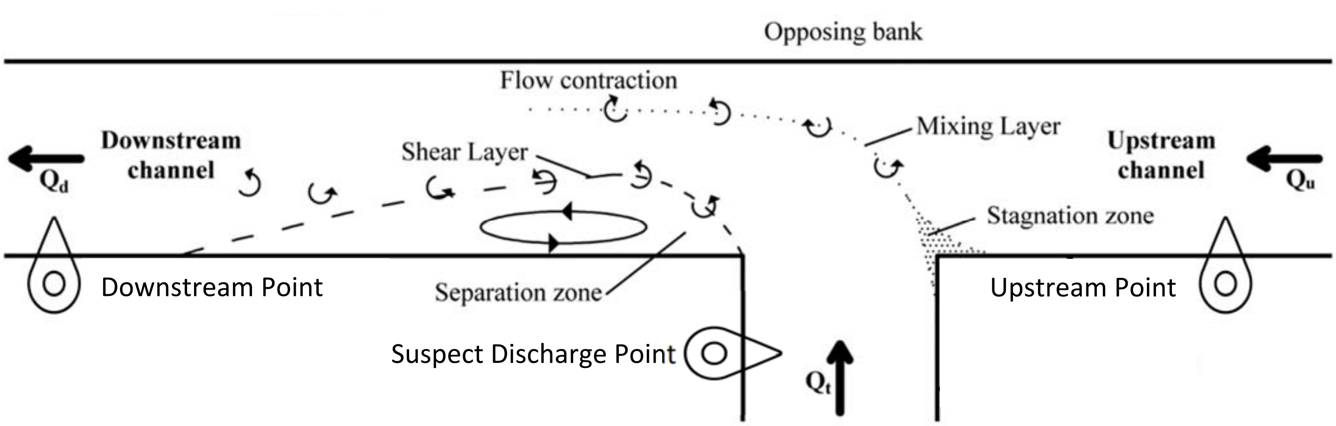
Depending on the suspected source/cause additional parameters are taken in the field or a sample is "grabbed" for the lab. The typical AMD suite includes alkalinity, acidity, metals (iron, aluminum, and manganese), sulfates, TDS (total dissolved solids) and TSS (total suspended solids). Record field water quality parameters in the Field Sampling Data form, but it is also helpful to keep a notebook to record additional notes that do not fit on the form. Use all your senses for notes. For example, is there an odor to the water or do you see oil/foam floating on the surface? Be sure to jot down the initials of everyone in your sampling team. You can never have too much detail in notes.

A pollution loading can be calculated with this formula where a concentration (c) is multiplied by flow (d) and a conversion factor (f). If the concentrations are given in mg/L and flow in CFS the conversion factor is 5.39 which yields a loading in lbs/day.

Loading $(L) = f \times c \times d$

Methods

Site selection – when monitoring a known or suspected pollution source you should get a sample of the water as close to the source as possible. This will limit chance for additional influences. To determine the impact on the stream, you will want to take samples upstream and downstream of the confluence with pollution source. The upstream site can be immediately upstream, but when choosing the downstream site be sure to go below the mixing zone. Conductivity may be helpful in determining this point or multiple samples can be taken across a transect of the stream. It is often helpful to draw a map to help determine sampling sites. This map should include any tributaries and important structures (ex. bridge or culvert), plants, and attributes of the bank and near stream areas. Use an arrow to indicate the direction of flow. Estimate "river mile" for the sampling reach for probable use in data management of the water resource agency. Use a hand-held Global Positioning System (GPS) for latitude and longitude determination taken at each sampling point and indicate location on the map.



Field sampling:

Success in obtaining accurate and consistent test results will depend on the care with which test procedures are carried out. Always follow the test instructions carefully and observe the stated standing periods and temperature conditions where applicable. Always carry extra batteries and a Philips screw driver, you never know whey batteries will expire and where you will be. The YSI Pro Plus takes 2 “C” batteries, the HANNA meter takes 4 watch batteries and the YSI Photometer takes 3 “AA” batteries.

YSI Professional Plus Probe (temperature, pH, dissolved oxygen, ORP):

The YSI Pro Plus is a handheld computer and probe on a 3’ cable. When placed in the soft sided bag for transportation and storage, the probe is covered with a cup with distilled water. Unscrew to remove this cup and replace with the weighted cage which protects the probes as it is placed into the water body to be sampled.

Press the Power key to turn the instrument on. The instrument will briefly display the splash screen with the YSI logo then go directly to the main run screen. The display at the left shows the run mode (main display) with temperature in °C, barometer in mmHg, DO in % and mg/L, and pH as the reported parameters. The date, time and battery level are indicated at the bottom of the screen. The logging preference of Log One Sample at a time is indicated at the top of the screen. Allow the probe to sit in the water until the letters “AS” next to each parameter stops blinking.

No other buttons need to be pressed unless the instrument has had a battery change (with batteries removed for more than 2 minutes), you will need to set the date and time. Follow the instructions under System Menu | Date/Time. This probe needs to be calibrated periodically. Instructions can be found in the user manual.

SOURCE: YSI PROFESSIONAL PLUS USER MANUAL REVISION D HTTPS://WWW.YSI.COM/FILE%20LIBRARY/DOCUMENTS/MANUALS/605596-YSI-PROPLUS-USER-MANUAL-REVD.PDF

HANNA EC/TDS Meter (temperature, conductivity, TDS):

Press and hold the Power/MODE button for 2-3 seconds to turn on/off instrument. All the used segments on the LCD will be visible for a few seconds, followed by a percent indication of the remaining battery life.

To take measurements, remove the sensor cap and submerge the probe in the solution to be tested. Use plastic beakers to minimize any electromagnetic interferences. Select either EC or TDS mode with the SET/HOLD button.

The measurements should be taken when the stability symbol (clock) on the top left of the LCD disappears. The EC (or TDS) value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

SOURCE: HI 98311 & HI 98312 WATERPROOF EC/TDS/TEMPERATURE TESTERS MANUAL HTTPS://DOCS.RS-ONLINE.COM/1F7D/0900766B80750554.PDF

YSI 9500 Photometer (metals, turbidity, alkalinity, sulfate, nitrate, phosphate and more):

The YSI 9500 Photometer feature digital electronics and built-in filters. The instruments are rugged, durable and IP-67 rated yet lightweight and portable for field or laboratory use. Additionally, the photometers are direct-reading, have automatic blank setting, automatic wavelength selection, and automatic power cut-off.

Keep the photometer clean and in good working order by adhering to the following recommendations:

- Do not pour out samples or prepare the tests directly over the instrument.
- Always cap the test tubes before inserting into the instrument for readings.
- Wipe test tubes with a clean tissue to remove drips or condensation before placing in the photometer.
- Do not leave tubes standing in the test chamber. Remove the tubes immediately after each test.
- Immediately wipe up any drips or spills on the instrument or in the test chamber with a clean tissue.
- Keep the instrument clean. Clean the test chamber regularly using a moistened tissue or cotton ball.
- Keep the instrument away from all chemicals and cleaning materials.
- Keep the instrument in a clean, dry place when it is not in use. Keep it on a clean, dry bench away from chemicals, place it in a storage cupboard or keep it in a carrying case.
- Keep the carrying case in a clean, dry condition. Make sure that the carrying case is dry before the case is closed up and the instrument is put away.

The photometer is pre-programmed with calibrations for each test parameter. Corresponding reagents are used and/or different test procedures are carried out at different wavelengths to optimize the sensitivity of each test. The required wavelength is selected automatically by the instrument.

Collect water to be sampled with a dipper on a handle to easily transport the water to the photometer.

Prepare a blank by pouring 10 ml of water to be tested into a test tube. Cap and set aside.

Prepare the sample by pouring 10 ml of water to be tested into a test tube and following the specific instructions related to the parameter you want to test. These instructions can be found in the manual in the photometer case.

When your samples are prepared, the photometer is controlled by a simple intuitive menu system:

1. The on/off button powers on or off the device. The photometer will auto power off after 5 minutes after the last press of a button (this and other automatic settings can be controlled in the settings menu)
2. The highlight indicates the active line or section of the screen. The ^ and v keys move the highlight through the menu choices. You can also key in the test number with the number keypad.
3. The flashing cursor in the 'Options' menu at the bottom of the screen indicates the action which will occur if the [OK] button is pressed.

Once a test is selected, the screen prompts guide the user toward the test result. Generally, the sequence is as follows. The photometer will prompt the dilution factor. If the sample is not diluted choose 1x. Next, insert the blank tube and place the light cap over the testing chamber. Push the OK button to "blank" the unit. After a few seconds, you will be prompted to remove the blank and insert the sample. Replace the light cap and push the OK button. The reading is taken, and results are displayed in a numerical format. If the test result can be expressed in different chemical forms, the chemical symbol will have flashing ^ and v to indicate this.

If the symbols << show up the result is lower than the test range. If the symbols >> show up the result is higher than the test range. You can dilute a sample to overcome a >> reading. This option may be used in conjunction with the YSI Dilution Tube which enables dilutions of x2, x3, x4, x5 and x10 to be made. Fill the water to be sampled to the desired marking in the dilution tube and fill the rest with distilled water. Remember that dilutions can add error. Be sure to measure carefully. Dilutions are done prior to adding reagents.

Dissolved parameters (ex. dissolved iron and turbidity) can be obtained by first running samples through a 0.45 micron filter using a portable field apparatus (ex. syringe or Buchner funnel).

SOURCE: YSI 9300 AND 9500 DIRECT-READ PHOTOMETERS USER MANUAL HTTPS://WWW.YSI.COM/FILE%20LIBRARY/ DOCUMENTS/MANUALS/YPT281-YSI-9500-PHOTOMETER-OPERATION-MANUAL-MAR07.PDF

Collection for Lab Analysis (typical AMD suite with metals included):

Procedures for individual labs may vary slightly. Contact the lab prior to sampling for their protocol and to obtain their chain of custody form.

1. At minimum, you will take one large sample (1000 - 500 mL) and one “acidified” small sample (250 - 125 mL). Additional filtered samples may be required for dissolved parameter analysis. In this case samples are filtered through a 0.45 micron filter using a portable field apparatus (ex. syringe or Buchner funnel).

2. Mark a large red “A” on the lid of the smaller bottle with permanent marker. If the bottles come pre acidified, the lab will often mark the bottle for you (and skip step 4).

3. Dip the bottles into the creek or discharge, cap and rinse several times with this water, then fill each bottle. If your small bottle is pre acidified, pour water into it until full without rinsing. Don’t let it overflow.

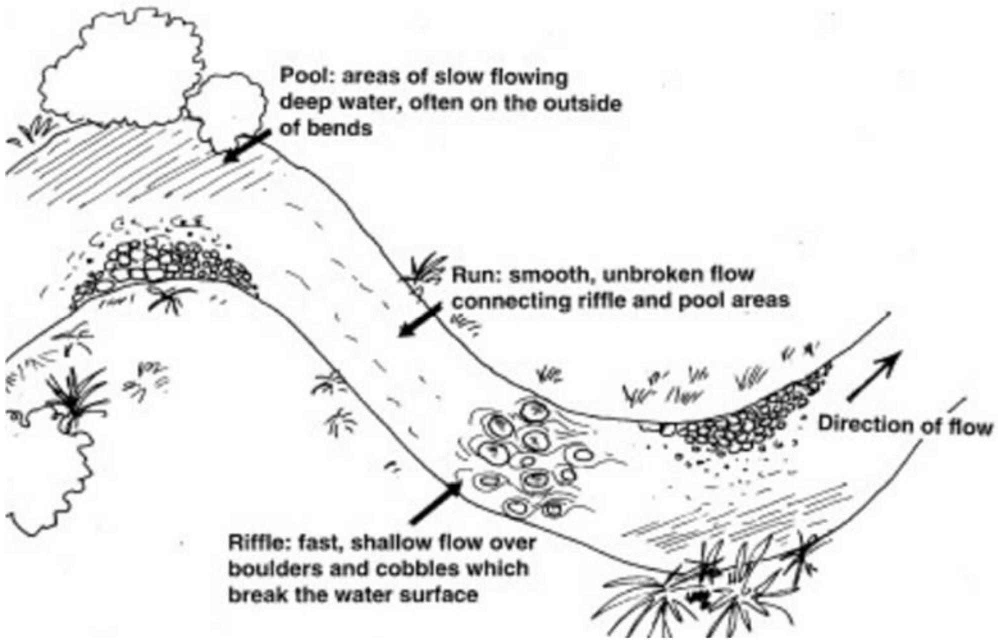
4. In the smaller bottle, add 3 drops of HNO3 (or another recommended acid).

5. Cap both bottles and keep in a cooler on ice until dropping them at the appropriate pick-up point.

6. Make sure you mark and have a record of which sample corresponds with which monitoring station.

SOURCE: MAHAFFEY LABORATORY, LTD. MINE DRAINAGE INFORMATION / CHAIN OF CUSTODY FORM

Introduction



Stream flows are an estimate of the amount of water going through a channel at a given time and are important to determine pollution loading. Most discharges or streams are variable with precipitation. Some remain relatively stable throughout the year especially if they are influenced mostly by groundwater. When choosing where to take flow along a stream corridor it is always best to choose a run. Figure to the right explains the difference between a pool, run and riffle. Try to find a stream section with a straight distance that is 2x the width of the stream. Also, if you are sampling chemistry at the same time be sure to take chemistry samples above the flow sampling point as you will inevitably stir up sediment as you move across the stream taking flow.

Things to Avoid:

- immediately downstream of a road crossing, drainage ditch or tributary confluence
- deflecting structures, sand bars and big boulders that will cause eddies and backwater areas
- abrupt almost vertical changes in depth (a uniform "U" shaped channel is ideal)

To calculate flow there are 3 dimensions to measure: stream width (w), stream depth (d) and water velocity (v).

"Ballpark" flow (Q) = w X d X v

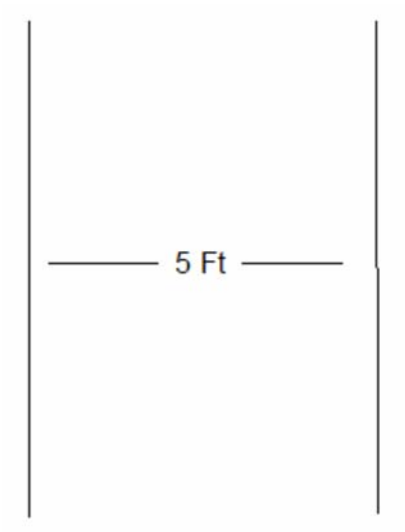
Methods

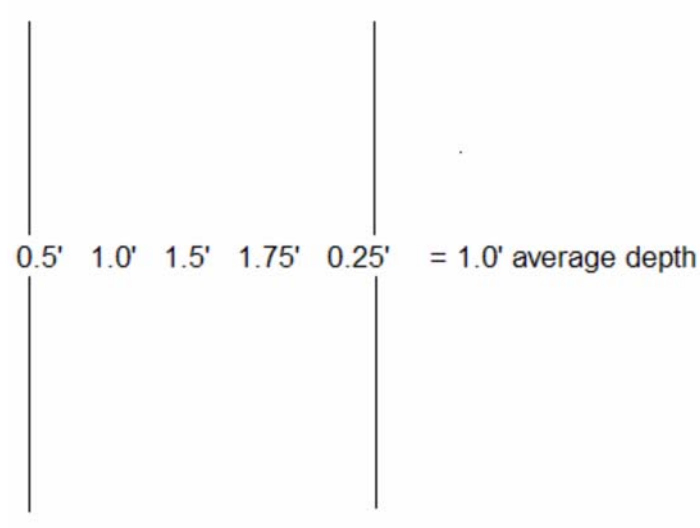
Small Streams / Discharges (< 5 ft across) "Ballpark" Method:

We call this the ballpark method because obviously not all streams are perfect rectangles with even flow throughout. However, if you do not have specific flow monitoring equipment and/or only need a rough idea of the flow this method "might not get you on home plate, but you will be in the ballpark."

1. Measure the stream's width in feet. Stretch a tape from water's edge to water's edge.

2. Measure the stream's depth by taking a depth (in feet) at every 1 foot interval and average the depths.





3. Measure the stream's velocity. If you have a flow probe, take the measurement a little more than ½ way down from the surface (4/10 off the bottom of the stream) in the thalweg (where most of the water looks to be flowing). No flow meter? Use float & stopwatch technique or head rod method to measure velocity (see below).

4. Ballpark Calculation: Flow cubic feet per second (CFS) = width (ft) X average depth (ft) X velocity (ft/sec).

So, in the example above: 5 ft w X 1 ft d X 0.733 ft/sec v = 3.66 CFS

Conversion to gallons per minute (gpm): Flow (gpm) = Flow (CFS) X 448.83

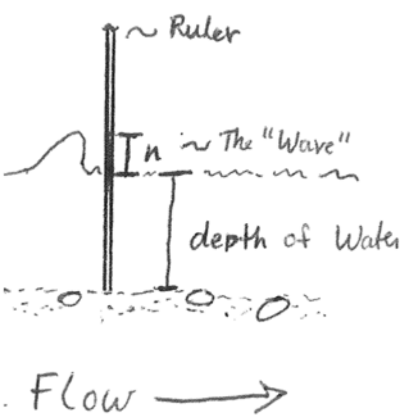
For a more exact flow calculation follow the Larger stream instructions and use ½ foot intervals.

(Optional) Float & Stopwatch Technique for measuring Velocity:

A. Lay out a tape measure along bank to a selected length (this example 5 ft)

B. Time how quickly a bobber (a ping pong ball or an orange works great too) takes to flow those 5 ft at every 1 ft interval down the stream and then average. Ex. v= 5 ft./10 sec. = 0.5 ft/sec

Interval	Time	Feet/Second
1 ft	10 sec	0.5
2 ft	7 sec	0.71
3 ft	5 sec	1.0
4 ft	6 sec	0.83
5 ft	8 sec	0.625
	Average	0.733 ft/sec



(Optional) Head Rod Flow Estimates for Velocity*:

*Only works for small streams & discharges < 5 ft across and 1"<18" deep.

A. Place rod in the water with sharp edge upstream to measure stream depth.

B. Place rod sideways in the water. This will create turbulence and the water will jump or rise above its normal depth. Measure the turbulent depth.

C. Subtract stream depth in Step 1 from the turbulent depth reading in Step 2 to obtain the "wave" height, or velocity head in inches (n); velocity is proportional to this "wave" height (n).

D. Find the stream velocity in feet per second from the table below. The formula is: $V = 8 \times \sqrt{n}$

Wave	Velocity	Wave	Velocity	Wave	Velocity	Wave	Velocity	Wave	Velocity	Wave	Velocity
¼"	1.2 f/s	1 ¼"	2.6 f/s	2 ¼"	3.5 f/s	3 ¼"	4.2 f/s	4 ¼"	4.8 f/s	5 ¼"	5.3 f/s
½"	1.6 f/s	1 ½"	2.8 f/s	2 ½"	3.7 f/s	3 ½"	4.3 f/s	4 ½"	4.9 f/s	5 ½"	5.4 f/s
¾"	2.0 f/s	1 ¾"	3.1 f/s	2 ¾"	3.8 f/s	3 ¾"	4.5 f/s	4 ¾"	5.0 f/s	5 ¾"	5.5 f/s
1"	2.3 f/s	2"	3.3 f/s	3"	4.0 f/s	4"	4.6 f/s	5"	5.2 f/s	6"	5.7 f/s

SOURCE: WEST VIRGINIA DEP SAVE OUR STREAMS (HTTPS://DEP.WV.GOV/WWE/GETINVOLVED/SOS/PAGES/SOPFLOW.ASPX).

Larger Streams / Discharges (> 5 ft across) use USGS Midsection Method

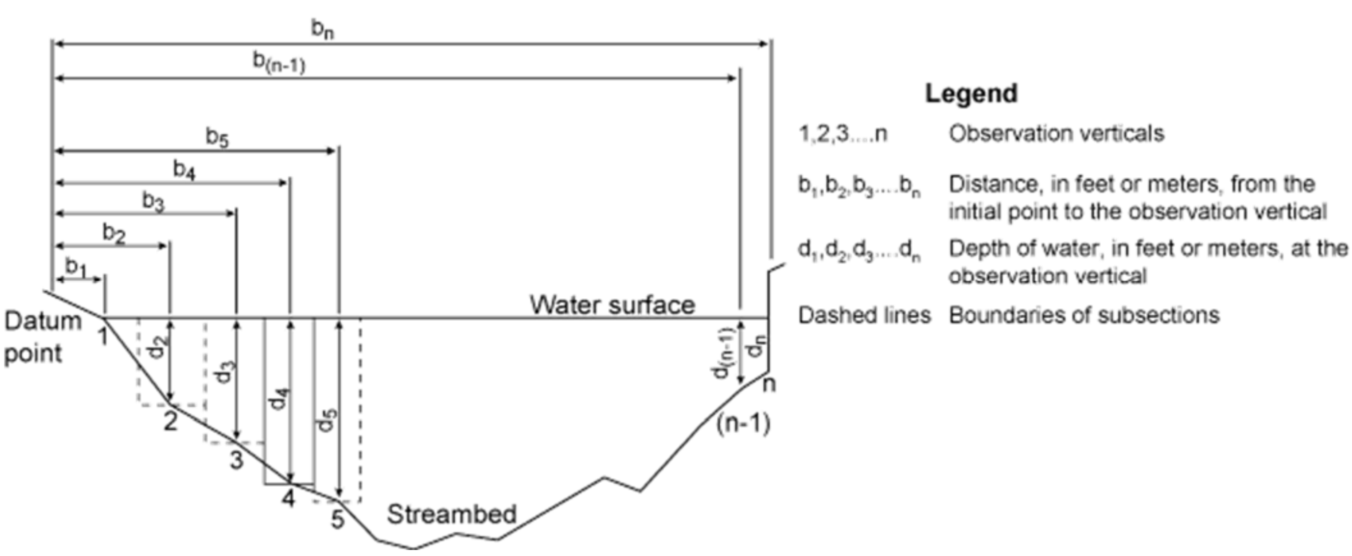
Follow steps for the small streams, except this method requires taking a velocity and depth at every interval (station) across the stream (see the diagram below). If the stream is > 20 feet wide stations can be 2 feet apart. The idea is to have between 10 and 20 stations to add together.

1. Stretch a tape across the stream perpendicular to the flow. Stake the tape end at a datum point away from the wetted edge or tie to a sturdy branch.

2. Move along the tape to take depth (d) and velocity (v) measurements with a wading rod at consistent intervals. Take the velocity measurement a little more than ½ way down from the surface (4/10 off the stream bed). If you have a 4/10 wading rod, there will be a slide to help you judge this depth.

3. Stop taking measurements after you have reached the opposite wetted edge. It usually is necessary to estimate the velocity at an end section. If you have an AquaCalc or Swoffer flow meter to enter the measurements, the computer will often calculate a flow using the formula below. Otherwise, it is helpful to have an assistant recording the measurements in a spreadsheet onshore to later calculate a flow with this formula:

Station flow $Q_n = v_n((b_n - b_{(n-1)})/2) \times ((b_{(n+1)} - b_n)/2)d_n$, then sum partials for the total flow



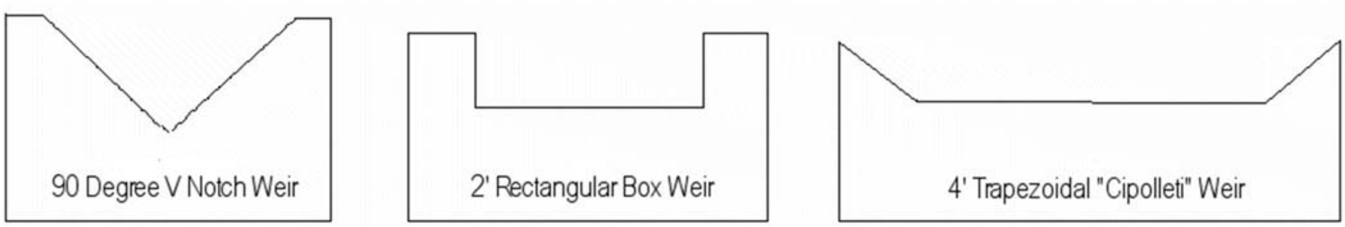
Example 1 (10 ft wide stream):
Take width and depth at <u>every one foot</u> interval across stream then add every CFS

Station	Velocity	Depth	CFS
1'	0.43	0.56	0.2408
2'	0.52	0.43	0.2236
3'	0.71	1.70	1.207
4'	0.86	0.56	0.4816
5'	0.34	0.43	0.1462
6'	0.90	0.89	0.801
7'	0.49	0.78	0.3822
8'	0.50	0.53	0.265
9'	0.87	0.45	0.3915
10'	0.23	0.23	0.0529
		Total CFS	**4.1918**
		Total gpm	**1881.28**

Example 2 (30 ft wide stream):
Take width and depth at <u>every three foot</u> interval across stream the add every CFS

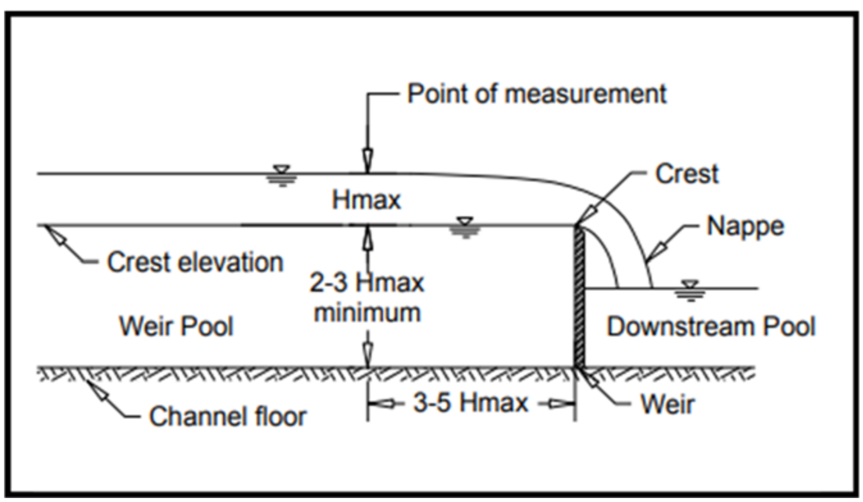
Station	Velocity	Depth	CFS (w X v X d)
3'	0.43	0.56	0.7224
6'	0.52	0.43	0.6708
9'	0.71	1.70	3.621
12'	0.86	0.56	1.4448
15'	0.34	0.43	0.4386
18'	0.90	0.89	2.403
21'	0.49	0.78	1.1466
24'	0.50	0.53	0.795
27'	0.87	0.45	1.1745
30'	0.23	0.23	0.1587
		Total CFS	**4.1918**
		Total gpm	**1881.28**

Using Weirs to Estimate Flow: 90 degree V notch, box and trapezoidal weirs



Step 1. Measure height of water over the crest or notch in inches or feet and use chart below to figure out flow.

Note: Measuring at the face of the weir is incorrect. As the water approaches the nappe and the velocity increases, the surface of the water drops. Instead, measure upstream 3-5X the max measurement you can take on the weir. Determine the depth of water at this point then determine the height of the crest from the channel floor and subtract for the correct height of water over the crest.



GENERAL SOURCE CITATION (UNLESS SPECIFIED): TURNIPSEED, D.P., AND SAUER, V.B., 2010, DISCHARGE MEASUREMENTS AT GAGING STATIONS: U.S. GEOLOGICAL SURVEY TECHNIQUES AND METHODS BOOK 3, CHAP. A8, 87 P.

Height of water over the crest and corresponding flows for 90 degree, box and Trapezoidal weirs

Water Height (in)	Water Height (ft)	90º V (CFS)	90º V (gpm)	2' Box (CFS)	2' Box (gpm)	4' Box (CFS)	4' Box (gpm)	3' Trap (CFS)	3' Trap (gpm)	4' Trap (CFS)	4' Trap (gpm)
0.5	0.04	0.001	0.54	0.056	25.32	0.113	50.74	0.086	38.56	0.115	51.41
0.6	0.05	0.002	0.85	0.074	33.25	0.149	66.67	0.113	50.69	0.151	67.58
0.7	0.06	0.003	1.24	0.093	41.87	0.187	83.98	0.142	63.87	0.190	85.16
0.8	0.07	0.004	1.72	0.114	51.11	0.229	102.56	0.174	78.04	0.232	104.05
0.9	0.08	0.005	2.30	0.136	60.93	0.273	122.33	0.207	93.12	0.277	124.16
1.0	0.08	0.007	2.99	0.159	71.31	0.319	143.21	0.243	109.06	0.324	145.42
1.1	0.09	0.008	3.78	0.183	82.19	0.368	165.15	0.280	125.82	0.374	167.77
1.2	0.10	0.010	4.68	0.209	93.58	0.419	188.10	0.319	143.37	0.426	191.15
1.3	0.11	0.013	5.71	0.235	105.42	0.472	212.00	0.360	161.66	0.480	215.54
1.4	0.12	0.015	6.85	0.262	117.72	0.528	236.83	0.403	180.66	0.537	240.88
1.5	0.13	0.018	8.12	0.291	130.45	0.585	262.54	0.446	200.36	0.595	267.15
1.6	0.13	0.021	9.52	0.320	143.58	0.644	289.11	0.492	220.73	0.656	294.30
1.7	0.14	0.025	11.06	0.350	157.12	0.705	316.50	0.539	241.74	0.718	322.32
1.8	0.15	0.028	12.73	0.381	171.04	0.768	344.69	0.587	263.38	0.782	351.17
1.9	0.16	0.032	14.55	0.413	185.33	0.833	373.65	0.636	285.63	0.849	380.84
2.0	0.17	0.037	16.51	0.446	199.99	0.899	403.36	0.687	308.47	0.916	411.30
2.1	0.18	0.041	18.62	0.479	214.99	0.967	433.81	0.739	331.90	0.986	442.53
2.2	0.18	0.047	20.88	0.513	230.33	1.036	464.96	0.793	355.88	1.057	474.51
2.3	0.19	0.052	23.30	0.548	246.00	1.107	496.82	0.848	380.42	1.130	507.23
2.4	0.20	0.058	25.88	0.584	262.00	1.179	529.34	0.903	405.50	1.205	540.67
2.5	0.21	0.064	28.62	0.620	278.31	1.253	562.53	0.961	431.11	1.281	574.81
2.6	0.22	0.070	31.53	0.657	294.92	1.329	596.37	1.019	457.23	1.358	609.64
2.7	0.23	0.077	34.60	0.695	311.83	1.406	630.84	1.078	483.86	1.437	645.15
2.8	0.23	0.084	37.85	0.733	329.03	1.484	665.93	1.138	510.99	1.518	681.32
2.9	0.24	0.092	41.27	0.772	346.52	1.563	701.62	1.200	538.61	1.600	718.14
3.0	0.25	0.100	44.87	0.812	364.29	1.644	737.91	1.263	566.70	1.684	755.61
3.1	0.26	0.108	48.65	0.852	382.32	1.726	774.79	1.326	595.27	1.768	793.70
3.2	0.27	0.117	52.61	0.893	400.63	1.810	812.23	1.391	624.31	1.855	832.41
3.3	0.28	0.126	56.76	0.934	419.19	1.894	850.24	1.457	653.80	1.942	871.73
3.4	0.28	0.136	61.09	0.976	438.02	1.980	888.81	1.523	683.74	2.031	911.66
3.5	0.29	0.146	65.62	1.018	457.09	2.068	927.91	1.591	714.13	2.121	952.17
3.6	0.30	0.157	70.34	1.062	476.41	2.156	967.55	1.660	744.95	2.213	993.27
3.7	0.31	0.168	75.26	1.105	495.97	2.245	1007.72	1.729	776.21	2.306	1034.94
3.8	0.32	0.179	80.38	1.149	515.77	2.336	1048.41	1.800	807.89	2.400	1077.18
3.9	0.33	0.191	85.69	1.194	535.80	2.428	1089.60	1.871	839.98	2.495	1119.98
4.0	0.33	0.203	91.21	1.239	556.06	2.521	1131.30	1.944	872.50	2.592	1163.33
4.1	0.34	0.216	96.94	1.285	576.54	2.615	1173.49	2.017	905.42	2.690	1207.23
4.2	0.35	0.229	102.87	1.331	597.25	2.710	1216.16	2.092	938.75	2.789	1251.66
4.3	0.36	0.243	109.02	1.377	618.17	2.806	1259.32	2.167	972.47	2.889	1296.63
4.4	0.37	0.257	115.38	1.424	639.31	2.903	1302.95	2.243	1006.59	2.990	1342.12
4.5	0.38	0.272	121.95	1.472	660.65	3.001	1347.05	2.320	1041.10	3.093	1388.14
4.6	0.38	0.287	128.75	1.520	682.21	3.101	1391.61	2.397	1076.00	3.196	1434.66
4.7	0.39	0.302	135.76	1.569	703.96	3.201	1436.62	2.476	1111.27	3.301	1481.70
4.8	0.40	0.319	142.99	1.617	725.92	3.302	1482.09	2.555	1146.93	3.407	1529.24
4.9	0.41	0.335	150.45	1.667	748.07	3.405	1527.99	2.636	1182.96	3.514	1577.27
5.0	0.42	0.352	158.14	1.717	770.42	3.508	1574.33	2.717	1219.35	3.622	1625.80

Source: Open Channel Flow Website (https://www.openchannelflow.com/blog/tag/weir)

Stopwatch and Bucket Method: The only "true way" to measure flow

This will only work if you have a weir, flume or pipe with enough drop to fit a container under and catch all the water with enough time to operate a stopwatch. First, calibrate a bucket or tote by pouring in exactly one gallon (milk jug for example) and marking the water level at each fill. You will find out that most 5-gallon buckets actually hold a little more than 5 gallons.

1. Get your stopwatch ready. Place the calibrated container under the flow making sure you catch all the water and simultaneously start the timer. Stop the timer once the water has reached one of the calibration lines. Pour out the water. It's best to repeat this step a few times and average the time.

2. Divide the number of gallons of water by the time it took to fill to get a flow in gallons per minute.

Pipe Flow Estimates with Manning Equation:

Measure the diameter (D) of the pipe in feet. Measure the depth (y) of the water in the pipe in feet. Measure the slope (S) of the pipe in feet/feet. Take notes as to the type of pipe to judge the manning's roughness coefficient (n) see chart on next page. Measure the velocity (V) of water in the pipe for a quality control check.

Common Calculations are as follows:

Radius (r) = D/2

Central Angle (Θ) = 2 arccos ((r-h)/r)

Pipe Less than Half Full Calculations are as follows:

Circ. Segment Height (h) = y

Cross Sectional Area (A)= $(r^2(\Theta - \sin\Theta))/2$

Wetted Perimeter (P) = r * Θ

Pipe More than Half Full Calculations are as follows:

Circ. Segment Height (h) = 2r – y

Cross Sectional Area (A)= $\pi r^2 - (r^2(\Theta - \sin\Theta))/2)$

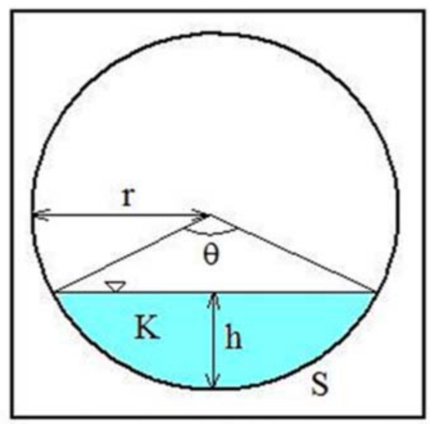
Wetted Perimeter (P) = $2\pi r - (r * \Theta)$

Back to Common Calculations:

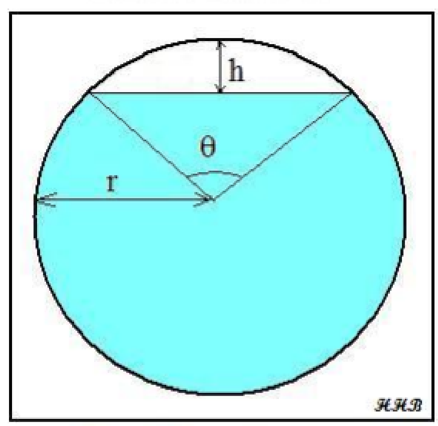
Hydraulic Radius (R_h) = A/P

Manning's Flow (Q) = $(1.49/n)(A)(R_h^{2/3})(S^{1/2})$

Velocity (V) = Q/A - check against the velocity taken



Partially Full Pipe Flow Parameters
(Less Than Half Full)



Partially Full Pipe Flow Parameters
(More Than Half Full)

It is always prudent to use more than one way to measure, calculate or estimate a flow and verify the methods.

Manning's Roughness Coefficient by Surface Material

Asbestos cement 0.011

Asphalt 0.016

Brass 0.011

Brickwork 0.015

Cast-iron, new 0.012

Clay tile 0.014

Concrete - steel forms 0.011

Concrete - finished 0.012

Concrete - wooden forms 0.015

Concrete - centrifugally spun 0.013

Copper 0.011

Corrugated metal 0.022

Earth 0.025

Earth channel - clean 0.022

Earth channel - gravelly 0.025

Earth channel - weedy 0.030

Earth channel - stony, cobbles 0.035

Floodplains - pasture, farmland 0.035

Floodplains - light brush 0.050

Floodplains - heavy brush 0.075

Floodplains - trees 0.15

Galvanized iron 0.016

Glass 0.010

Gravel 0.029

Lead 0.011

Masonry 0.025

Metal - corrugated 0.022

Natural streams - clean and straight 0.030

Natural streams - major rivers 0.035

Natural streams - sluggish with deep pools 0.040

Plastic 0.009

Polyethylene PE - Corrugated with smooth inner walls 0.009 - 0.015

Polyethylene PE - Corrugated with corrugated inner walls 0.018 - 0.025

Polyvinyl Chloride PVC - with smooth inner walls 0.009 - 0.011

Steel - Coal-tar enamel 0.010

Steel - smooth 0.012

Steel - New unlined 0.011

Steel - Riveted 0.019

Wood - planed 0.012

Wood - unplaned 0.013

Wood stave 0.012

SOURCE: HARLAN H. BENGTSON, PHD, P.E. 2011. SPREADSHEET USE FOR PARTIALLY FULL PIPE FLOW CALCULATIONS.

Mon. in field

USDA

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

National Water and Climate Center
Technical Note 99-1

Stream Visual Assessment Protocol

Issued December 1998

Cover photo: Stream in Clayton County, Iowa, exhibiting an impaired riparian zone.

Preface

This document presents an easy-to-use assessment protocol to evaluate the condition of aquatic ecosystems associated with streams. The protocol does not require expertise in aquatic biology or extensive training. Least-impacted reference sites are used to provide a standard of comparison. The use of reference sites is variable depending on how the state chooses to implement the protocol. The state may modify the protocol based on a system of stream classification and a series of reference sites. Instructions for modifying the protocol are provided in the technical information section. Aternatively, a user may use reference sites in a less structured manner as a point of reference when applying the protocol.

The Stream Visual Assessment Protocol is the first level in a hierarchy of ecological assessment protocols. More sophisticated assessment methods may be found in the Stream Ecological Assessment Field Handbook. The field handbook also contains background information on basic stream ecology. Information on chemical monitoring of surface water and groundwater may be found in the National Handbook of Water Quality Monitoring.

The protocol is designed to be conducted with the landowner. Educational material is incorporated into the protocol. The document is structured so that the protocol (pp. 7–20) can be duplicated to provide a copy to the landowner after completion of an assessment. The assessment is recorded on a single sheet of paper (copied front and back).

Acknowledgments

This protocol was developed by the Natural Resources Conservation Service (NRCS) Aquatic Assessment Workgroup. The principal authors were **Bruce Newton**, limnologist, National Water and Climate Center, NRCS, Portland, OR; **Dr. Catherine Pringle**, associate professor of Aquatic Ecology, University of Georgia, Athens, GA; and **Ronald Bjorkland**, University of Georgia, Athens, GA. The NRCS Aquatic Assessment Workgroup members provided substantial assistance in development, field evaluation, and critical review of the document. These members were:

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Contents:

Tables

Figures

Stream Visual Assessment Protocol

Introduction

This assessment protocol provides a basic level of stream health evaluation. It can be successfully applied by conservationists with little biological or hydrological training. It is intended to be conducted with the landowner and incorporates talking points for the conservationist to use during the assessment. This protocol is the first level in a four-part hierarchy of assessment protocols. Tier 2 is the NRCS Water Quality Indicators Guide, Tier 3 is the NRCS Stream Ecological Assessment Field Handbook, and Tier 4 is the intensive bioassessment protocol used by your State water quality agency.

This protocol provides an assessment based primarily on physical conditions within the assessment area. It may not detect some resource problems caused by factors located beyond the area being assessed. The use of higher tier methods is required to more fully assess the ecological condition and to detect problems originating elsewhere in the watershed. However, most landowners are mainly interested in evaluating conditions on their land, and this protocol is well suited to supporting that objective.

What makes for a healthy stream?

A stream is a complex ecosystem in which several biological, physical, and chemical processes interact. Changes in any one characteristic or process have cascading effects throughout the system and result in changes to many aspects of the system.

Some of the factors that influence and determine the integrity of streams are shown in figure 1. Often several factors can combine to cause profound changes. For example, increased nutrient loads alone might not cause a change to a forested stream. But when combined with tree removal and channel widening, the result is to shift the energy dynamics from an aquatic biological community based on leaf litter inputs to one based on algae and macrophytes. The resulting chemical changes caused by algal photosynthesis and respiration and elevated temperatures may further contribute to a completely different biological community.

Many stream processes are in a delicate balance. For example, stream power, sediment load, and channel roughness must be in balance. Hydrologic changes that increase stream power, if not balanced by greater channel complexity and roughness, result in "hungry" water that erodes banks or the stream bottom. Increases in sediment load beyond the transport capacity of the stream leads to deposition, lateral channel movement into streambanks, and channel widening.

Most systems would benefit from increased complexity and diversity in physical structure. Structural complexity is provided by trees fallen into the channel, overhanging banks, roots extending into the flow, pools and riffles, overhanging vegetation, and a variety of bottom materials. This complexity enhances habitat for organisms and also restores hydrologic properties that often have been lost.

Chemical pollution is a factor in most streams. The major categories of chemical pollutants are oxygen depleting substances, such as manure, ammonia, and organic wastes; the nutrients nitrogen and phosphorus; acids, such as from mining or industrial activities; and toxic materials, such as pesticides and salts or metals contained in some drain water. It is important to note that the effects of many chemicals depend on several factors. For example, an increase in the pH caused by excessive algal and aquatic plant growth may cause an otherwise safe concentration of ammonia to become toxic. This is because the equilibrium concentrations of nontoxic ammonium ion and toxic un-ionized ammonia are pH-dependent.

Finally, it is important to recognize that streams and flood plains need to operate as a connected system. Flooding is necessary to maintain the flood plain biological community and to relieve the erosive force of flood discharges by reducing the velocity of the water. Flooding and bankfull flows are also essential for maintaining the instream physical structure. These events scour out pools, clean coarser substrates (gravel, cobbles, and boulders) of fine sediment, and redistribute or introduce woody debris.

What's the stream type?

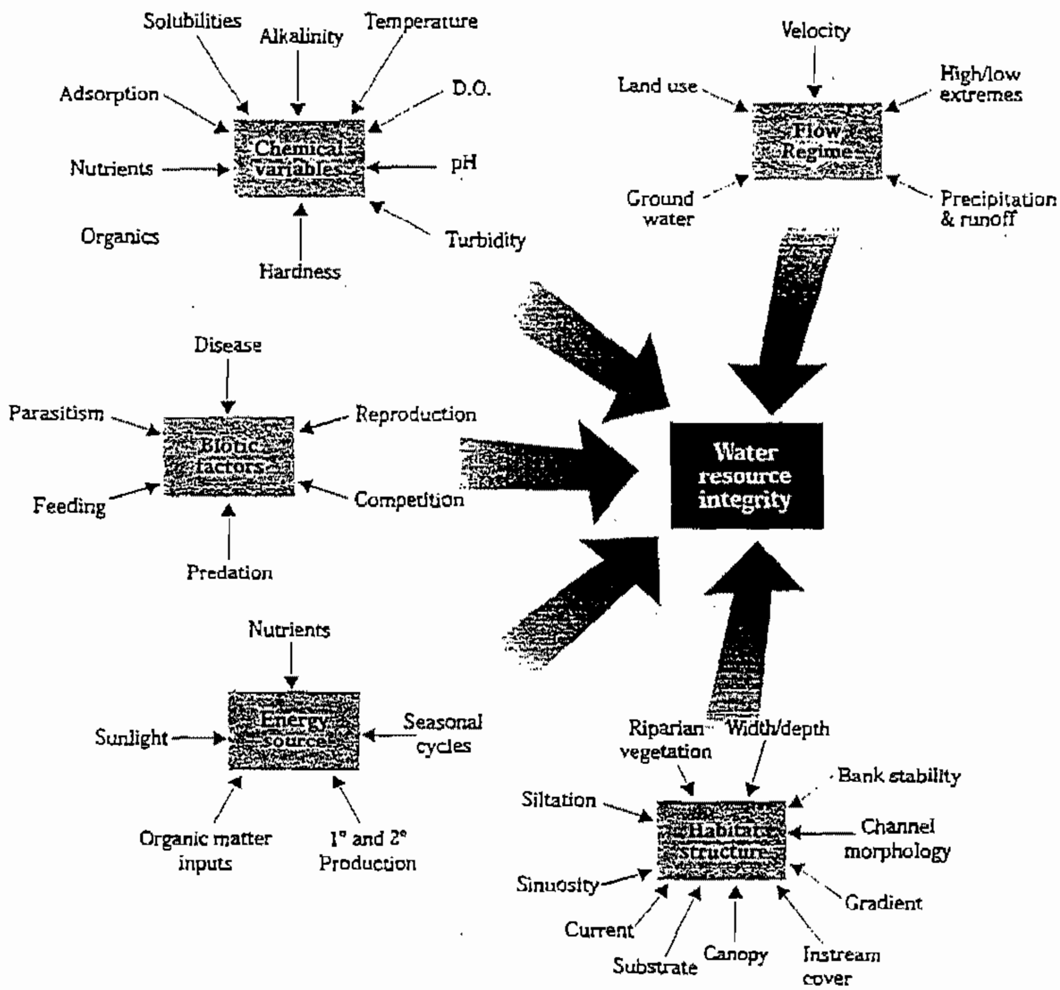
A healthy stream will look and function differently in different parts of the country and in different parts of the landscape. A mountain stream in a shale bedrock is different from a valley stream in alluvial deposits. Coastal streams are different from piedmont streams. Figuring out the different types of streams is called stream classification. Determining what types of streams are in your area is important to assessing the health of a particular stream.

There are many stream classification systems. For the purpose of a general assessment based on biology and habitat, you should think in terms of a three-level classification system based on ecoregion, drainage area, and gradient. *Ecoregions* are geographic areas in which ecosystems are expected to be similar. A national-level ecoregion map is available, and many states are working to develop maps at a higher level of resolution. *Drainage area* is the next most important factor to defining stream type. Finally, the slope or *gradient* of the reach you are assessing will help you determine the stream type. If you are familiar with another classification system, such as Rosgen or Montgomery/Buffington, you should use that system. This protocol may have been adjusted by your state office to reflect stream types common in your area.

Reference sites

One of the most difficult issues associated with stream ecosystems is the question of historic and potential conditions. To assess stream health, we need a benchmark of what the healthy condition is. We can usually assume that historic conditions were healthy. But in areas where streams have been degraded for 150 years or more, knowledge of historic conditions may have been lost. Moreover, in many areas returning to historic conditions is impossible or the historic conditions would not be stable under the current hydrology. Therefore, the question becomes what is the best we can expect for a particular stream. Scientists have grappled with this question for a long time, and the

Figure 1 Factors that influence the integrity of streams (modified from Karr 1986)



consensus that has emerged is to use reference sites within a classification system.

Reference sites represent the best conditions attainable within a particular stream class. The identification and characterization of reference sites is an ongoing effort led in most states by the water quality agency. You should determine whether your state has identified reference sites for the streams in your area. Such reference sites could be in another county or in another state. Unless your state office has provided photographs and other descriptive information, you should visit some reference sites to learn what healthy streams look like as part of your skills development. Visiting reference sites should also be part of your orientation after a move to a new field office.

Using this protocol

This protocol is intended for use in the field with the landowner. Conducting the assessment with the landowner gives you the opportunity to discuss natural resource concerns and conservation opportunities.

Before conducting the assessment, you should determine the following information in the field office:

- ecoregion (if in use in your State)
- drainage area
- stream gradients on the property
- overall position on the landscape

Your opening discussion with landowners should start by acknowledging that they own the land and that you understand that they know their operation best. Point out that streams, from small creeks to large rivers, are a resource that runs throughout the landscape—how they manage their part of the stream affects the entire system. Talk about the benefits of healthy streams and watersheds (improved baseflow, forage, fish, waterfowl, wildlife, aesthetics, reduced flooding downstream, and reduced water pollution). Talk about how restoring streams to a healthy condition is now a national priority.

Explain what will happen during the assessment and what you expect from them. An example follows:

This assessment will tell us how your stream is doing. We'll need to look at sections of the stream that are representative of different conditions. As we do the assessment we'll discuss how the functioning of different aspects of the stream work to keep the system healthy. After we're done, we can talk about the results of the assessment. I may recommend further assessment work to better understand what's going on. Once we understand what is happening, we can explore what you would like to accomplish with your stream and ideas for improving its condition, if necessary.

You need to assess one or more representative reaches. A reach is a length of stream. For this protocol, the length of the assessment reach is 12 times the active channel width. The reach should be representative of the stream through that area. If conditions change dramatically along the stream, you should identify additional assessment reaches and conduct separate assessments for each.

As you evaluate each element, try to work the talking points contained in the scoring descriptions into the conversation. If possible, involve the owner by asking him or her to help record the scores.

The assessment is recorded on a two-page worksheet. A completed worksheet is shown in figure 2. (A worksheet suitable for copying is at the end of this note.) The stream visual assessment protocol worksheet consists of two principal sections: reach identification and assessment. The identification section records basic information about the reach, such as name, location, and land uses. Space is provided for a diagram of the reach, which may be useful to locate the reach or illustrate problem areas. On this diagram draw all tributaries, drainage ditches, and irrigation ditches; note springs and ponds that drain to the stream; include road crossings and note whether they are fords, culverts, or bridges; note the direction of flow; and draw in any large woody debris, pools, and riffles.

The assessment section is used to record the scores for up to 15 assessment elements. Not all assessment elements will be applicable or useful for your site. Do not score elements that are not applicable. Score an element by comparing your observations to the descriptions provided. If you have difficulty matching descriptions, try to compare what you are observing to the conditions at reference sites for your area.

The overall assessment score is determined by adding the values for each element and dividing by the number of elements assessed. For example, if your scores add up to 76 and you used 12 assessment elements, you would have an overall assessment value of 6.3, which is classified as *fair*. This value provides a numerical assessment of the environmental condition of the stream reach. This value can be used as a general statement about the "state of the environment" of the stream or (over time) as an indicator of trends in condition.

Figure 2 Stream visual assessment protocol worksheet

USDA

Stream Visual Assessment Protocol

Owners name *Elmer Smith* Evaluator's name *Mary Soylkahn* Date *6-20-99*

Stream name *Camp Creek* Waterbody ID number ______

Reach location *About 2,000 feet upstream of equipment shed*

Ecoregion ______ Drainage area *2,200 acres* Gradient *1.2 % (map)*

Applicable reference site *Cherry Creek north of the Rt 310 bridge*

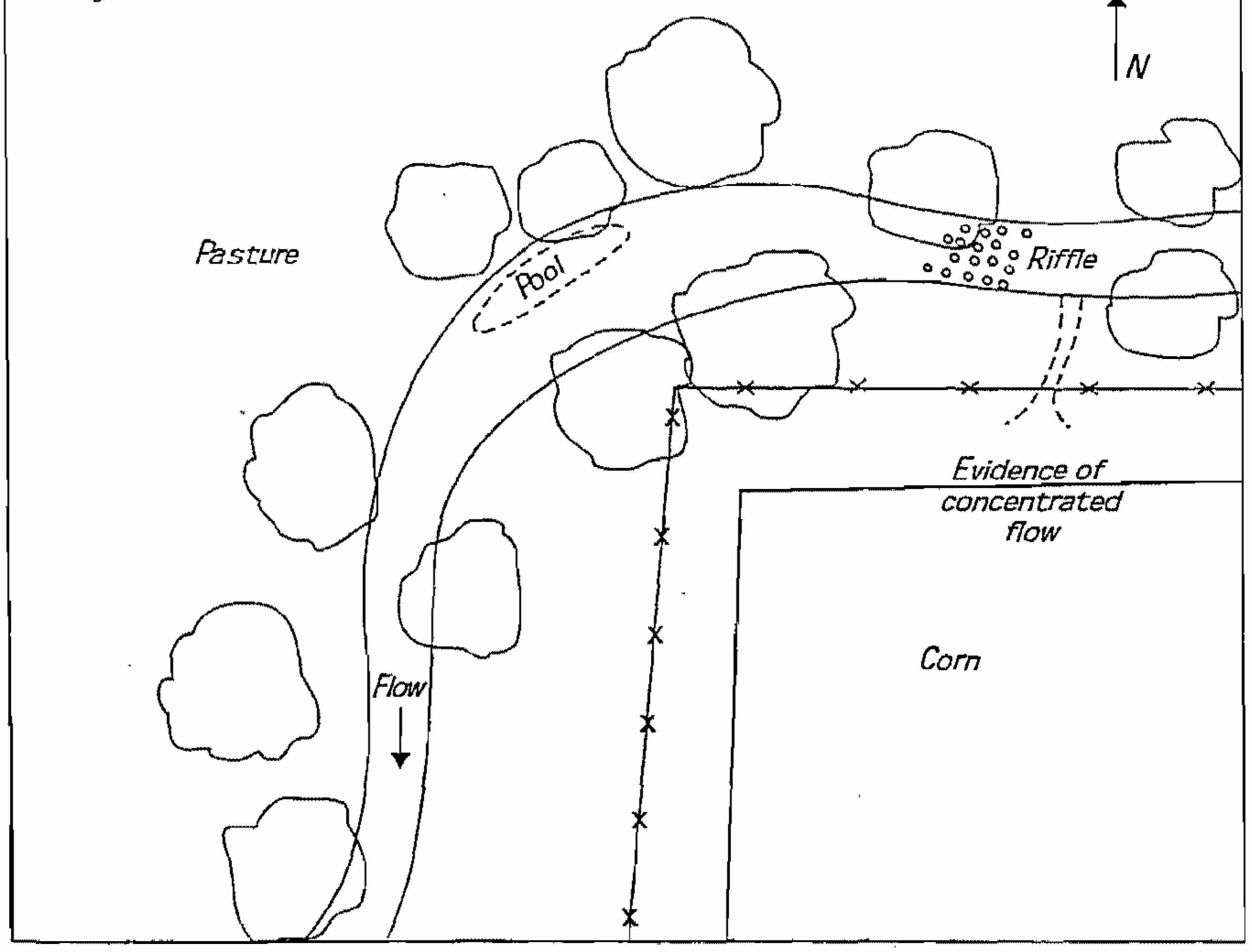
Land use within drainage (%): row crop *40* hayland *30* grazing/pasture *20* forest *10* residential ______

confined animal feeding operations ______ Cons. Reserve ______ industrial ______ Other: ______

Weather conditions-today *clear* Past 2-5 days *clear*

Active channel width *15 feet* Dominant substrate: boulder ______ gravel *X* sand *X* silt ______ mud ______

Site Diagram



Assessment Scores

Channel condition	8
Hydrologic alteration	10
Riparian zone	1
Bank stability	5
Water appearance	3
Nutrient enrichment	7
Barriers to fish movement	10
Instream fish cover	3
Pools	3
Invertebrate habitat	7

Score only if applicable

Canopy cover	3
Manure presence	7
Salinity	
Riffle embeddedness	5
Marcroinvertebrates Observed (optional)	10

Overall score (Total divided by number scored) 76/14	5.4	<6.0	Poor
		6.1-7.4	Fair
		7.5-8.9	Good
		>9.0	Excellent

Suspected causes of observed problems *This reach is typical of the reaches on the property. Severely degraded riparian zones lack brush, small trees. Some bank problems from livestock access. Channel may be widening due to high sediment load. Does not appear to be downcutting.*

Recommendations *Install 391-Riparian Forest Buffer. Need to encourage livestock away from stream using water sources and shade or exclude livestock. Concentrated flows off fields need to be spread out in zone 3 of buffer. Relocate fallen trees if they deflect current into bank–use as stream barbs to deflect current to maintain channel.*

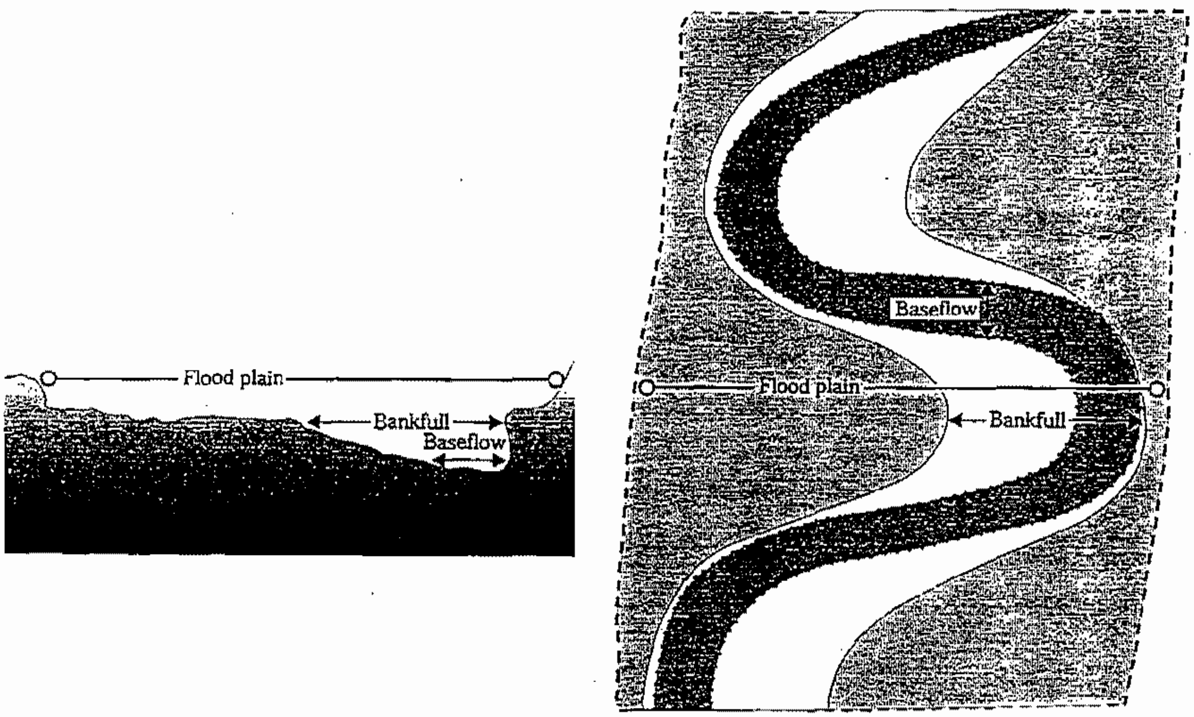
Reach description

The first page of the assessment worksheet records the identity and location of the stream reach. Most entries are self-explanatory. Waterbody ID and ecoregion should be filled out only if these identification and classification aids are used in your state.

Active channel width can be difficult to determine. However, active channel width helps to characterize the stream. It is also an important aspect of more advanced assessment protocols; therefore, it is worth becoming familiar with the concept and field determination. For this protocol you do not need to measure active channel width accurately — a visual estimate of the average width is adequate.

Active channel width is the stream width at the bankfull discharge. Bankfull discharge is the flow rate that forms and controls the shape and size of the active channel. It is approximately the flow rate at which the stream begins to move onto its flood plain if the stream has an active flood plain. The bankfull discharge is expected to occur every 1.5 years on average. Figure 3 illustrates the relationship between baseflow, bankfull flow, and the flood plain. Active channel width is best determined by locating the first flat depositional surface occurring above the bed of the stream (i.e., an active flood plain). The lowest elevation at which the bankfull surface could occur is at the top of the point bars or other sediment deposits in the channel bed. Other indicators of the bankfull surface include a break in slope on the bank, vegetation change, substrate, and debris. If you are not trained in locating the bankfull stage, ask the landowner how high the water gets every year and observe the location of permanent vegetation.

Figure 3 Baseflow, bankfull, and flood plain locations (Rosgen 1996)



Scoring descriptions

Each assessment element is rated with a value of 1 to 10. Rate only those elements appropriate to the stream. Using the Stream Visual Assessment Protocol worksheet, record the score that best fits the observations you make based on the narrative descriptions provided. Unless otherwise directed, assign the lowest score that applies. For example, if a reach has aspects of several narrative descriptions, assign a score based on the lowest scoring description that contains indicators present within the reach. You may record values intermediate to those listed. Some background information is provided for each assessment element, as well as a description of what to look for. The length of the assessment reach should be 12 times the active channel width.

Channel condition

Natural channel; no structures, dikes. No evidence of down-cutting or excessive lateral cutting.	Evidence of past channel alteration, but with significant recovery of channel and banks. Any dikes or levies are set back to provide access to an adequate flood plain.	Altered channel; <50% of the reach with riprap and/or channelization. Excess aggradation; braided channel. Dikes or levees restrict flood plain width.	Channel is actively downcutting or widening. >50% of the reach with riprap or channelization. Dikes or levees prevent access to the flood plain.
10	7	3	1

Stream meandering generally increases as the gradient of the surrounding valley decreases. Often, development in the area results in changes to this meandering pattern and the flow of a stream. These changes in turn may affect the way a stream naturally does its work, such as the transport of sediment and the development and maintenance of habitat for fish, aquatic insects, and aquatic plants. Some modifications to stream channels have more impact on stream health than others. For example, channelization and dams affect a stream more than the presence of pilings or other supports for road crossings.

Active downcutting and excessive lateral cutting are serious impairments to stream function. Both conditions are indicative of an unstable stream channel. Usually, this instability must be addressed before committing time and money toward improving other stream problems. For example, restoring the woody vegetation within the riparian zone becomes increasingly difficult when a channel is downcutting because banks continue to be undermined and the water table drops below the root zone of the plants during their growing season. In this situation or when a channel is fairly stable, but already incised from previous downcutting or mechanical dredging, it is usually necessary to plant upland species, rather than hydrophytic, or to apply irrigation for several growing seasons, or both. Extensive bank-armoring of channels to stop lateral cutting usually leads to more problems (especially downstream). Often stability can be obtained by using a series of structures (barbs, groins, jetties, deflectors, weirs, vortex weirs) that reduce water velocity, deflect currents, or act as gradient controls. These structures are used in conjunction with large woody debris and woody vegetation plantings. Hydrologic alterations are described next.

What to look for: Signs of channelization or straightening of the stream may include an unnaturally straight section of the stream, high banks, dikes or berms, lack of flow diversity (e.g., few point bars and deep pools), and uniform-sized bed materials (e.g., all cobbles where there should be mixes of gravel and cobble). In newly channelized reaches, vegetation may be missing or appear very different (different species, not as well developed) from the bank vegetation of areas that were not channelized. Older channelized reaches may also have little or no vegetation or have grasses instead of woody vegetation. Drop structures (such as check dams), irrigation diversions, culverts, bridge abutments, and riprap also indicate changes to the stream channel.

Indicators of downcutting in the stream channel include nickpoints associated with headcuts in the stream bottom and exposure of cultural features, such as pipelines that were initially buried under the stream. Exposed footings in bridges and culvert outlets that are higher than the water surface during low flows are other examples. A lack of sediment depositional features, such as regularly-spaced point bars, is normally an indicator of incision. A low vertical scarp at the toe of the streambank may indicate downcutting, especially if the scarp occurs on the inside of a meander. Another visual indicator of current or past downcutting is high streambanks with woody vegetation growing well below the top of the bank (as a channel incises the bankfull flow line moves downward within the former bankfull channel). Excessive bank erosion is indicated by raw banks in areas of the stream where they are not normally found, such as straight sections between meanders or on the inside of curves.

Hydrologic alteration

Flooding every 1.5 to 2 years. No dams, no water withdrawals, no dikes or other structures limiting the stream's access to the flood plain. Channel is not incised.	Flooding occurs only once every 3 to 5 years; limited channel incision. or Withdrawals, although present, do not affect available habitat for biota.	Flooding occurs only once every 6 to 10 years; channel deeply incised. or Withdrawals significantly affect available low flow habitat for biota.	No flooding; channel deeply incised or structures prevent access to flood plain or dam operations prevent flood flows. or Withdrawals have caused severe loss of low flow habitat. or Flooding occurs on a 1-year rain event or less.
10	7	3	1

Bankfull flows, as well as flooding, are important to maintaining channel shape and function (e.g., sediment transport) and maintaining the physical habitat for animals and plants. High flows scour fine sediment to keep gravel areas clean for fish and other aquatic organisms. These flows also redistribute larger sediment, such as gravel, cobbles, and boulders, as well as large woody debris, to form pool and riffle habitat important to stream biota. The river channel and flood plain exist in dynamic equilibrium, having evolved in the present climatic regime and geomorphic setting. The relationship of water and sediment is the basis for the dynamic equilibrium that maintains the form and function of the river channel. The energy of the river (water velocity and depth) should be in balance with the bedload (volume and particle size of the sediment). Any change in the flow regime alters this balance.

If a river is not incised and has access to its flood plain, decreases in the frequency of bankfull and out-of-bank flows decrease the river's ability to transport sediment. This can result in excess sediment deposition, channel widening and shallowing, and, ultimately, in *braiding* of the channel. Rosgen (1996) defines braiding as a stream with three or more smaller channels. These smaller channels are extremely unstable, rarely have woody vegetation along their banks, and provide poor habitat for stream biota. A *split channel*, however, has two or more smaller channels (called side channels) that are usually very stable, have woody vegetation along their banks, and provide excellent habitat.

Conversely, an increase in flood flows or the confinement of the river away from its flood plain (from either incision or levees) increases the energy available to transport sediment and can result in bank and channel erosion.

The low flow or baseflow during the dry periods of summer or fall usually comes from groundwater entering the stream through the stream banks and bottom. A decrease in the low-flow rate will result in a smaller portion of the channel suitable for aquatic organisms. The withdrawal of water from streams for irrigation or industry and the placement of dams often change the normal low-flow pattern. Baseflow can also be affected by management and land use within the watershed --- less infiltration of precipitation reduces baseflow and increases the frequency and severity of high flow events. For example, urbanization increases runoff and can increase the frequency of flooding to every year or more often and also reduce low flows. Overgrazing and clearcutting can have similar, although typically less severe, effects. The last description in the last box refers to the increased flood frequency that occurs with the above watershed changes.

What to look for: Ask the landowner about the frequency of flooding and about summer low-flow conditions. A flood plain should be inundated during flows that equal or exceed the 1.5- to 2.0-year flow event (2 out of 3 years or every other year). Be cautious because water in an adjacent field does not necessarily indicate natural flooding. The water may have flowed overland from a low spot in the bank outside the assessment reach.

Evidence of flooding includes high water marks (such as water lines), sediment deposits, or stream debris. Look for these on the banks, on the bankside trees or rocks, or on other structures (such as road pilings or culverts).

Excess sediment deposits and wide, shallow channels could indicate a loss of sediment transport capacity. The loss of transport capacity can result in a stream with three or more channels (braiding).

Riparian zone

Natural vegetation extends at least two active channel widths on each side.	Natural vegetation extends one active channel width on each side. or If less than one width, covers entire flood plain.	Natural vegetation extends half of the active channel width on each side.	Natural vegetation extends a third of the active channel width on each side. or Filtering function moderately compromised.	Natural vegetation less than a third of the active channel width on each side. or Lack of regeneration. or Filtering function severely compromised.
10	8	5	3	1

This element is the width of the natural vegetation zone from the edge of the active channel out onto the flood plain. For this element, the word *natural* means plant communities with (1) all appropriate structural components and (2) species native to the site or introduced species that function similar to native species at reference sites.

A healthy riparian vegetation zone is one of the most important elements for a healthy stream ecosystem. The quality of the riparian zone increases with the width and the complexity of the woody vegetation within it. This zone:

- Reduces the amount of pollutants that reach the stream in surface runoff.
- Helps control erosion.
- Provides a microclimate that is cooler during the summer providing cooler water for aquatic organisms.
- Provides large woody debris from fallen trees and limbs that form instream cover, create pools, stabilize the streambed, and provide habitat for stream biota.
- Provides fish habitat in the form of undercut banks with the "ceiling" held together by roots of woody vegetation.
- Provides organic material for stream biota that, among other functions, is the base of the food chain in lower order streams.
- Provides habitat for terrestrial insects that drop in the stream and become food for fish, and habitat and travel corridors for terrestrial animals.
- Dissipates energy during flood events.
- Often provides the only refuge areas for fish during out-of-bank flows (behind trees, stumps, and logs).

The type, timing, intensity, and extent of activity in riparian zones are critical in determining the impact on these areas. Narrow riparian zones and/or riparian zones that have roads, agricultural activities, residential or commercial structures, or significant areas of bare soils have reduced functional value for the stream. The filtering function of riparian zones can be compromised by concentrated flows. No evidence of concentrated flows through the zone should occur or, if concentrated flows are evident, they should be from land areas appropriately buffered with vegetated strips.

What to look for: Compare the width of the riparian zone to the active channel width. In steep, V-shaped valleys there may not be enough room for a flood plain riparian zone to extend as far as one or two active channel widths. In this case, observe how much of the flood plain is covered by riparian zone. The vegetation must be natural and consist of all of the structural components (aquatic plants, sedges or rushes, grasses, forbs, shrubs, understory trees, and overstory trees) appropriate for the area. A common problem is lack of shrubs and understory trees. Another common problem is lack of regeneration. The presence of only mature vegetation and few seedlings indicates lack of regeneration. Do not consider incomplete plant communities as natural. Healthy riparian zones on both sides of the stream are important for the health of the entire system. If one side is lacking the protective vegetative cover, the entire reach of the stream will be affected. In doing the assessment, examine both sides of the stream and note on the diagram which side of the stream has problems. There should be no evidence of concentrated flows through the riparian zone that are not adequately buffered before entering the riparian zone.

Bank stability

Banks are stable; banks are low (at elevation of active flood plain); 33% or more of eroding surface area of banks in outside bends is protected by roots that extend to the base-flow elevation.	Moderately stable; banks are low (at elevation of active flood plain); less than 33% of eroding surface area of banks in outside bends is protected by roots that extend to the baseflow elevation.	Moderately unstable; banks may be low, but typically are high (flooding occurs 1 year out of 5 or less frequently); outside bends are actively eroding (overhanging vegetation at top of bank, some mature trees falling into steam annually, some slope failures apparent).	Unstable; banks may be low, but typically are high; some straight reaches and inside edges of bends are actively eroding as well as outside bends (overhanging vegetation at top of bare bank, numerous mature trees falling into stream annually, numerous slope failures apparent).
10	7	3	1

This element is the existence of or the potential for detachment of soil from the upper and lower stream banks and its movement into the stream. Some bank erosion is normal in a healthy stream. Excessive bank erosion occurs where riparian zones are degraded or where the stream is unstable because of changes in hydrology, sediment load, or isolation from the flood plain. High and steep banks are more susceptible to erosion or collapse. All outside bends of streams erode, so even a stable stream may have 50 percent of its banks bare and eroding. A healthy riparian corridor with a vegetated flood plain contributes to bank stability. The roots of perennial grasses or woody vegetation typically extend to the baseflow elevation of water in streams that have bank heights of 6 feet or less. The root masses help hold the bank soils together and physically protect the bank from scour during bankfull and flooding events. Vegetation seldom becomes established below the elevation of the bankfull surface because of the frequency of inundation and the unstable bottom conditions as the stream moves its bedload.

The type of vegetation is important. For example, trees, shrubs, sedges, and rushes have the type of root masses capable of withstanding high streamflow events, while Kentucky bluegrass does not. Soil type at the surface and below the surface also influences bank stability. For example, banks with a thin soil cover over gravel or sand are more prone to collapse than are banks with a deep soil layer.

What to look for: Signs of erosion include unvegetated stretches, exposed tree roots, or scalloped edges. Evidence of construction, vehicular, or animal paths near banks or grazing areas leading directly to the water's edge suggest conditions that may lead to the collapse of banks. Estimate the size or area of the bank affected relative to the total bank area. This element may be difficult to score during high water.

Water appearance

Very clear, or clear but tea-colored; objects visible at depth 3 to 6 ft (less if slightly colored); no oil sheen on surface; no noticeable film on submerged objects or rocks.	Occasionally cloudy, especially after storm event, but clears rapidly; objects visible at depth 1.5 to 3 ft; may have slightly green color; no oil sheen on water surface.	Considerable cloudiness most of the time; objects visible to depth 0.5 to 1.5 ft; slow sections may appear pea-green; bottom rocks or submerged objects covered with heavy green or olive-green film. or Moderate odor of ammonia or rotten eggs.	Very turbid or muddy appearance most of the time; objects visible to depth < 0.5 ft; slow moving water may be bright-green; other obvious water pollutants; floating algal mats, surface scum, sheen or heavy coat of foam on surface. or Strong odor of chemicals, oil, sewage, other pollutants.
10	7	3	1

This element compares turbidity, color, and other visual characteristics with a healthy or reference stream. The depth to which an object can be clearly seen is a measure of turbidity. Turbidity is caused mostly by particles of soil and organic matter suspended in the water column. Water often shows some turbidity after a storm event because of soil and organic particles carried by runoff into the stream or suspended by turbulence. The water in some streams may be naturally tea-colored. This is particularly true in watersheds with extensive bog and wetland areas. Water that has slight nutrient enrichment may support communities of algae, which provide a greenish color to the water. Streams with heavy loads of nutrients have thick coatings of algae attached to the rocks and other submerged objects. In degraded streams, floating algal mats, surface scum, or pollutants, such as dyes and oil, may be visible.

What to look for: Clarity of the water is an obvious and easy feature to assess. The deeper an object in the water can be seen, the lower the amount of turbidity. Use the depth that objects are visible only if the stream is deep enough to evaluate turbidity using this approach. For example, if the water is clear, but only 1 foot deep, do not rate it as if an object became obscured at a depth of 1 foot. This measure should be taken after a stream has had the opportunity to "settle" following a storm event. A pea-green color indicates nutrient enrichment beyond what the stream can naturally absorb.

Nutrient enrichment

Clear water along entire reach; diverse aquatic plant community includes low quantities of many species of macrophytes; little algal growth present.	Fairly clear or slightly greenish water along entire reach; moderate algal growth on stream substrates.	Greenish water along entire reach; overabundance of lush green macrophytes; abundant algal growth, especially during warmer months.	Pea green, gray, or brown water along entire reach; dense stands of macrophytes clog stream; severe algal blooms create thick algal mats in stream.
10	7	3	1

Nutrient enrichment is often reflected by the types and amounts of aquatic vegetation in the water. High levels of nutrients (especially phosphorus and nitrogen) promote an overabundance of algae and floating and rooted macrophytes. The presence of some aquatic vegetation is normal in streams. Algae and macrophytes provide habitat and food for all stream animals. However, an excessive amount of aquatic vegetation is not beneficial to most stream life. Plant respiration and decomposition of dead vegetation consume dissolved oxygen in the water. Lack of dissolved oxygen creates stress for all aquatic organisms and can cause fish kills. A landowner may have seen fish gulping for air at the water surface during warm weather, indicating a lack of dissolved oxygen.

What to look for: Some aquatic vegetation (rooted macrophytes, floating plants, and algae attached to substrates) is normal and indicates a healthy stream. Excess nutrients cause excess growth of algae and macrophytes, which can create greenish color to the water. As nutrient loads increase the green becomes more intense and macrophytes become more lush and deep green. Intense algal blooms, thick mats of algae, or dense stands of macrophytes degrade water quality and habitat. Clear water and a diverse aquatic plant community without dense plant populations are optimal for this characteristic.

Barriers to fish movement

No barriers	Seasonal water withdrawals inhibit movement within the reach	Drop structures, culverts, dams, or diversions (< 1 foot drop) within the reach	Drop structures, culverts, dams, or diversions (> 1 foot drop) within 3 miles of the reach	Drop structures, culverts, dams, or diversions (> 1 foot drop) within the reach
10	8	5	3	1

Barriers that block the movement of fish or other aquatic organisms, such as fresh water mussels, must be considered as part of the overall stream assessment. If sufficiently high, these barriers may prevent the movement or migration of fish, deny access to important breeding and foraging habitats, and isolate populations of fish and other aquatic animals.

What to look for: Some barriers are natural, such as waterfalls and boulder dams, and some are developed by humans. Note the presence of such barriers along the reach of the stream you are assessing, their size, and whether provisions have been made for the passage of fish. Ask the landowner about any dams or other barriers that may be present 3 to 5 miles upstream or downstream. Larger dams are often noted on maps, so you may find some information even before going out into the field. Beaver dams generally do not prevent fish migration. Look for structures that may not involve a drop, but still present a hydraulic barrier. Single, large culverts with no slope and sufficient water depth usually do not constitute a barrier. Small culverts or culverts with slopes may cause high water velocities that prevent passage.

Instream fish cover

>7 cover types available	6 to 7 cover types available	4 to 5 cover types available	2 to 3 cover types available	None to 1 cover type available
10	8	5	3	1

Cover types: Logs/large woody debris, deep pools, overhanging vegetation, boulders/cobble, riffles, undercut banks, thick root mats, dense macrophyte beds, isolated/backwater pools, other: ______________________________.

This assessment element measures availability of physical habitat for fish. The potential for the maintenance of a healthy fish community and its ability to recover from disturbance is dependent on the variety and abundance of suitable habitat and cover available.

What to look for: Observe the number of different habitat and cover types *within a representative subsection of the assessment* reach that is equivalent in length to *five times* the active channel width. Each cover type must be present in appreciable amounts to score. Cover types are described below.

Logs/large woody debris—Fallen trees or parts of trees that provide structure and attachment for aquatic macroinvertebrates and hiding places for fish.

Deep pools—Areas characterized by a smooth undisturbed surface, generally slow current, and deep enough to provide protective cover for fish (75 to 100% deeper than the prevailing stream depth).

Overhanging vegetation—Trees, shrubs, vines, or perennial herbaceous vegetation that hangs immediately over the stream surface, providing shade and cover.

Boulders/cobble—Boulders are rounded stones more than 10 inches in diameter or large slabs more than 10 inches in length; cobbles are stones between 2.5 and 10 inches in diameter.

Undercut banks—Eroded areas extending horizontally beneath the surface of the bank forming underwater pockets used by fish for hiding and protection.

Thick root mats—Dense mats of roots and rootlets (generally from trees) at or beneath the water surface forming structure for invertebrate attachment and fish cover.

Dense macrophyte beds—Beds of emergent (e.g., water willow), floating leaf (e.g., water lily), or submerged (e.g., riverweed) aquatic vegetation thick enough to provide invertebrate attachment and fish cover.

Riffles—Area characterized by broken water surface, rocky or firm substrate, moderate or swift current, and relatively shallow depth (usually less than 18 inches).

Isolated/backwater pools—Areas disconnected from the main channel or connected as a "blind" side channel, characterized by a lack of flow except in periods of high water.

Pools

Deep and shallow pools abundant; greater than 30% of the pool bottom is obscure due to depth, or the pools are at least 5 feet deep.	Pools present, but not abundant; from 10 to 30% of the pool bottom is obscure due to depth, or the pools are at least 3 feet deep.	Pools present, but shallow; from 5 to 10% of the pool bottom is obscure due to depth, or the pools are less than 3 feet deep.	Pools absent, or the entire bottom is discernible.
10	7	3	1

Pools are important resting and feeding sites for fish. A healthy stream has a mix of shallow and deep pools. A *deep* pool is 1.6 to 2 times deeper than the prevailing depth, while a *shallow* pool is less than 1.5 times deeper than the prevailing depth. Pools are abundant if a deep pool is in each of the meander bends in the reach being assessed. To determine if pools are abundant, look at a longer sample length than one that is 12 active channel widths in length. Generally, only 1 or 2 pools would typically form within a reach as long as 12 active channel widths. In low order, high gradient streams, pools are abundant if there is more than one pool every 4 channel widths.

What to look for: Pool diversity and abundance are estimated based on walking the stream or probing from the streambank with a stick or length of rebar. You should find deep pools on the outside of meander bends. In shallow, clear streams a visual inspection may provide an accurate estimate. In deep streams or streams with low visibility, this assessment characteristic may be difficult to determine and should not be scored.

Insect/invertebrate habitat

At least 5 types of habitat available. Habitat is at a stage to allow full insect colonization (woody debris and logs not freshly fallen).	3 to 4 types of habitat. Some potential habitat exists, such as overhanging trees, which will provide habitat, but have not yet entered the stream.	1 to 2 types of habitat. The substrate is often disturbed, covered, or removed by high stream velocities and scour or by sediment deposition.	None to 1 type of habitat.
10	7	3	1

Cover types: Fine woody debris, submerged logs, leaf packs, undercut banks, cobble, boulders, coarse gravel, other: ______________________________.

Stable substrate is important for insect/invertebrate colonization. *Substrate* refers to the stream bottom, woody debris, or other surfaces on which invertebrates can live. Optimal conditions include a variety of substrate types within a relatively small area of the stream (5 times the active channel width). Stream and substrate stability are also important. High stream velocities, high sediment loads, and frequent flooding may cause substrate instability even if substrate is present.

What to look for: Observe the number of different types of habitat and cover within a representative subsection of the assessment reach that is equivalent in length to five times the active channel width. Each cover type must be present in appreciable amounts to score.

Score the following assessment elements only if applicable.

Canopy cover (if applicable)

Coldwater fishery

> 75% of water surface shaded and upstream 2 to 3 miles generally well shaded.	>50% shaded in reach. or >75% in reach, but upstream 2 to 3 miles poorly shaded.	20 to 50% shaded.	< 20% of water surface in reach shaded.
10	7	3	1

Warmwater fishery

25 to 90% of water surface shaded; mixture of conditions.	> 90% shaded; full canopy; same shading condition throughout the reach.	(intentionally blank)	< 25% water surface shaded in reach.
10	7		1

Do not assess this element if active channel width is greater than 50 feet. Do not assess this element if woody vegetation is naturally absent (e.g., wet meadows).

Shading of the stream is important because it keeps water cool and limits algal growth. Cool water has a greater oxygen holding capacity than does warm water. When streamside trees are removed, the stream is exposed to the warming effects of the sun causing the water temperature to increase for longer periods during the daylight hours and for more days during the year. This shift in light intensity and temperature causes a decline in the numbers of certain species of fish, insects, and other invertebrates and some aquatic plants. They may be replaced altogether by other species that are more tolerant of increased light intensity, low dissolved oxygen, and warmer water temperature. For example, trout and salmon require cool, oxygen-rich water. Loss of streamside vegetation (and also channel widening) that cause increased water temperature and decreased oxygen levels are major contributing factors to the decrease in abundance of trout and salmon from many streams that historically supported these species. Increased light and the warmer water also promote excessive growth of submerged macrophytes and algae that compromises the biotic community of the stream. The temperature at the reach you are assessing will be affected by the amount of shading 2 to 3 miles upstream.

What to look for: Try to estimate the portion of the water surface area for the whole reach that is shaded by estimating areas with no shade, poor shade, and shade. Time of the year, time of the day, and weather can affect your observation of shading. Therefore, the relative amount of shade is estimated by assuming that the sun is directly overhead and the vegetation is in full leaf-out. First evaluate the shading conditions for the reach; then determine (by talking with the landowner) shading conditions 2 to 3 miles upstream. Alternatively, use aerial photographs taken during full leaf out. The following rough guidelines for percent shade may be used:

stream surface not visible .... >90
surface slightly visible or visible only in patches .. 70 – 90
surface visible, but banks not visible .... 40 – 70
surface visible and banks visible at times .... 20 – 40
surface and banks visible .... <20

Manure presence (if applicable)

(Intentionally blank)	Evidence of livestock access to riparian zone.	Occasional manure in stream or waste storage structure located on the flood plain.	Extensive amount of manure on banks or in stream. or Untreated human waste discharge pipes present.
	5	3	1

Do not score this element unless livestock operations or human waste discharges are present.

Manure from livestock may enter the water if livestock have access to the stream or from runoff of grazing land adjacent to the stream. In some communities untreated human waste may also empty directly into streams. Manure and human waste increase biochemical oxygen demand, increase the loading of nutrients, and alter the trophic state of the aquatic biological community. Untreated human waste is a health risk.

What to look for: Do not score this element unless livestock operations or human waste discharges are present. Look for evidence of animal droppings in or around streams, on the streambank, or in the adjacent riparian zone. Well-worn livestock paths leading to or near streams also suggest the probability of manure in the stream. Areas with stagnant or slow-moving water may have moderate to dense amounts of vegetation or algal blooms, indicating localized enrichment from manure.

Salinity (if applicable)

(Intentionally blank)	Minimal wilting, bleaching, leaf burn, or stunting of aquatic vegetation; some salt-tolerant streamside vegetation.	Aquatic vegetation may show significant wilting, bleaching, leaf burn, or stunting; dominance of salt-tolerant streamside vegetation.	Severe wilting, bleaching, leaf burn, or stunting; presence of only salt-tolerant aquatic vegetation; most streamside vegetation salt tolerant.
	5	3	1

Do not assess this element unless elevated salinity from anthropogenic sources is known to occur in the stream.

High salinity levels most often occur in arid areas and in areas that have high irrigation requirements. High salinity can also result from oil and gas well operations. Salt accumulation in soil causes a breakdown of soil structure, decreased infiltration of water, and potential toxicity. High salinity in streams affects aquatic vegetation, macroinvertebrates, and fish. Salts are a product of natural weathering processes of soil and geologic material.

What to look for: High salinity levels cause a "burning" or "bleaching" of aquatic vegetation. Wilting, loss of plant color, decreased productivity, and stunted growth are readily visible signs. Other indicators include whitish salt encrustments on the streambanks and the displacement of native vegetation by salt-tolerant aquatic plants and riparian vegetation (such as tamarix or salt cedar).

Riffle embeddedness (if applicable)

Gravel or cobble particles are < 20% embedded.	Gravel or cobble particles are 20 to 30% embedded.	Gravel or cobble particles are 30 to 40% embedded.	Gravel or cobble particles are >40% embedded.	Riffle is completely embedded.
10	8	5	3	1

Do not assess this element unless riffles are present or they are a natural feature that should be present.

Riffles are areas, often downstream of a pool, where the water is breaking over rocks or other debris causing surface agitation. In coastal areas riffles can be created by shoals and submerged objects. (This element is sensitive to regional differences and should be related to reference conditions.) Riffles are critical for maintaining high species diversity and abundance of insects for most streams and for serving as spawning and feeding grounds for some fish species. Embeddedness measures the degree to which gravel and cobble substrate are surrounded by fine sediment. It relates directly to the suitability of the stream substrate as habitat for macroinvertebrates, fish spawning, and egg incubation.

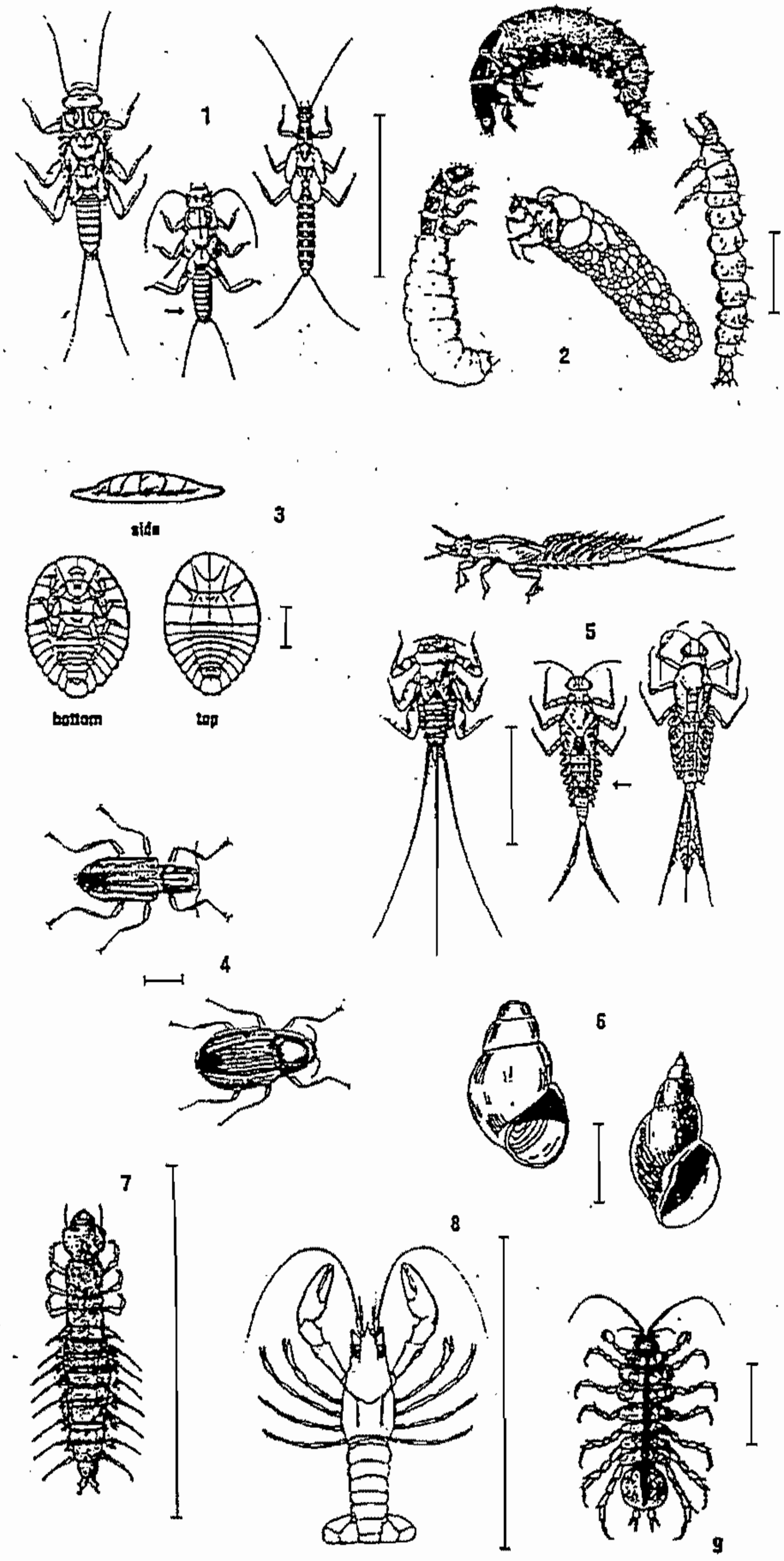
What to look for: This assessment characteristic should be used only in riffle areas and in streams where this is a natural feature. The measure is the depth to which objects are buried by sediment. This assessment is made by picking up particles of gravel or cobble with your fingertips at the fine sediment layer. Pull the particle out of the bed and estimate what percent of the particle was buried. Some streams have been so smothered by fine sediment that the original stream bottom is not visible. Test for complete burial of a streambed by probing with a length of rebar.

Macroinvertebrates observed

Community dominated by Group I or intolerant species with good species diversity. Examples include caddisflies, mayflies, stoneflies, hellgrammites.	Community dominated by Group II or facultative species, such as damselflies, dragonflies, aquatic sowbugs, blackflies, crayfish.	Community dominated by Group III or tolerant species, such as midges, craneflies, horseflies, leeches, aquatic earthworms, tubificid worms.	Very reduced number of species or near absence of all macroinvertebrates.
15	6	2	– 3

This important characteristic reflects the ability of the stream to support aquatic invertebrate animals. However, successful assessment requires knowledge of the life cycles of some aquatic insects and other macroinvertebrates and the ability to identify them. For this reason, this is an optional element. The presence of intolerant insect species (cannot survive in polluted water) indicates healthy stream conditions. Some kinds of macroinvertebrates, such as stoneflies, mayflies, and caddisflies, are sensitive to pollution and do not live in polluted water; they are considered Group I. Another group of macroinvertebrates, known as Group II or facultative macroinvertebrates, can tolerate limited pollution. This group includes damselflies, aquatic sowbugs, and crayfish. The presence of Group III macroinvertebrates, including midges, craneflies and leeches, suggests the water is significantly polluted. The presence of a single Group I species in a community does not constitute good diversity and should generally not be given a score of 15.

What to look for: You can collect macroinvertebrates by picking up cobbles and other submerged objects in the water. Look carefully for the insects; they are often well camouflaged and may appear as part of the stone or object. Note the kinds of insects, number of species, and relative abundance of each group of insects/macroinvertebrates. Each of the three classes of macroinvertebrates are illustrated on pages 19 and 20. ***Note that the scoring values for this element range from – 3 to 15.***



Bar line indicate relative size

Stream Invertebrates

Group One Taxa

Pollution sensitive organisms found in good quality water.

1 **Stonefly Order Plecoptera.** 1/2" to 1 1/2", 6 legs with hooked antenna, 2 hair-line 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 **Grilled Snail: Class Gastropoda.** Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

6 **Mayfly: Order Ephemeroptera.** 1/4" to 1", brown, moving, plate-like or feathery gills on the sides of lower body (see below), 6 large hooked legs, antennae, 2 or 3 long hair-like tails. Tails may be webbed together.

7 **Dobsonfly (hellgrammite): Family Corydalidae.** 3/4" to 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.

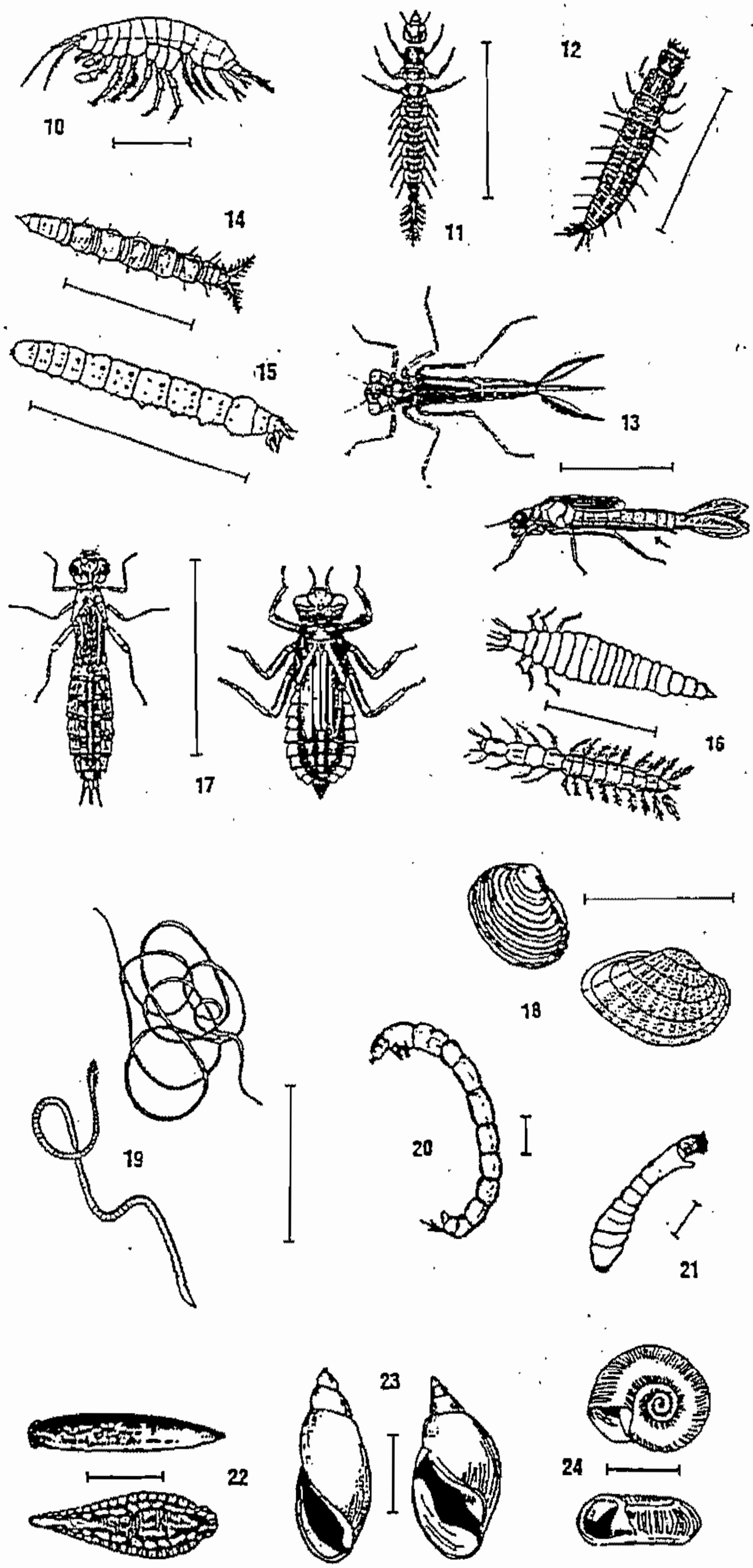
Group Two Taxa

Somewhat pollution tolerant organisms can be in good or fair quality water.

8 **Crayfish: Order Decapoda.** Up to 6", 1 large claws, 8 legs, resembles small lobster.

9 **Sowbug: Order Isopoda.** 1/4" to 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

Source: Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878-2983. (800) BUG-IWLA



Bar line indicate relative size

Group Two Taxa

Somewhat pollution tolerant organisms can be in good or fair quality water.

10 **Scud: Order Amphipoda.** 1/4", white to gray, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 **Alderfly Larva: Family Sialedae.** 1" long. Looks like small Hellgramite but has long, thin, branched tail at back end (no hooks). No gill tufts underneath.

12 **Fishfly Larva: Family Cordalidae.** Up to 1/2" long. Looks like small hellgramite but often a lighter reedish-tan color, or with eyllowish streaks. No gill tufts underneath.

13 **Damselfly: Suborder Zugoptera.** 1/2" to 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 Atherici-dae (Atherix).** 1/4" to 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 **Crane Fly: Suborder Nematocera.** 1/3" to 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" to 1", light-colored, 6 legs on upper half of body, feelers, antennae.

17 **Dragon fly: Suborder Anisoptera.** 1/2" to 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" to 2", can be very tiny, thin worm-like body.

20 **Midge Fly Larva: Suborder Nemato-cera.** Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

21 **Blackfly Larva: Family Simulidae.** Up to 1/4", one end of body wider. Black head, suction pad on other end.

22 **Leech: Order Hirudinea.** 1/4" to 2", brown, slimy body, ends with suction pads.

23 **Pouch Snail and Pond Snails: Class Gastropoda.** No operculum. Breath air. When opening is facing you, shell usually open to left.

24 **Other Snails: Class Gastropoda.** No operculum.Breath air. Snail shell coils in one plane.

Technical information to support implementation

Introduction

This section provides a guide for implementation of the Stream Visual Assessment Protocol (SVAP). The topics covered in this section include the origin of the protocol, development history, context for use in relation to other methods of stream assessment, instructions for modifying the protocol, and references.

Origin of the protocol

In 1996 the NRCS National Water and Climate Center surveyed the NRCS state biologists to determine the extent of activity in stream ecological assessment and the need for technical support. The survey indicated that less than a third of the NRCS states were active in supporting stream assessment within their state. Most respondents said they believed they should be more active and requested additional support from the National Centers and Institutes. In response to these findings, the NRCS Aquatic Assessment Workgroup was formed. In their first meeting the workgroup determined that a simple assessment protocol was needed. The Water Quality Indicators Guide (WQIG) had been available for 8 years, but was not being used extensively. The workgroup felt a simpler and more streamlined method was needed as an initial protocol for field office use.

The workgroup developed a plan for a tiered progression of methods that could be used in the field as conservationists became more skilled in stream assessment. These methods would also serve different assessment objectives. The first tier is a simple 2-page assessment — the Stream Visual Assessment Protocol (SVAP). The second tier is the existing WQIG. The third tier is a series of simple assessment methods that could be conducted by conservationists in the field. An example of a third tier method would be macroinvertibrate sampling and identification to the taxonomic level of Order. The fourth tier is fairly sophisticated methods used in special projects. Examples of fourth tier methods would be fish community sampling and quantitative sampling of macroinvertebrates with shipment of samples to a lab for identification.

The workgroup also found that introductory training and a field handbook that would serve as a comprehensive reference and guidance manual are needed. These projects are under development as of this writing.

Context for use

The Stream Visual Assessment Protocol is intended to be a simple, comprehensive assessment of stream condition that maximizes ease of use. It is suitable as a basic first approximation of stream condition. It can also be used to identify the need for more accurate assessment methods that focus on a particular aspect of the aquatic system.

The relationship of the SVAP to other assessment methods is shown in figure 4. In this figure a specific reference to a guidance document is provided for some methods. The horizontal bars indicate which aspects of stream condition (chemical, physical, or biological) are addressed by the method. The SVAP is the simplest method and covers all three aspects of stream condition. As you move upwards in figure 4 the methods provide more accuracy, but also become more focused on one or two aspects of stream condition and require more expertise or resources to conduct.

The SVAP is intended to be applicable nationwide. It has been designed to utilize factors that are least sensitive to regional differences. However, regional differences are a significant aspect of stream assessment, and the protocol can be enhanced by tailoring the assessment elements to regional conditions. The national SVAP can be viewed as a framework that can evolve over time to better reflect State or within-State regional differences. Instructions for modification are provided later in this document.

Development

The SVAP was developed by combining parts of several existing assessment procedures. Many of these sources are listed in the references section. Three drafts were developed and reviewed by the workgroup and others between the fall of 1996 and the spring of 1997. During the summer of 1997, the workgroup conducted a field trial evaluation of the third draft. Further field trials were conducted with the fourth draft in 1998. A report on the field trial results is appendix A of this document.

The field trials involved approximately 60 individuals and 182 assessment sites. The field trial consisted of a combination of replication studies (in which several individuals independently assessed the same sites) and accuracy studies (in which SVAP scores were compared to the results from other assessment methods). The average coefficient of variation in the replication studies was 10.5 percent. The accuracy results indicated that SVAP version 3 scores correlated well with other methods for moderately impacted and high quality sites, but that low quality sites were not scoring correspondingly low in the SVAP. Conservationists in the field who participated in the trial were surveyed on the usability and value of the protocol. The participants indicated that they found it easy to use and thought it would be valuable for their clients.

Revisions were made to the draft to address the deficiencies identified in the field trial, and some reassessments were made during the winter of 1998 to see how the revisions affected performance. Performance was improved. Additional revisions were made, and the fifth draft was sent to all NRCS state offices, selected Federal agencies, and other partners for review and comment during the spring of 1998.

Comments were received from eight NRCS state offices, the Bureau of Land Management, and several NRCS national specialists. Comments were uniformly supportive of the need for the guidance and for the document as drafted. Many commenters provided improved explanatory text for the supporting descriptions accompanying the assessment elements. Most of the suggested revisions were incorporated.

Implementation

The SVAP is issued as a national product. States are encouraged to incorporate it within the Field Office Technical Guide. The document may be modified by States. The electronic file for the document may be downloaded from the National Water and Climate Center web site at http://www.wcc.nrcs.usda.gov.

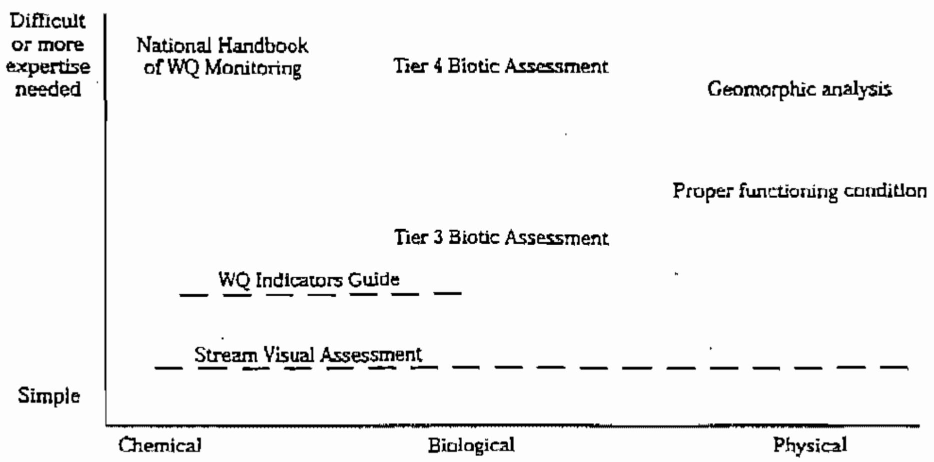
A training course for conservationists in the field suitable for use at the state or area level has been developed to facilitate implementation of the SVAP. It is designed as either a 1-day or 2-day session. The first day covers basic stream ecology and use of the SVAP. The second day includes an overview of several stream assessment methods, instruction on a macroinvertebrate survey method, and field exercises to apply the SVAP and macroinvertibrate protocols. The training materials consist of an instructor's guide, slides, video; a macroinvertebrate assessment training kit, and a student workbook. Training materials have been provided to each NRCS state office.

Instructions for modification

The national version of the Stream Visual Assessment Protocol may be used without modification. It has been designed to use assessment elements that are least sensitive to regional differences. Nonetheless, it can be modified to better reflect conditions within a geographic area. Modifying the protocol would have the following benefits:

- The protocol can be made easier to use with narrative descriptions that are closer to the conditions users will encounter.
- The protocol can be made more responsive to differences in stream condition.
- Precision can be improved by modifying elements that users have trouble evaluating.
- The rating scale can be calibrated to regionally-based criteria for excellent, good, fair, and poor condition.

Figure 4 Relationship of various stream condition assessment methods in terms of complexity or expertise required and the aspects of stream condition addressed



Two parts of the SVAP may be modified—the individual elements and their narrative descriptions, and the rating scale for assigning an overall condition rating of excellent, good, fair, or poor.

The simplest approach to modifying the SVAP is based on professional experience and judgment. Under this approach an interdisciplinary team should be assembled to develop proposed revisions. Revisions should then be evaluated by conducting comparison assessments at sites representing a range of conditions and evaluating accuracy (correlation between different assessment methods), precision (reproducibility among different users), and ease of use.

A second, more scientifically rigorous method for modifying the protocol is described below. This approach is based on a classification system for stream type and the use of reference sites.

Step 1 Decide on tentative number of versions.
Do you want to develop a revised version for your state, for each ecoregion within your state, or for several stream classes within each ecoregion?

Step 2 Develop tentative stream classification.
If you are developing protocols by stream class, you need to develop a tentative classification system. (If you are interested in a statewide or ecoregion protocol, go to step 3.) You might develop a classification system based on stream order, elevation, or landscape character. Do not create too many categories. The greater the number of categories, the more assessment work will be needed to modify the protocol and the more you will be accommodating degradation within the evaluation system. As an extreme example of the latter problem, you would not want to create a stream class consisting of those streams that have bank-to-bank cropping and at least one sewage outfall.

Step 3 Assess sites.
Assess a series of sites representing a range of conditions from highly impacted sites to least impacted sites. Try to have at least 10 sites in each of your tentative classes. Those sites should include several potential "least impacted reference sites." Try to use sites that have been assessed by other assessment methods (such as sites assessed by state agencies or universities). As part of the assessments, be sure to record information on potential classification factors and if any particular elements are difficult to score. Take notes so that future revisions of the elements can be rescored without another site visit.

Step 4 Rank the sites.
Begin your data analysis by ranking all the sites from most impacted to least impacted. Rank sites according to the independent assessment results (preferred) or by the SVAP scores. Initially, rank all of the sites in the state data set. You will test classifications in subsequent iterations.

Step 5 Display scoring data.
Prepare a chart of the data from all sites in your state. The columns are the sites arranged by the ranking. The rows are the assessment elements, the overall numerical score, and the narrative rating. If you have independent assessment data, create a second chart by plotting the overall SVAP scores against the independent scores.

Step 6 Evaluate responsiveness.
Does the SVAP score change in response to the condition gradient represented by the different sites? Are the individual element scores responding to key resource problems? Were users comfortable with all elements? If the answers are yes, do not change the elements and proceed to step 7. If the answers are no, isolate which elements are not responsive. Revise the narrative descriptions for those elements to better respond to the observable conditions. Conduct a "desktop" reassessment of the sites with the new descriptions, and return to step 4.

Step 7 Evaluate the narrative rating breakpoints.
Do the breakpoints for the narrative rating correspond to other assessment results? The excellent range should encompass only reference sites. If not, you should reset the narrative rating breakpoints. Set the excellent breakpoint based on the least impacted reference sites. You must use judgment to set the other breakpoints.

Step 8 Evaluate tentative classification system.
Go back to step 4 and display your data this time by the tentative classes (ecoregions or stream classes). In other words, analyze sites from each ecoregion or each stream class separately. Repeat steps 5 through 7. If the responsiveness is significantly different from the responsiveness of the statewide data set or the breakpoints appear to be significantly different, adopt the classification system and revise the protocol for each ecoregion or stream class. If not, a single statewide protocol is adequate.

After the initial modification of the SVAP, the state may want to set up a process to consider future revisions. Field offices should be encouraged to locate and assess least impacted reference sites to build the data base for interpretation and future revisions. Ancillary data should be collected to help evaluate whether a potential reference site should be considered a reference site.

Caution should be exercised when considering future revisions. Revisions complicate comparing SVAP scores determined before and after the implementation of conservation practices if the protocol is substantially revised in the intervening period. Developing information to support refining the SVAP can be carried out by graduate students working cooperatively with NRCS. The Aquatic Assessment Workgroup has been conducting a pilot Graduate Student Fellowship program to evaluate whether students would be willing to work cooperatively for a small stipend. Early results indicate that students can provide valuable assistance. However, student response to advertisements has varied among states. If the pilot is successful, the program will be expanded.

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Glossary

Active channel width	The width of the stream at the bankfull discharge. Permanent vegetation generally does not become established in the active channel.
Aggradation	Geologic process by which a stream bottom or flood plain is raised in elevation by the deposition of material.
Bankfull discharge	The stream discharge (flow rate, such as cubic feet per second) that forms and controls the shape and size of the active channel and creates the flood plain. This discharge generally occurs once every 1.5 years on average.
Bankfull stage	The stage at which water starts to flow over the flood plain; the elevation of the water surface at bankfull discharge.
Baseflow	The portion of streamflow that is derived from natural storage; average stream discharge during low flow conditions.
Benthos	Bottom-dwelling or substrate-oriented organisms.
Boulders	Large rocks measuring more than 10 inches across.
Channel	A natural or artificial waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks that serve to confine the water.
Channel roughness	Physical elements of a stream channel upon which flow energy is expended including coarseness and texture of bed material, the curvature of the channel, and variation in the longitudinal profile.
Channelization	Straightening of a stream channel to make water move faster.
Cobbles	Medium-sized rocks which measure 2.5 to 10 inches across.
Confined channel	A channel that does not have access to a flood plain.
Degradation	Geologic process by which a stream bottom is lowered in elevation due to the net loss of substrate material. Often called downcutting.
Downcutting	See Degradation.
Ecoregion	A geographic area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.
Embeddedness	The degree to which an object is buried in steam sediment.
Emergent plants	Aquatic plants that extend out of the water.
Flood plain	The flat area of land adjacent to a stream that is formed by current flood processes.
Forb	Any broad-leaved herbaceous plant other than those in the Gramineae (Poceae), Cyperacea, and Juncaceae families (Society for Range Management, 1989).

Gabions A wire basket filled with rocks; used to stabilize streambanks and to control erosion.

Geomorphology The study of the evolution and configuration of landforms.

Glide A fast water habitat type that has low to moderate velocities, no surface agitation, no defined thalweg, and a U-shaped, smooth, wide bottom.

Gradient Slope calculated as the amount of vertical rise over horizontal run expressed as ft/ft or as percent (ft/ft * 100).

Grass An annual to perennial herb, generally with round erect stems and swollen nodes; leaves are alternate and two-ranked; flowers are in spikelets each subtended by two bracts.

Gravel Small rocks measuring 0.25 to 2.5 inches across.

Habitat The area or environment in which an organism lives.

Herbaceous Plants with nonwoody stems.

Hydrology The study of the properties, distribution, and effects of water on the Earth's surface, soil, and atmosphere.

Incised channel A channel with a streambed lower in elevation than its historic elevation in relation to the flood plain.

Intermittent stream A stream in contact with the ground water table that flows only certain times of the year, such as when the ground water table is high or when it receives water from surface sources.

Macrophyte bed A section of stream covered by a dense mat of aquatic plants.

Meander A winding section of stream with many bends that is at least 1.2 times longer, following the channel, than its straight-line distance. A single meander generally comprises two complete opposing bends, starting from the relatively straight section of the channel just before the first bend to the relatively straight section just after the second bend.

Macroinvertebrate A spineless animal visible to the naked eye or larger than 0.5 millimeters.

Nickpoint The point where a stream is actively eroding (downcutting) to a new base elevation. Nickpoints migrate upstream (through a process called headcutting).

Perennial stream A steam that flows continuously throughout the year.

Point bar A gravel or sand deposit on the inside of a meander; an actively mobile river feature.

Pool Deeper area of a stream with slow-moving water.

Reach A section of stream (defined in a variety of ways, such as the section between tributaries or a section with consistent characteristics).

Riffle A shallow section in a stream where water is breaking over rocks, wood, or other partly submerged debris and producing surface agitation.

Riparian	The zone adjacent to a stream or any other waterbody (from the Latin word ripa, pertaining to the bank of a river, pond, or lake).
Riprap	Rock material of varying size used to stabilize streambanks and other slopes.
Run	A fast-moving section of a stream with a defined thalweg and little surface agitation.
Scouring	The erosive removal of material from the stream bottom and banks.
Sedge	A grasslike, fibrous-rooted herb with a triangular to round stem and leaves that are mostly three-ranked and with close sheaths; flowers are in spikes or spikelets, axillary to single bracts.
Substrate	The mineral or organic material that forms the bed of the stream; the surface on which aquatic organisms live.
Surface fines	That portion of streambed surface consisting of sand/silt (less than 6 mm).
Thalweg	The line followed by the majority of the streamflow. The line connecting the lowest or deepest points along the streambed.
Turbidity	Murkiness or cloudiness of water caused by particles, such as fine sediment (silts, clays) and algae.
Watershed	A ridge of high land dividing two areas that are drained by different river systems. The land area draining to a waterbody or point in a river system; catchment area, drainage basin, drainage area.

Appendix A—1997 and 1998 Field Trial Results

Purpose and methods

The purpose of the field trials was to evaluate the accuracy, precision, and usability of the draft Steam Visual Assessment Protocol. The draft protocols evaluated were the third draft dated May 1997 and the fourth draft dated October 1997. A field trial workplan was developed with study guidelines and a survey form to solicit feedback from users. Accuracy was evaluated by comparison to other stream assessment methods. Precision was evaluated by replicate assessments conduced by different individuals at the same sites. In all studies an attempt was made to utilize sites ranging from high quality to degraded. Results consisted of the scoring data and the user feedback form for each site.

Results

Overall, 182 sites were assessed, and approximately 60 individuals participated in the field trials. The individual studies are summarized in table A–1.

Precision could be evaluated using data from the Colorado, New Jersey, Oregon, Virginia, and Georgia studies. Results are summarized in table A–2. The New Jersey sites had coefficients of variation of 9.0 (n=8), 14.4 (n=5), and 5.7 (n=4) percent. The Oregon site with three replicates was part of a course and had a coefficient of variation of 11.1 percent. One Georgia site was assessed using the fourth draft during a pilot of the training course. There were 11 replicates, and the coefficient of variation was 8.8 percent. In May 1998 the workgroup conducted replicate assessments of two sites in Virginia using the fifth draft of the protocol. Coefficients of variation were 14.7 and 3.6 percent. The average coefficient of variation of all studies in table A–2 is 10.5 percent.

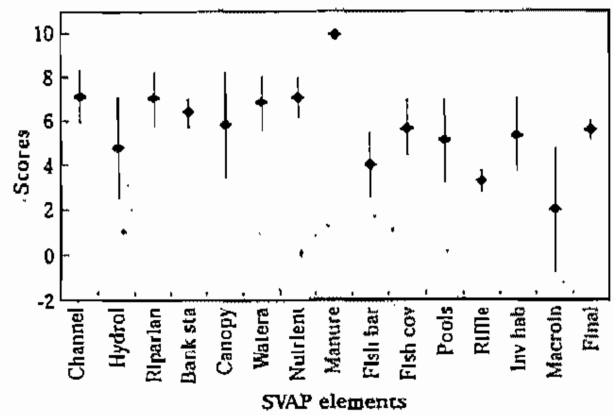
Variability within the individual elements of the SVAP was evaluated using the Georgia site with 11 replicates. The results of the individual element scores are presented in figure A–1. It should be noted that two individuals erroneously rated the "presence of manure" element.

Accuracy was evaluated by comparing the SVAP rating to other methods as noted in table A–1. Some of the comparisons involved professional judgment. In others the SVAP score could be compared with a quantitative evaluation. Figures A–2 through A–5 present data from the two studies that had larger numbers of sites. The Pearson's Correlation Coefficient is presented for these data. The results from other sites are presented in table A–3.

Table A–1 Summary of studies in the field trial

Location	Number of sites	Number of replicates	SVAP compared to	SVAP conducted by
VA	56	3, 5	IBI (fish) and Ohio QHEI	FO personnel
NC/SC	90	none	IBI, EPT	Soil scientists
MI	5	none	professional judgment	State biologist
NJ	3	4, 5, 8	NJDEP ratings	FO personnel
OR	3	none	IBI	NWCC scientist
CO	1	3	professional judgment	FO personnel
WA	3	none	professional judgment	State biologist
OR	2	3	no comparisons	FO personnel
GA	8	4-5	macroinvertebrates	FO personnel
GA	2	12, none	IBI, macroinvertebrate	FO personnel

Figure A–1 Means and standard deviations from the Parker's Mill Creek site in Americus, GA (n=11) (mean plus and minus one standard deviation is shown: SVAP version 4 used)



The SVAP version 3 scores correlated extremely well with the Ohio Qualitative Habitat Index and reasonably well with the fish community IBI in the Virginia study (fig. A–2 and A–3). However, the SVAP version 3 scores in the Carolinas study did not correlate well with either IBI or EPT Taxa (fig. A–4 and A–5). These results may reflect the fact that the SVAP primarily assesses physical habitat within the assessment reach whereas IBI and EPT Taxa are influenced by both physical habitat within the assessment reach and conditions within the watershed. Onsite physical habitat may have been a relatively more important factor at the Virginia sites than at the Carolina sites.

Overall, the field trial results for the third draft seemed to indicate that SVAP scores reflected conditions for sites in good to moderate condition. However, SVAP scores tended to be too high for poor quality sites.

Both the user questionnaires and verbal feedback indicated that users found the SVAP easy to use. Users reported that they thought it would be an effective tool to use with landowners. The majority indicated that they would recommend it to landowners.

Table A–2 Summary of replication results (version refers to the SVAP draft used; mean for overall score reported)

Site	SVAP version	No. replicates	Mean 1/	Standard deviation	Coefficient of variation
Alloway Cr. NJ	3	5	3.6 F	0.52	14.4
Manasquan R. NJ	3	4	5.1 G	0.29	5.7
S. Br. Raritan R. NJ	3	8	5.9 G	0.53	9.0
Gales Cr. OR	3	3	5.5 G	0.61	11.1
Clear Cr. CO	3	3	5.4 G	0.74	13.7
Piscola Cr. GA #1	4	5	9.2 E	0.77	8.4
Piscola Cr. GA #2	4	5	9.0 E	0.85	9.4
Piscola Cr. GA #3	4	4	4.7 F	1.10	23.4
Piscola Cr. GA #4	4	4	7.4 G	0.96	13.0
Little R. GA # 1	4	4	8.3 E	0.73	8.8
Little R. GA # 2	4	4	7.4 E	0.83	11.2
Little R. GA # 3	4	4	8.1 E	0.41	5.1
Little R. GA # 4	4	4	7.3 G	0.60	8.2
Parker's Mill Cr. GA	4	11	5.7 F	0.50	8.8
Cedar Run (up), VA	5	5	7.7 G	1.1	14.7
Cedar R. (down), VA	5	5	6.6 F	.2	3.6

1/ Includes SVAP narrative ratings (P = poor, F = fair, G = good, E = excellent)

Table A-3 Accuracy comparison data from studies with too few sites to determine a correlation coefficient

Site	SVAP version	SVAP score and rating	Comparative rating	Comparative method
Alloway Cr. NJ	3	3.6* — fair	12 — mod. impaired	NJIS (macro.)
Manasquan R. NJ	3	5.1* — good	12 — mod. impaired	NJIS (macro.)
S. Br. Raritan R. NJ	3	5.9* — good	30 — not impaired	NJIS (macro.)
Site 1 OR	3	2.7 — fair	12 — very poor	IBI (fish)
Site 2 OR	3	4.6 — good	22 — poor	IBI (fish)
Site 3 OR	3	7.0 — excellent	44 — good	IBI (fish)
Muckalee Cr. GA	4	8.6 — good	good to excellent	mussel taxa

* Mean value of replicates

Figure A-2 Correlation between SVAP and IBI values in the Virginia study (n=56)

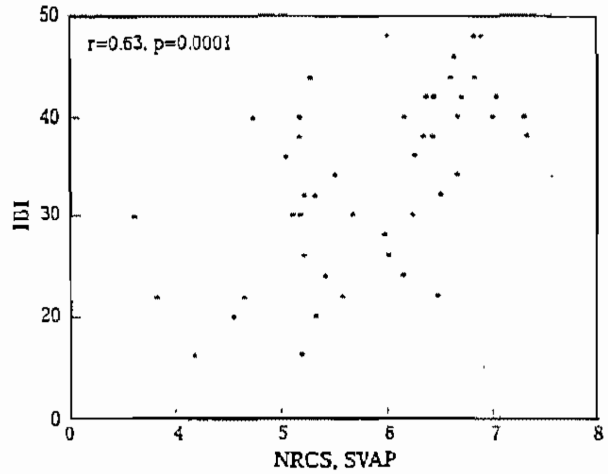


Figure A-3 Correlation between SVAP and Ohio Qualitative Habitat Evaluation Index values in the Virginia study (n=56)

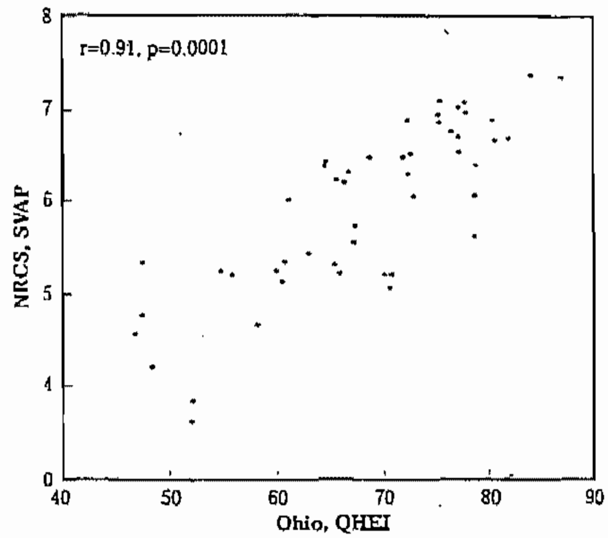


Figure A-4 Correlation between SVAP and IBI values in the Carolinas study (n=90)

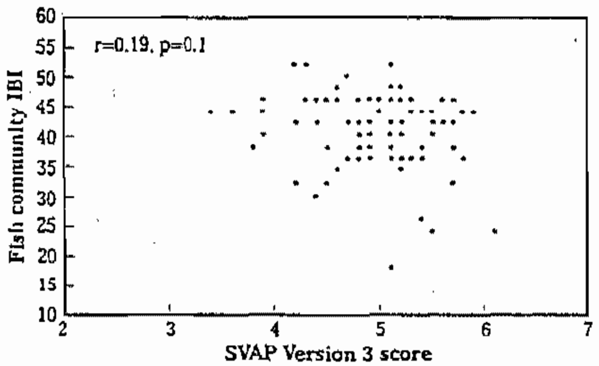
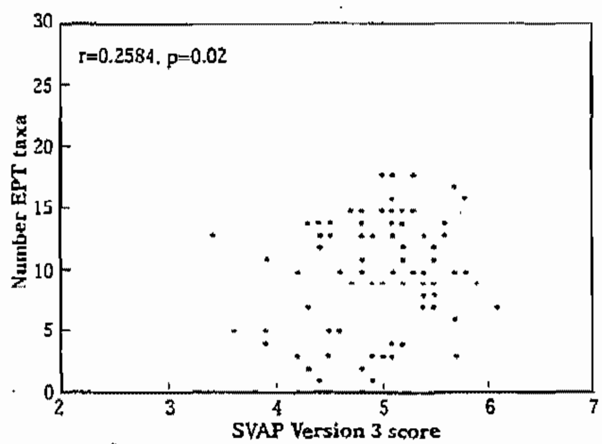


Figure A-5 Correlation between SVAP and macroinvertebrate index values in Carolinas study (n=90)



Discussion

Overall, the workgroup concluded from the first field trial that the SVAP could be used by conservationists in the field with reasonable reproducibility and a level of accuracy commensurate with its objective of providing a basic assessment of ecological condition provided the poor response to degraded streams could be corrected.

Several potential causes for the lack of accuracy with degraded sites were identified by the workgroup as follows:

- Because the overall score is an average of all assessed elements, the effect of low scoring elements can be damped out by averaging if the degradation is not picked up by many of the other assessed elements.
- Some of the elements needed to be adjusted to give lower scores for problems.
- The numerical breakpoints for the narrative ratings of poor/fair and fair/good were set too low.

To correct these problems the number of assessment elements was reduced and the instructions were modified so that certain elements are not scored if they do not apply. For example, the "presence of manure" element is not scored unless there are animal operations present. These changes reduced the potential for low scores to be damped out by the averaging process.

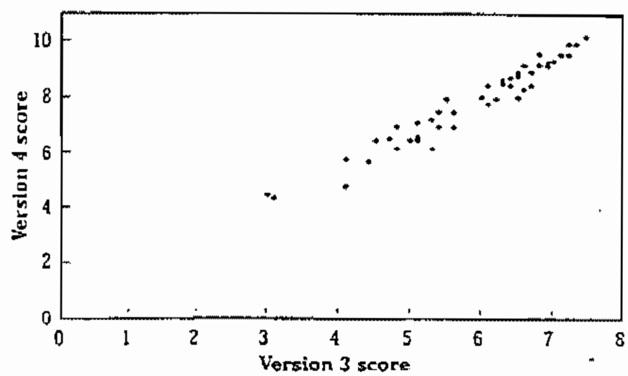
Several elements were also rewritten to reduce ambiguity at the low end of the rating scale. Additionally, several elements were rewritten to have five narrative descriptions instead of four to address a concern that users might err on the high side. The scoring scale was changed from a scale of 1 to 7 to a scale of 1 to 10 because it was felt that most people have a tendency to think in terms of a decimal scale.

The revisions were incorporated into a fourth draft and evaluated by the workgroup. Sites from the first field trial were rescored using the new draft. Response seemed to have improved as indicated by the greater separation of sites at lower scores in figure A–6.

During pilot testing of the training materials in March 1998, the fourth draft was used by 12 students independently at one site and collectively at another site. The coefficient of variation at the replication site was 8.8 percent. One of the sites had been previously assessed using other methods, and the SVAP rating corresponded well to the previous assessments.

After the evaluation of the fourth draft, minor revisions were made for the fifth draft. The breakpoints for the narrative rating of excellent, good, fair, and poor for the fifth draft were set using the Virginia data set. These breakpoints may be adjusted by the NRCS state office as explained in this document.

Figure A–6 Version 4 scores for VA plotted against version 3 scores (n=56)



Stream Visual Assessment Protocol

Owners name ______________________ Evaluator's name ______________________ Date __________

Stream name ______________________ Waterbody ID number ______________________

Reach location ____

____

Ecoregion ______________________ Drainage area ______________ Gradient ______________

Applicable reference site ____

Land use within drainage (%): row crop ______ hayland ______ grazing/pasture ______ forest ______ residential ______

confined animal feeding operations ______ Cons. Reserve ______ industrial ______ Other: ______________

Weather conditions-today ______________________ Past 2-5 days ______________________

Active channel width ______________ Dominant substrate: boulder ______ gravel ______ sand ______ silt ______ mud ______

Site Diagram

Assessment Scores

Channel condition	
Hydrologic alteration	
Riparian zone	
Bank stability	
Water appearance	
Nutrient enrichment	
Barriers to fish movement	
Instream fish cover	
Pools	
Invertebrate habitat	

Score only if applicable

Canopy cover	
Manure presence	
Salinity	
Riffle embeddedness	
Marcroinvertebrates Observed (optional)	

Overall score		<6.0	**Poor**
(Total divided by number scored)		6.1-7.4	**Fair**
	______	7.5-8.9	**Good**
		>9.0	**Excellent**

Suspected causes of observed problems____

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Recommendations____

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NAACC Stream Crossing Instruction Manual for Aquatic Passability Assessments in Non-tidal Stream and Rivers

North Atlantic Aquatic Connectivity Collaborative

Version 1.3 – June 2, 2019
(for Data Form dated May 26, 2016)

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For more information, go to: **www.streamcontinuity.org/naacc**

ACKNOWLEDGEMENTS

The development of this instruction guide and the survey protocol it explains would not have been possible without the effort of many people involved with the NAACC. First and foremost, we would like to thank our colleagues from the NAACC Core Group who worked so diligently to develop and refine the concepts reflected here, and the documents resulting from their many days and hours of effort. The core group includes Rich Kirn of the Vermont Department of Fish and Wildlife, Jessie Levine, Erik Martin, and Michelle Brown of The Nature Conservancy, Jed Wright of the U.S. Fish and Wildlife Service Gulf of Maine Coastal Program, Melissa Ocana and Bob English of the University of Massachusetts Amherst, and Keith Nislow of the U.S. Forest Service. We are particularly thankful to Jessie Levine for her many hours of thorough editing.

In addition, the NAACC relies on a Working Group composed of dozens of professionals working across the region in state and federal agencies and nongovernmental organizations dedicated to improving stream connectivity for the health and resilience of our aquatic and terrestrial ecosystems, as well as safeguarding our infrastructure in the face of a changing climate and increasingly intense, and sometimes devastating storms. Thanks to all those who have lent their time and expertise to making our collaborative successful.

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Alex Abbott & Scott Jackson

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TABLE OF CONTENTS

OVERVIEW

This document provides guidance for completing the North Atlantic Aquatic Connectivity (NAACC) Stream Crossing Survey Data Form.

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from universities, conservation organizations, and state and federal natural resource and transportation departments focused on improving aquatic connectivity across a thirteen-state region, from Maine to Virginia. The NAACC has developed common protocols for assessing road-stream crossings (culverts and bridges) and developed a regional database for these field data. The information collected will identify high priority bridges and culverts for upgrade and replacement. The NAACC will support planning and decision-making by providing information about where restoration projects are likely to bring the greatest improvements in aquatic connectivity.

The survey data form is to be used for an entire road-stream crossing, which may include single or multiple culverts or multiple cell bridges. On the first page, the top of the form contains general information about the crossing, and the bottom half of that page is for data on the first (or only) structure at the crossing. Subsequent pages are used to add data where there are additional culverts or bridge cells. It can be difficult to determine how best to evaluate multiple culvert/cell crossings. Please remember that it is essential to gather all of the data required for each structure (pipe or bridge cell) for accurate assessment of the entire crossing.

Stream crossing survey data can be collected digitally on a variety of devices, including tablet computers and smart phones. While data collected digitally must be reviewed before upload to the NAACC database, data upload can be done in “batches” without the need for manual entry. Paper forms can also be used, with subsequent manual data entry to the NAACC online database. Further instructions for data entry by each of these methods is provided in survey training sessions, and at www.streamcontinuity.org.

Please be sure to complete every possible element of the field data form.

SURVEY PLANNING

GENERAL PLANNING

Any effort to survey stream crossings should be based on a plan that includes answers to the following key questions:

1. ***Who is primarily responsible for managing the surveys?***
   Each NAACC state or region has a coordinator who helps decide on priority areas for survey and how to manage the data once surveys are completed. This coordinator will also plan for, oversee, and collect data from the surveys. Contact the project at contact@streamcontinuity.org for more information, or refer to the NAACC website to locate a coordinator in your region: https://www.streamcontinuity.org/participating_states.htm.

2. ***How will surveyors be trained?***
   Training should be arranged through your regional or state coordinator, and includes both classroom and field survey practice. Trainings are posted on https://www.streamcontinuity.org/about_naacc/training_prog.htm. The most important elements of training are becoming familiar with this instruction manual and gaining practice through survey of a variety of crossings with an experienced surveyor.

3. ***When should surveys be done?***
   Ideally, surveys should be conducted during low-flow periods, particularly summer and early fall.

4. ***How should we decide where to survey?***
   Consult with your regional coordinator to decide whether surveys will be conducted in one or more watersheds, towns, or counties. Plan to have maps to help you navigate to sites you plan to survey, either copies of existing maps such as the DeLorme Atlas and Gazeteer, or more sophisticated maps from a geographic information system (GIS). When collecting data digitally on a tablet computer or smart phone, survey coordinators must identify and map planned survey sites for your chosen survey area.

   For each state in the NAACC region, United States Geological Survey (USGS) HUC-12 subwatersheds have been prioritized for field surveys by the NAACC project team. These subwatersheds were prioritized based on several objectives including brook trout, diadromous fish, and the potential vulnerability of culverts to failure. These prioritized results can be a useful starting place for identifying areas to survey. In addition, there may be locally important watersheds or habitats in your state or region that may help guide location of surveys. To see the NAACC priority subwatersheds in your area, visit the web map at http://arcg.is/1F2rPJu. This web map also depicts road-stream crossings symbolized by their estimated restoration potential which can help focus survey efforts within a subwatershed.

5. ***Which sites will be surveyed?***
   Work with your state or regional coordinator to decide whether all crossings, or only certain types or sizes of streams will be considered. Some crossing surveys focus primarily on designated *perennial* streams containing most aquatic habitats, while other survey projects include all *ephemeral* and *intermittent* streams. In other cases, certain places in the watershed or town may be identified as highest priority for surveys, based on ecological or other criteria.

6. ***How will we keep track of the sites visited?***
   You should maintain records, possibly as notations on paper maps, or in a table listing each planned survey site, showing which sites have been surveyed and when. Organize your survey forms by date, and be sure each survey form is complete. Once data has been entered to the NAACC database (https://streamcontinuity.org/cdb2), you will be able to see all surveyed sites through online maps to verify that you have completed all planned crossings.

7. ***How can we access crossings on major highways, railroads and private land?***
   Depending on the scope of your surveys, you should have easy access to stream crossings on most public roads, though it is important to be aware of the right-of-way to avoid inadvertently trespassing on private land. Access to interstate highways and railroads is generally much more limited. For cases with limited access to crossings, you are responsible for contacting the appropriate owner or manager of those crossings to request access to conduct surveys. Similarly, for crossings on private roads, you should make concerted efforts to notify private landowners to request permission to conduct surveys on their lands. It may help to work with a local land trust, town or county governments, or state resource agencies to gain access from these landowners, as they often have similar needs for conducting habitat surveys or other resource assessments. In some survey efforts, when allowed by specific laws in effect in those jurisdictions, it has been considered permissible to survey crossings on private roads, particularly if good faith efforts to notify landowners have been undertaken first, or so long as crossings are not on posted or gated roads.

8. ***How can we be sure our data will lead to crossing improvements?***
   For your data to be useful in setting stream restoration priorities, we encourage you to collect data as completely and accurately as possible and ensure that the data are entered properly into the database. Finally, be sure that all data, including survey forms and site photographs, whether collected digitally or on paper, are transmitted to your state or regional coordinator for archiving.

Safety

Streams can be hazardous places, so take care to sensibly evaluate risks before you begin a survey at each stream crossing. While these efforts to record data about crossings are important, they are not nearly as important as your safety and well-being. Working around roads can be dangerous, so be sure to wear highly visible clothing, preferably safety vests in bright colors with reflective material; some vests have the additional bonus of containing many pockets to hold gear. Take care when parking and exiting your vehicle, and when crossing busy roads.

These surveys are best undertaken by teams of two people. This will facilitate taking measurements, making decisions in challenging situations, and recording data.

Take measurements seriously and carefully, but make estimates if necessary for your safety. Avoid wading into streams – even small ones – at high flows and entering pools of unknown depths, and take care scaling steep and rocky embankments. There are usually ways to effectively estimate some dimensions without risk. For example, an accurate laser rangefinder is a safe way to measure longer distances when conditions are unsafe, such as measuring culvert lengths through them instead of across busy roads.

Stream crossing inventory work may place NAACC observers in situations where they inadvertently contribute to the spread of aquatic invasive species (AIS), particularly when they cross watershed boundaries. AIS are harmful non-native plants, animals, and microorganisms living in some aquatic habitats that damage ecosystems or threaten commercial, agricultural, and recreational activities. The following best management practices are recommended for NAACC observers to prevent the spread of AIS between drainage basins.

Avoiding the Spread of Invasive Species

Stream crossing inventory work may place NAACC observers in situations where they inadvertently contribute to the spread of aquatic invasive species (AIS), particularly when they cross watershed boundaries. AIS are harmful non-native plants, animals, and microorganisms living in some aquatic habitats that damage ecosystems or threaten commercial, agricultural, and recreational activities. The following best management practices are recommended for NAACC observers to prevent the spread of AIS between drainage basins.

Survey planning:

- Complete surveys of HUC12 watersheds one at a time. Staying within a HUC12 rather than changing sub-basins can help stop the spread of invasive species.
- Whenever possible, start surveying stream crossing sites at the upstream end of a HUC12 watershed and progress downstream over the course of the day. Invasive species are naturally moved downstream by streamflow but do not easily move upstream on their own. By progressing from upstream to downstream in surveys, observers can avoid helping move invasive species to upstream locations.
- Do not use waders with felt soles.
- In waters known to contain invasive species, try to avoid entering the stream to take measurements. This may not be possible at many sites but could be at some.

Between site surveys:

- Before leaving a survey site, clean, drain, and dry (or treat) equipment. Clean equipment by inspecting it for attached mud, plants, and debris. Remove and dispose of anything found. Scrub equipment with a stiff brush and rinse with water. Drain any standing water in waders and other equipment.
- Keep a plastic drum filled with bleach or quaternary ammonia solution (which is less harmful on gear than bleach) in the back of the vehicle and put the wading boots in the drum while driving to the next site.
- When survey schedules or logistics prevent cleaning and drying/treating of equipment, a set of duplicate wading boots are recommended when observers change watershed boundaries during a single day. Observers should change into dry boots before surveying crossings in new watersheds and cycle the previous pair to be clean and dry for the following day.

At the end of the day, or when moving between HUC12 watersheds, use one of these options:

- Dry equipment completely for at least 48 hours. Preferable ways to dry equipment include direct sunlight, a heated garage, or a boot drying device such as a PEET Dryer device.
- Soak or spray equipment with a mild bleach solution (1 Tbsp bleach per gallon of water) for 10 minutes. The bleach solution must be mixed daily to maintain its effectiveness after 24 hours.
- Visit a “wader wash” station, if available.
- Freeze equipment for 6-8 hours.

EQUIPMENT

To collect data on stream crossing structures, you will need several essential pieces of equipment for measuring and recording, and some other items to keep you healthy and safe:

- ✓ **Instruction Guide for the NAACC Stream Crossing Survey Data Form** (this document)
- ✓ **Measuring Implements** in feet and tenths (decimal feet rather than inches)
    - o **Reel Tape:** For measuring structure lengths and channel widths; 100 feet.
    - o **Pocket Tape:** Best in 6 foot “Pocket Rod” version with no spring to rust.
    - o **Stadia Rod:** Telescoping, 13 feet long to measure structure dimensions such as water depth.
- ✓ **Safety Vests:** Brightly colored, reflective vests, preferably with lots of pockets to hold equipment, but most importantly to be seen on the road.
- ✓ **Waders or Hip Boots:** To stay dry, insulate from cold water, minimize abrasions, and allow access to tailwater pools and deeper streams**.**
- ✓ **Flashlight:** To be able to see features inside long dark structures.
- ✓ **Rangefinder** (optional): To safely take measurements without crossing structures, busy roadways or streams; should be accurate to within one foot for adequate data accuracy.
- ✓ **Sun Protection:** Hat, sunglasses, and sunscreen as needed.

- ✓ **Insect Repellent:** To protect from annoying or dangerous bites.
- ✓ **First Aid Kit:** To deal with any minor injuries, cuts, scrapes, etc.
- ✓ **Cell Phone:** In case of emergency, to coordinate surveys, or to ask questions of coordinators.

For Paper Surveys

- ✓ **Stream Crossing Survey Forms**: Best printed on waterproof paper. Bring along more than you expect to use. Even digital surveys should include these in case a digital device becomes inoperable.
- ✓ **Clipboard**, **Pencils & Erasers**
- ✓ **Stream Crossing Maps**: For planning sites to survey, and for recording sites assessed, a *DeLorme Atlas and Gazeteer* or similarly accurate and updated set of maps with topography is helpful for navigation.
- ✓ **GPS Receiver**: Set GPS to collect data in WGS84 datum, with Latitude and Longitude in decimal degrees.
- ✓ **Digital Camera**: Best if waterproof and shockproof, with sufficient battery power for a full day of surveying, and capable of storing approximately 100 low to moderate resolution images (approximately 100 - 500 kilobyte stored size, generally less than 1 million pixels–1 megapixel). Include batteries or battery charger, and download cable. A backup memory chip can be very useful to have on hand.

For Digital Surveys:

- ✓ **Tablet Computer:** Should be waterproof, and preferably shockproof, to be able to survive wet and rugged field conditions. Various mapping applications can be run to allow navigation to planned survey sites, replacing paper maps. For more information on this method of survey, refer to the NAACC Digital Data Collection User's Guide available at https://www.streamcontinuity.org/resources/naacc_documents.htm
- ✓ **GPS Receiver:** If not integral to the tablet computer, an external GPS device will be needed either to connect to the tablet via Bluetooth or wire, or at the least, to be able to provide correct coordinates for entering to the tablet manually.
- ✓ **Stream Crossing Survey Forms**: As a backup in case digital devices fail.

Unmapped Sites and Nonexistent Crossings

Survey teams may encounter unmapped crossings, or it may be unclear whether a crossing they have found in the field is on their map because its location does not match the map. In most cases, the surveyed crossing should be within 100-200 feet of the planned crossing. Survey teams also may encounter unmapped crossings because either the road was not mapped, as in the case of a road built to serve a new housing development, or because of an error in the road or stream data.

If there is no planned crossing near the site you are assessing, you need to assign a temporary *Crossing Code* to that crossing. A *Crossing Code* is composed of the prefix "xy" followed by the latitude and longitude of the site, with decimal degree latitude and longitude values as seven-digit numbers. For instance, a crossing located at 42.32914 degrees north and -72.67522 degrees west, will have the resulting *xy code* = "xy42329147267522," followed by the notation: "NEW XY" to indicate that this crossing site must be added to the map.

Conversely, a crossing may exist on the map but not in the field. If you try to navigate to a site and are certain that there is no crossing in the vicinity, you should select the "No Crossing" option for *Crossing Type* on the field data form. Some crossings may not actually exist due to errors in generating the crossing points. Another possibility is that there may have been a road crossing there at one time, but the crossing has been removed, but may still need to be surveyed to note passage problems. For these sites, you will select the "Removed Crossing" option. Similarly, sometimes an entire stream reach has been moved, particularly underground, in which case you will select the "Buried Stream" *Crossing Type*.

In all cases where a survey crew either cannot locate a mapped crossing or intends to add a new unmapped crossing, it is essential to check the location carefully to minimize navigation and data collection errors.

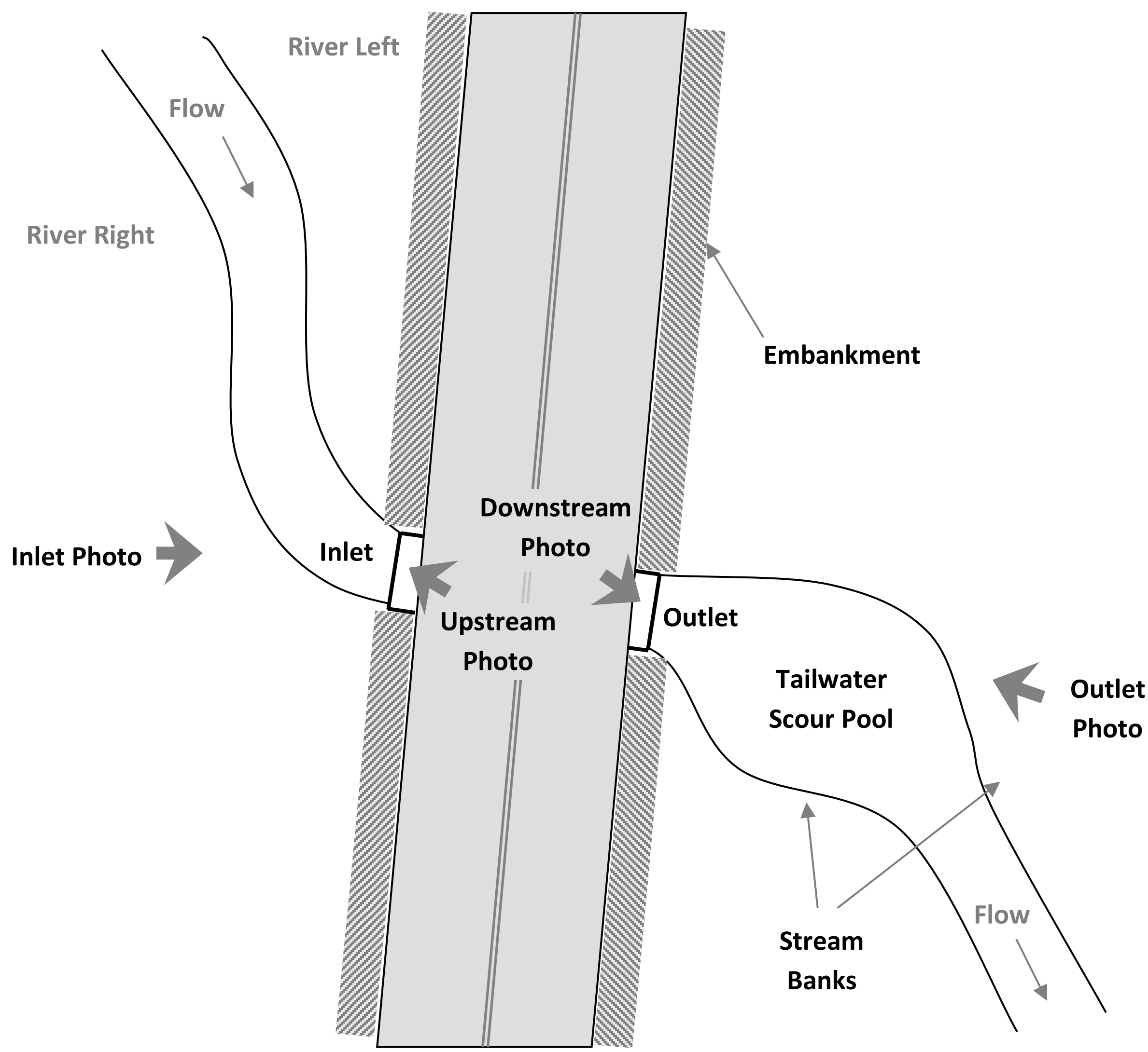
COMPLETING THE SURVEY DATA FORM

SHADED BOXES

The shading on the data form is intended to make the form easier to follow and complete. The different shading sets off elements related to certain groups of information from others.

SITE IDENTIFICATION

While each crossing will be different from others in its details, many common features will be assessed, measured, or otherwise observed during all surveys. The diagram below contains the basic terminology for key stream crossing features in a simplified overhead view.



UNDISTURBED STREAM REFERENCE REACHES

When conducting crossing surveys, elements of this data form require you to understand key characteristics of an undisturbed, "natural" section of the stream (called a *reference reach*) near where the crossing is located. These characteristics include the stream's approximate width, depth, and velocity, and the type of substrate that predominates there. In general, you will need to go a distance upstream or downstream from the crossing that is between 10 and 20 times the width of the stream to get away from the influence of the crossing. This means for a 10-foot wide stream, you will need to go between 100 and 200 feet upstream or downstream from the crossing to find an undisturbed reach. The distance will be much larger for larger streams. Note that sometimes you will be unable to locate such a reference reach, either because upstream and downstream reaches are too disturbed or modified, or because access is limited, such as by *No Trespassing* signs.

CROSSING DATA

Complete this section for the entire crossing. Choose only one option for the fields with checkboxes in the crossing data section.

Crossing Code: This is the 18-character "xy code" assigned to each planned survey crossing on survey maps. Be very careful to record the correct numbers, as they represent the precise latitude and longitude of the planned crossing, which can be compared with the actual location you record as GPS Coordinates below.

Local ID: Optional field for a program's own coding systems. Does NOT replace the Crossing Code.

Date Observed: Date that the crossing was evaluated, following the form *M/D/Y*.

Lead Observer: The name of the survey team leader responsible for the quality of the data collected.

Town/County: The town or county in which the assessed crossing is located according to the map.

Stream: The name of the stream taken from the map, or if not named on the map, the name as known locally, or otherwise list as *Unnamed*.

Road: The name of the road taken from the map or from a road sign. Numbered roads should be listed as "Route #", where # is the route number, with multiple numbers separated by "/" when routes overlap at the crossing (e.g., "Route 1/95"). For driveways, trails, or railroads lacking known names, enter *Unnamed*.

Road Type: Choose only one option:

Multilane: > 2 lanes, including divided highways (assumed paved)
Paved: public or private roads
Unpaved: public or private roads
Driveway: serving only one or two houses or businesses (paved or unpaved)
Trail: primarily unpaved, or for all-terrain vehicles only, but includes paved recreational paths
Railroad: with tracks, whether or not currently used

GPS Coordinates: Latitude and Longitude in decimal degrees to 5 decimal places. Use of a GPS (Global Positioning System) receiver is required, but your smart phone or tablet computer may include this capability.

Map Datum: It is best to use *WGS84* datum.

Location Format: Use Latitude-Longitude decimal-degrees (often in GPS menu as "hddd.ddddd").

You should stand above the stream centerline, and ideally on the road centerline, when taking the GPS point, but use your judgment and beware of traffic.

Location Description: If there is any doubt about whether someone could find this crossing again, provide enough information about the exact location of the crossing so that others with your data sheet would be confident that they are at the same crossing that you evaluated. For example, the description might include "between houses at 162 and 164 Smith Road," "across from the Depot Restaurant," or "driveway north of Smith Road off Route 193." This information could also include additional location information, such as a site identification number used by road owners or managers.

Crossing Type: If a crossing is found at the planned location, choose the one most appropriate option.

Bridge: A bridge has a deck supported by abutments (or stream banks). It may have more than one cell or section separated by one or more piers, in which case enter the number of cells to *Number of Culverts/Bridge* Cells. Enter data for any additional cells in *Structure 2 Data*, *Structure 3 Data*, etc.

Culvert: A culvert consists of a structure buried under some amount of fill. If it is a single culvert, you need only complete the first page of the data form.

Multiple Culvert: If there is more than one culvert, you must indicate that in *Number of Culverts/Bridge Cells* to the right. Data must be entered in sections for additional structures starting on the second page (*Structure 2 Data*, *Structure 3 Data*, etc.). Count ALL structures, regardless of their size.

Ford: A ford is a shallow, open stream crossing, in which vehicles pass through the water. Fords may be armored to decrease erosion, and may include pipes to allow flow through the ford (*vented ford*).

If a planned crossing cannot be found or surveyed, the site will fit one of the following types:

No Crossing: There is no crossing where anticipated, usually because of incorrect road or stream location on maps. No further data is required. (Be sure you are in the correct location.)

Removed Crossing: A crossing apparently existed previously at the site but has been removed, so the stream now flows through the site with no provision for vehicles to cross over it. Continue to complete the survey form to the extent possible. Include information in Crossing Comments to explain your observations. For instance, indicate if an old culvert pipe is seen at the site, or if removal of the previous crossing structure left the stream with problems for aquatic organism passage.

Buried Stream: The planned crossing site does not include an inlet and/or outlet, likely because a stream previously in this location has been rerouted, probably underground. In this case, survey is not possible, and no further data is required.

Inaccessible: Survey is not possible because roads or trails to the crossing are not accessible. This may be due to private property posting, gates, poor condition, or other factors. Record in Crossing Comments why the site is inaccessible. No further data is required.

Partially Inaccessible: Use this option when you can access a crossing well enough to collect some but not all required data. This is most likely to occur when you cannot access either the inlet or outlet side of a crossing and cannot reasonably estimate the dimensions or assess things like inlet grade, outlet grade, scour pool or tailwater armoring.

No Upstream Channel: This option is for places where water crosses a road through a culvert but no road-stream crossing occurs because there is no channel up-gradient of the road. This can occur at the very headwaters of a stream or where a road crosses a wetland that lacks a stream channel (at least on the up-gradient side).

Bridge Adequate: Coordinators have the option of using this classification for large bridges for which it is obvious that they present no barrier to aquatic organism passage. Observers may collect and enter data for these crossings but these data are not required.

Number of Culverts/Bridge Cells: For all Bridges with multiple sections or cells, and for all multiple culverts, you must enter the number of those cells or culvert structures here.

Photo IDs: All surveys should include a minimum of four digital photos of the following: crossing inlet, crossing outlet, stream channel upstream of crossing, and stream channel downstream of crossing. These photos are immensely useful in setting priorities for restoration. Note that photos of buried streams are optional but recommended.

It is essential that all photos be associated with the correct crossing. If you take photos with a digital camera (and sometimes when using a smart phone or tablet computer), you should record the photo numbers assigned by the camera on the survey form in the space for each photo perspective. To record the correct photo numbers from any camera, each person taking photos must be familiar with the numbering system of the camera used. Record the ID number of each photo in the blanks on the data form.

While you may take multiple photos at a site in order to choose the best ones later, you must record on the data form the ID numbers of all photos taken at the site. It can be very helpful to have one or more additional photos, especially when important characteristics are not captured on the four required photos. For instance, if there is extreme erosion at the site, or if other aspects of the crossing make it a likely barrier to connectivity, it is useful to capture these with one or two additional photos.

A simple way to know which photos were taken at a particular site is to use a black marker on a white dry-erase board to record the date and Crossing Code, and to have the first photo at the crossing show this white board displaying the date and Crossing Code. The white board should be strategically placed in the photo so that it is legible and does not block key features of the crossings. This will make the photo readily identifiable with the appropriate crossing. Some people have noted that white dry-erase boards and white paper reflect so much light that they are often “washed out” in the photos, making the codes written on the board impossible to read; use of a small blackboard and chalk may be preferable depending on light conditions.

Another option for keeping track of photos is to make the first photo at each site an image of the field data sheet with the xycode and location information. All other photos of that crossing should immediately follow the photo of data form (with the xycode). It is important to remember to photograph the data form first, before you take any other photos for each crossing. Otherwise, you risk mixing up photos from different crossings.

Here are several additional tips for taking useful photos:

- Always include more than just the structure or stream area you are photographing; it is better to capture more context. Remember that with digital photos, we can zoom in to see detail.
- Including a stadia rod in photos of the inlet and outlet can be valuable to verify some measurements, and as a general reference for scale.
- When available, use a date/time stamp to code each photo.
- Set your camera to record in low to medium resolution so that the photos do not take up too much space on the memory card and when downloaded for storage. To minimize storage space but still allow a reasonable quality image, each photo should be between 100 and 500 kilobytes in size when downloaded. This often equates to a camera resolution setting of “1 Megapixel.”
- Review photos at the site to discard bad photos and to be sure all perspectives are well represented.
- If you haven’t used the camera before, practice to be sure you know how to take photos in dark or mixed light situations, as these often exist when surveying stream crossings.

The following are some examples of useful photos:

	Site 1	Site2	Site 3
Inlet			



Outlet



Upstream



Downstream

Flow Condition: Check the appropriate box to indicate how much water is flowing in the stream. Normally, the value selected for the first perennial crossing of the day will hold for all perennial sites in the area during that day, unless a rainfall event changes the situation. Choose only one option.

No Flow: No water is flowing in the natural stream channel; this option is typical of extreme droughts for perennial streams, or frequent conditions for intermittent or ephemeral streams.

Typical-Low: This is the most commonly used and expected value for surveys conducted during summer low flows, particularly on perennial streams. Water level in the stream will typically be below the level of non-aquatic vegetation, exposing portions of stream banks and bottom.

Moderate: This value is selected when recent rains have raised water levels at or above the level of herbaceous (non-woody) stream bank vegetation.

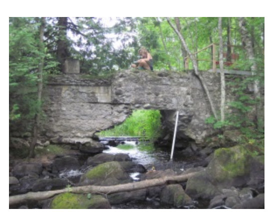
High: This value is selected only rarely, when flows are very high relative to stream banks, making crossing surveys very difficult or impossible, normally due to very recent, or ongoing major rain events. Avoid surveying crossings under high flows as data will not reflect more frequent flow conditions.

Crossing Condition: Check one box that best summarizes the condition of the crossing, based on your observations of the overall state or quality of the crossing, including all structures, particularly the largest or those carrying most of the flow. We are primarily trying to identify crossings in immediate danger of failing or in imminent need of replacement, as well as those that have been very recently installed. Focus primarily on the condition of structure materials.

OK: This is the value given to the vast majority of crossings. Many crossings have deficiencies such as surface rust, dents, dings, or cracks which do not indicate risk of failure.

Poor: This value is intended for structures where the material appears to be failing, such as metal culverts with rot (not just surface rust), or concrete, stone or wooden structures that are already collapsing, or in danger of immediate failure (see images below as examples).



New: This value is assigned only to a crossing that has been installed very recently. Look for unblemished structures with new riprap and/or vegetative bank stabilization.

Unknown: This value applies to all sites where the condition of the crossing cannot be assessed, such as when submerged.

Tidal Site: Sites in tidal areas will often require additional survey to fully assess aquatic organism passage. This element is primarily meant to identify sites in a tidal zone. Choose only one option. Survey of tidal crossings is best done within one hour of low tide to improve access and provide the most useful data. Freshwater streams influenced by tides, often at great distances from the ocean, are more difficult to identify. Coordinators working in such areas should provide Lead Observers with guidance on survey of such sites.

Yes: Evidence shows that tidal waters regularly reach the crossing site. Evidence includes a clear wrack line (line of debris) marking the limit of recent tides. Other indications include observation of salt marsh plants (*spartina spp.*, not upland vegetation or freshwater wetland plants like cattails and common reed (*phragmites*), though both of these wetland plants *can* exist on the fringes of salt marshes) in the vicinity.

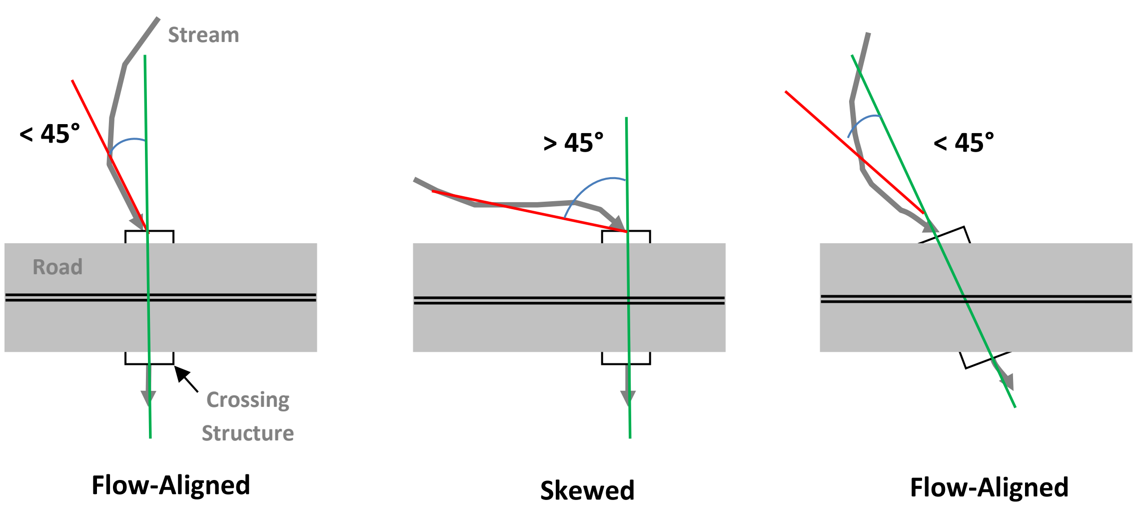
No: Sites are not tidal if downstream banks obviously contain plants that could not survive salt water inundation, such as alders, maples, ferns, etc., normally seen on stream banks in upland areas.

Unknown: Select when unsure of whether a crossing is in a tidal zone.

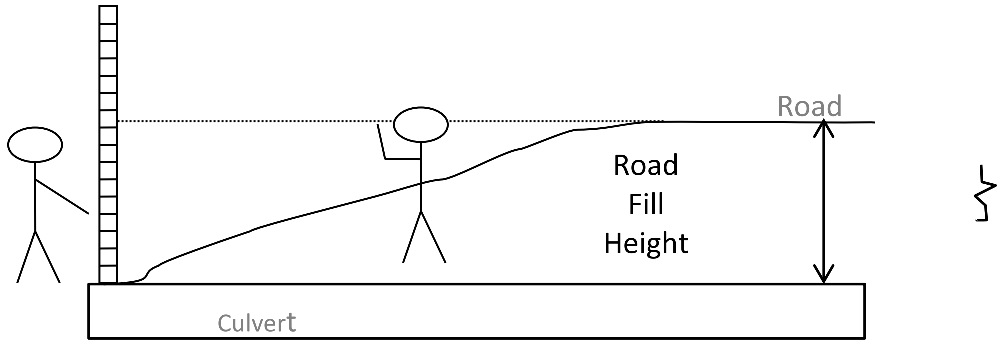
Alignment: Indicates the alignment of the crossing structure(s) relative to the stream at the inlet(s). Compare the crossing centerline (green lines below) to a centerline of the stream where it enters the crossing (red lines below).

Flow-Aligned: The stream approaches the crossing at less than a 45 degree angle from the centerline.

Skewed: The stream approaches the crossing structure(s) at an angle greater than 45 degrees from the centerline. Note that for some crossings the centerline is not perpendicular to the road.

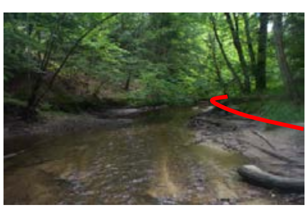


Road Fill Height: Within 1 foot, measure the height of fill material between the top of the crossing structure(s) and the road surface. This is best measured with two people when the road surface or fill height is above a surveyor's height, with one person holding a stadia rod, and the other sighting the elevation of the road surface from the side (see diagram below). For multiple culverts with differing amounts of fill over them, provide an average fill height.

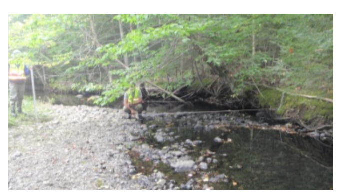


Bankfull Width (optional measurement)**:** This is a measure of the active stream channel width at bankfull flow, the point at which water completely fills the stream channel and where additional water would overflow into the floodplain. Estimates of the frequency of bankfull flows vary, but they may happen as often as twice a year, or only once every one or two years. Each state or regional coordinator will define whether or not you should measure bankfull width in your surveys. When done with high confidence (see next metric), bankfull width can be an extremely useful measurement, but it can be difficult and time consuming, and it will not be possible for all surveyors and sites (even with experienced surveyors). The first step is to identify bankfull flow indicators in an undisturbed reach, and the second step is to measure the width from bank to bank at those locations. Indicators of bankfull flow (shown in the photographs below as the red line) include[1]:

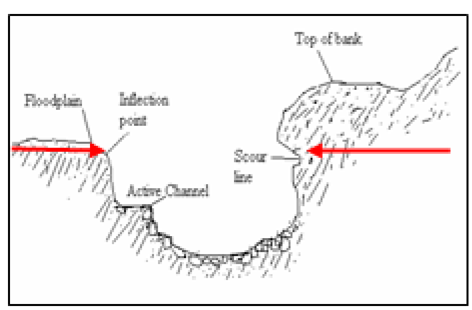
Abrupt transition from bank to floodplain: The point of change from a vertical bank to a more horizontal surface is the best identifier of bankfull stage, especially in low-gradient meandering streams.



Top of point bars: The point bar consists of channel material deposited on the inside of meander bends. Set the top elevation of point bars as the lowest possible bankfull.



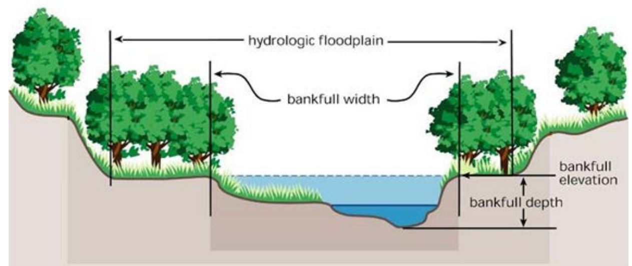
Bank undercuts: Maximum heights of bank undercuts are useful indicators of bankfull flow in steep channels lacking floodplains.



[1] Adapted from Georgia Adopt-A-Stream "Visual Stream Survey" manual. Georgia Department of Natural Resources, 2002.

Changes in bank material: Changes in the particle size of sediment (rocks, soil, etc.) may indicate the upper limits of bankfull flows, with larger sediments exposed to more frequent channel-forming flows.

Change in vegetation: Look for the low limit of woody vegetation, especially trees, on the bank, or a sharp break in the density or type of vegetation.



Bankfull Width Confidence: This qualifies your assessment of Bankfull Width based on your experience with its measurement and whether sufficient criteria were met in your measurements. Choose only one option.

High: Select this option only when you are highly confident that your assessment of Bankfull Width meets the following criteria:

- Clear indicators are present to define the limits of Bankfull Width.
- The recorded value is an average of at least three measurements in different locations.
- All measurements of Bankfull Width were taken in undisturbed locations well upstream or downstream of the crossing.
- No tributaries enter between the crossing and your area(s) of measurements.
- No measures taken at stream bends, pools, braided channels, or close to stream obstructions.

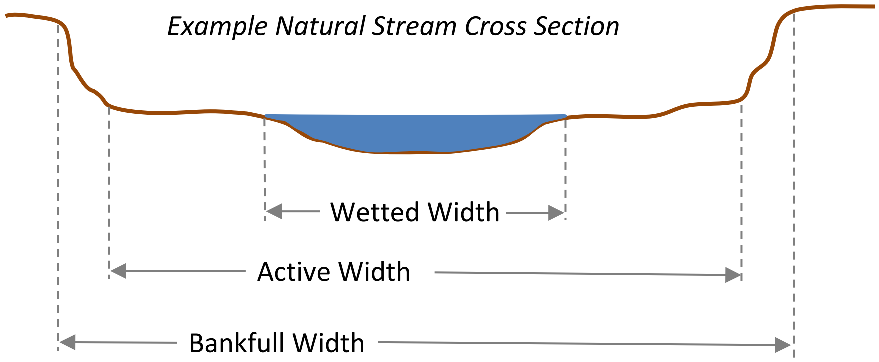
Low/Estimated: Select this when **any** of the above criteria cannot be met.

Constriction: Regardless of whether you measured Bankfull Width above, this element assesses how the width of the crossing (including all of its structures) compares to the width of the natural stream channel. Refer to the above section on determining Bankfull Width for reference. Two other ways of assessing the width of the natural stream channel consider the *active channel* and the *wetted channel*.

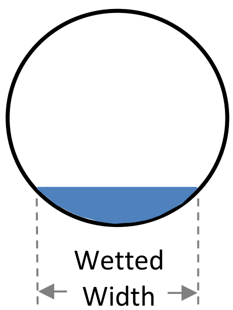
The *active channel* is the area of the stream that is very frequently affected by flowing water. The width of the *active channel* can often be very close to the Bankfull Width when stream banks are very steep. The *wetted channel* is simply the area of the stream that contains water at the time of survey, which may be significantly less than the *active channel*, depending on flow.

Refer to the general illustrations below, and check the appropriate description from the list below to assess how constricted the flow of the stream is by the crossing compared to either the *bankfull*, *active*, or *wetted* channel. Choose only one option.

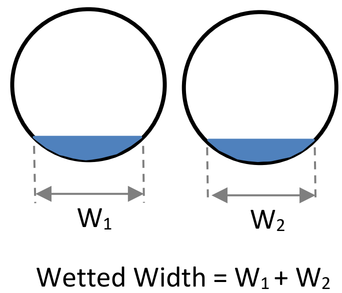
Example Natural Stream Cross Section



Example Culvert Cross Section



Example Multiple Culvert Cross Section



Severe: The total width of the crossing (sum of widths of all crossing structures) is less than 50% of the bankfull or active width of the natural stream, or the total *wetted width* of the crossing is less than 50% of the wetted width of the stream.

Moderate: The crossing is *greater than* 50% of the bankfull or active width of the natural stream, but less than the full bankfull or active channel width.

Spans Only Bankfull/Active Channel: The crossing encompasses the approximate width of the bankfull or active channel.

Spans Full Channel & Banks: The crossing completely spans beyond the *Bankfull Width* of the natural stream, as often evidenced by banks within the crossing structure.

Tailwater Scour Pool: This is a pool created downstream of a crossing as a result of high flows exiting the crossing. Use as a reference natural pools in a portion of the stream that is outside the influence of the crossing structure. A scour pool is considered to exist when its size (a combination of length, width, and depth) is larger than pools found in the natural stream. Check *Large* if the length, width **or** depth of the pool is two or more times larger than of pools in the natural stream channel. Otherwise, check *Small* if the pool is between one and two times the length, width, **or** depth of pools in the natural channel.

None: There is no difference between the length, width, or depth of the tailwater pool compared with reference pools, or no tailwater pool exists at the site.

Small: The tailwater pool is between one and two times the length, width, or depth of reference pools.

Large: The tailwater pool is more than twice the length, width or depth of reference pools.

Crossing Comments: Use this area for brief comments about any aspect of the overall crossing survey that warrants additional information. Do <u>not</u> use this box for comments about particular structures; comment boxes for each structure are provided elsewhere on the form.

STRUCTURE DATA

Choose only one option for structure data fields **except** when identifying Internal Structures and Physical Barriers.

When there are multiple culverts and/or bridge cells, number them from left to right, while looking downstream toward the culvert inlet. The left-most structure is Structure 1, and structure numbers increase to the right. See examples below. When entering data via the ODM or data entry screen make sure that you enter the structures in the same order in which they are numbered.

For each structure, you will complete the following information.

Structure Material: Record here the primary material of which the structure is made, i.e., the material that makes up the majority of the structure. When in doubt, focus on the material that is most in contact with the stream. If a structure is made of two materials, such as a bridge with concrete abutments and a steel deck structure, a metal culvert that has been lined along its entire bottom with concrete, or a crossing with different types of structures at inlet and outlet, select *Combination*. Choose only one option.

Outlet Shape: Refer to the diagrams on the last page of the field data form, and record here the structure number that best matches the shape of the structure opening observed at the inlet of the culvert. This is usually simple, but when a shape seems unusual, you should carefully choose the most reasonable option from among the eight available. We collect this information to be able to find the "open area" inside the structure above any water or substrate, so the shape is vital to accurately calculate area. Choose only one option.

1 - Round Culvert: This is a circular pipe. It may or may not have substrate inside, even though the diagram on the field form shows a layer of substrate. It may be compressed slightly in one dimension, and should be considered round unless it is truly squashed so that it reflects a type 2 shape below.




2 - Pipe Arch/Elliptical Culvert: This is essentially a squashed round culvert, where the lower portion is flatter, and the upper portion is a semicircular arch, or as on the right below, more of a pure ellipse. It may or may not have substrate inside (the diagram on the field form shows a layer of substrate).



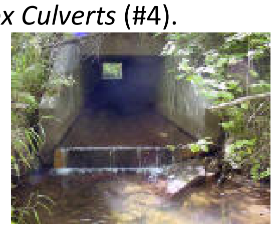

3 - Open Bottom Arch Bridge/Culvert: This structure will often look like a round culvert on the top half, but it will not have a bottom. There will be some sort of footings to stabilize it, either buried metal or concrete footings, or concrete footings that rise some height above the channel bottom. There will be natural substrate throughout the structure. To distinguish between an embedded Pipe Arch Culvert and an Open Bottom Arch, note that the sides of the Pipe Arch curve inward in their lower section, while the sides of the Open Bottom Arch will run straight downward into the streambed substrate or to a vertical footing. Beware of confusion between an Open Bottom Arch and an embedded Round Culvert; Open Bottom Arches tend to be larger than most Round Culverts. This shape could also be selected for certain bridges that have a similar arched shape and are not well represented by other bridge types (Types 5, 6, 7, below).




4 - Box Culvert: These structures are usually made of concrete or stone, but sometimes of corrugated metal with a slightly arched top. Typically, they have a top, two sides, and a bottom.

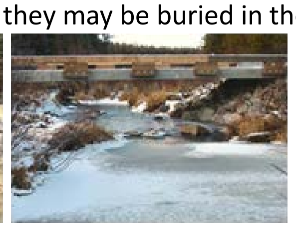
A box culvert <u>without</u> a bottom, called a bottomless box culvert, should be classified as a *Box/Bridge with Abutments* (#6, below). If you cannot tell if the structure has a bottom, classify it as a *Box/Bridge with Abutments* (#6). The images below show *Box Culverts* (#4).






5 - Bridge with Side Slopes: This is a bridge with angled banks up to the bottom of the road deck. This type will have no obvious abutments, though they may be buried in the road fill.

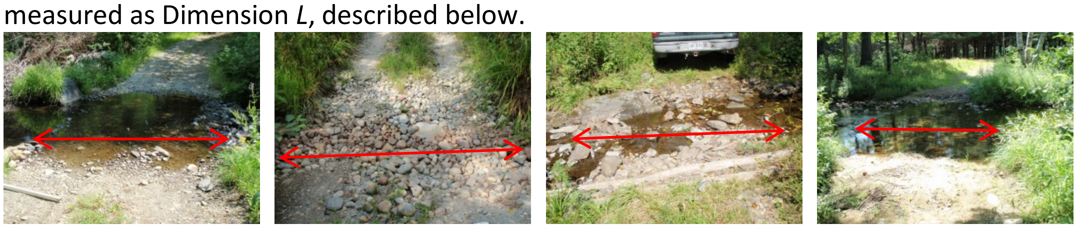





6 - Box/Bridge with Abutments: This is a bridge or bottomless box culvert with vertical sides.

7 - Bridge with Side Slopes and Abutments: This is a bridge with sloping banks and vertical abutments (typically short) that support the bridge deck. (Arrows below show the abutments.)

Ford: A ford is a shallow, open stream crossing that may have aminimal structure to stabilize where vehicles drive across the stream bottom. The arrows below indicate the length of a ford, to be measured as Dimension *L*, described below.



Unknown: Select when a structure's shape is unidentifiable for any reason. Typically, the inlet shape may be unidentifiable because it is submerged or completely blocked with debris.

Removed: Select when the structure is no longer present.

Outlet Armoring: Select from the options to indicate the presence and extent of material placed below the outlet for the purpose of diffusing flow and minimizing scour. The most common form of outlet armoring is riprap (angular rock) placed below the outlet. A few pieces of rock that may have fallen into the stream near the structure's outlet **do not** constitute outlet armoring. Armoring of the road embankment and stream banks should not be confused with armoring of the stream bottom at the outlet. <u>Choose only one option</u>.

Refer to the photos below for examples of each option.

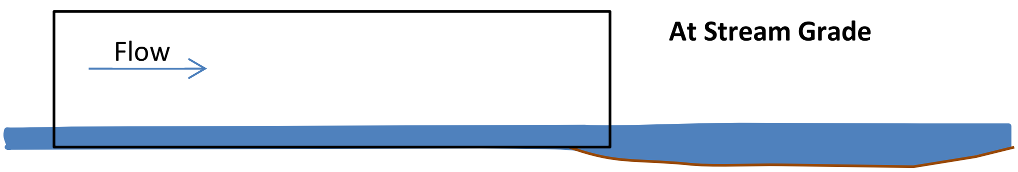
None: This situation represents the majority of crossing structures. You may observe rocks that have fallen from the embankment or that are natural to the stream. Most cascades do not constitute armoring unless specifically put in place to minimize outlet scour.

Not Extensive: There is of a layer of material covering an area *less than 50% of the stream width* placed purposefully below the outlet specifically to minimize the effects of scour.

Extensive: Select this option only if you observe an extensive layer of material covering an area more than 50% of the stream width, which was put in place specifically to minimize scour at the outlet.

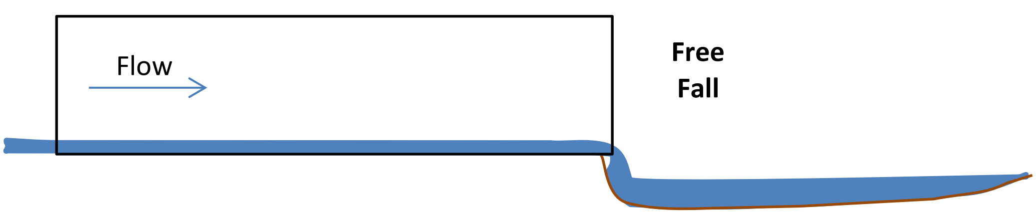
Outlet Grade: Outlet grade is an observation of the relative elevation of the structure to the streambed and how water flows as it exits the structure. This is not an assessment of stream slope (gradient).
<u>Choose only one option</u>.

At Stream Grade: The bottom of the outlet of the structure is at approximately the same elevation as the stream bottom (there may be a small drop from the inside surface of the structure down to the stream bottom), such that **<u>water does not drop downward at all</u>** when flowing out of the structure. Such outlets can normally be considered to be "backwatered" by the downstream stream bed.



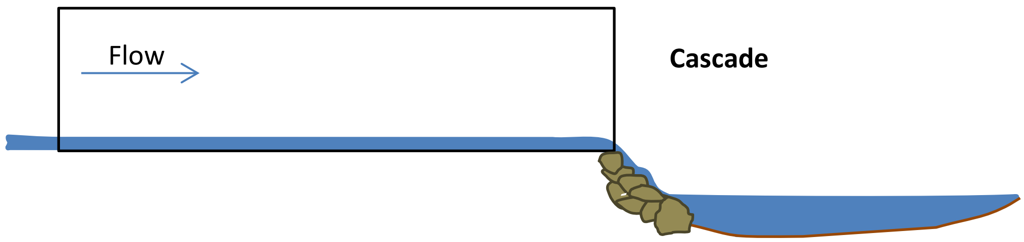
At Stream Grade

Free Fall: The outlet of the structure is above the stream bottom such that **<u>water drops vertically</u>** when flowing out of the structure.

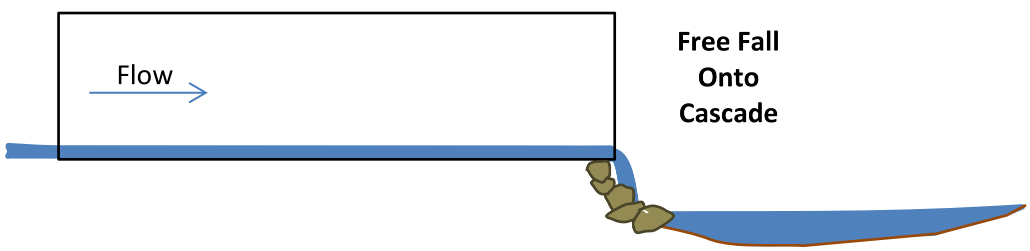


Free Fall

Cascade: The outlet of the structure is raised above the stream bottom at the outlet such that **water flows very steeply downward across rock or other hard material** when flowing from the structure. Think of this as series of small waterfalls at the outlet.



Free Fall Onto Cascade: The outlet of the structure is raised above the stream bottom at the outlet such that **water drops vertically onto a steep area of rock or other hard material, then flows very steeply downward** until it reaches the stream.



Clogged/Collapsed/Submerged: The structure outlet is either full of debris, collapsed, or completely underwater (not usually all three), making outlet measurements impossible. This may be found in places where beavers or sediment have plugged or inundated a structure so completely that water has backed up and covered the outlet, or where a crossing has collapsed to the point that it cannot be measured at its outlet. **Chose this option only if you are unable to collect data on outlet dimensions.**

Outlet Dimensions: <u>Four</u> measurements should be taken at the outlet and <u>inside</u> all structures, and an additional **<u>two</u>** should be taken for all structures with an Outlet Grade marked as *Free Fall, Cascade* or Free *Fall Onto Cascade*. The four measurements are shown on the diagrams on the last page of the field data form, and the others are illustrated below.

Dimension A, ***Structure Width***: To the nearest tenth of a foot, measure the full width of the structure outlet according to the location of the horizontal arrows labeled ***A*** in the diagrams. Take this measurement **<u>inside</u>** the structure.

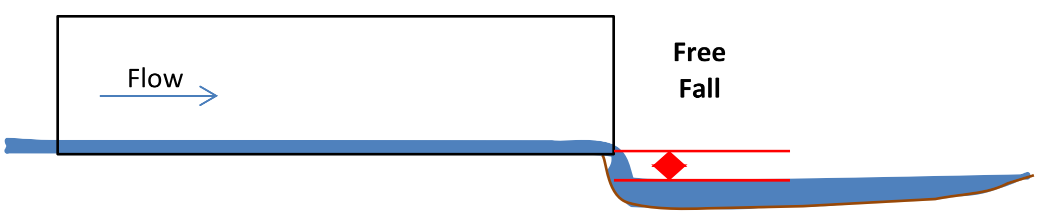
Dimension B, ***Structure Height***: To the nearest tenth of a foot, measure the height of the structure outlet according to the location of the vertical arrows labeled ***B*** in the diagrams. Take this measurement **<u>inside</u>** the structure. If there is no substrate inside, this will be the full height of a structure from bottom to top. If there is substrate inside, this will be the height from the top of the stream bottom substrate up to the inside top of the structure.

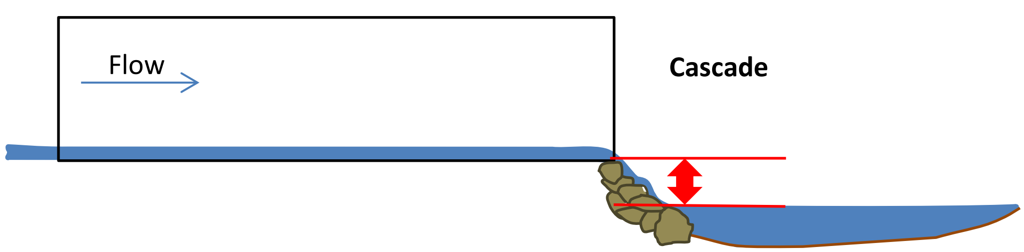
*Dimension C, **Substrate/Water Width***: To the nearest tenth of a foot, measure the width of **either** the substrate layer in the bottom of the structure, or of the water surface, whichever is **<u>wider</u>** according to the general location indicated by the arrows labeled ***C*** in the diagrams. This measurement must be taken **<u>inside</u>** the structure near the outlet. Some rules of thumb for Dimension C are below:

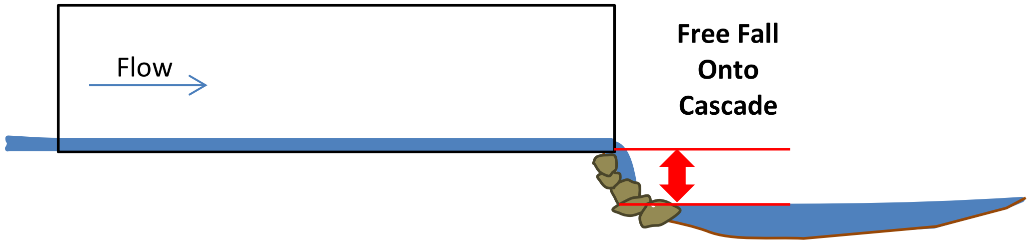
- When there is no substrate in a structure, measure only the width of the water surface.
- When there is no water in a structure, but there is substrate, measure the width of substrate.
- When there is no substrate or water in a structure, C = 0.

*Dimension D, **Water Depth***: To the nearest tenth of a foot (except when < 0.1 foot, to the nearest hundredth of a foot), measure the average depth of water in the structure at the outlet according to the location of the vertical arrows labeled ***D*** in the diagrams. This measurement must be taken **<u>inside</u>** the structure. When there are lots of different depths due to a very uneven bottom, take several measurements and record the average. For fords, measure the water depth at the downstream limit of the ford.

Outlet Drop to Water Surface: This measurement is only applicable to *Free Fall, Cascade* and Free *Fall Onto Cascade* outlets. To the nearest tenth of a foot, measure from the inside bottom surface of the structure (**not** the top of the water) down to the water surface outside the structure. For *Cascade* and *Free Fall Onto Cascade* structures, measure to the surface of the water at the bottom of the cascade. Refer to the diagrams and photos below for guidance; the red arrows indicate where to make this measurement. When assessing *At Stream* Grade structures or dry structures in streams without flow or water in an outlet pool, this measurement must be *zero*.



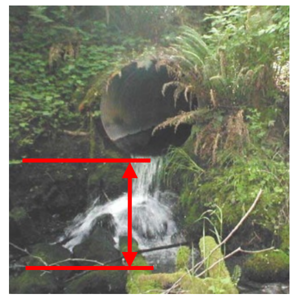




Free Fall Onto Cascade

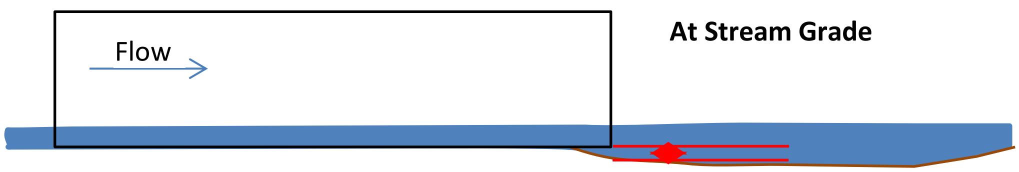
Free Fall

Free Fall

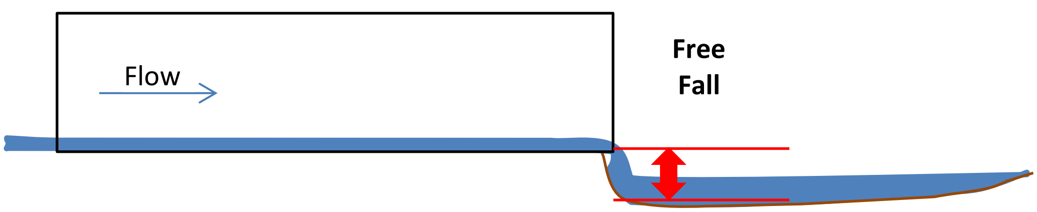


Free Fall onto Cascade

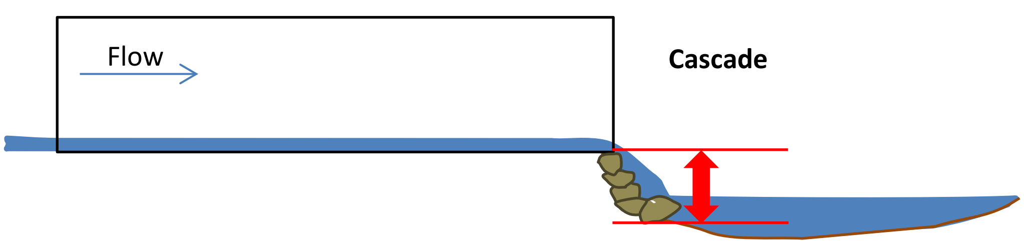
Outlet Drop to Stream Bottom: To the nearest tenth of a foot, measure from the inside bottom surface of the structure (**not** the top of the water) down to the stream bottom at the place where the water falls from the outlet. For At Stream Grade structures, this may be hard to measure, and may be a very small drop. For Cascade and Free Fall Onto Cascade structures, measure the full vertical drop to the stream bottom at the end of the cascade. Refer to the diagrams below for guidance.



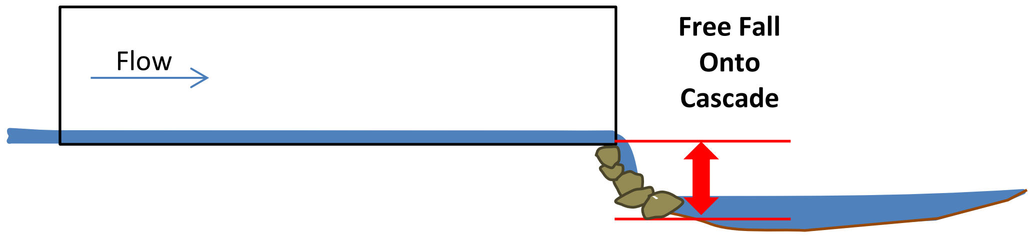
At Stream Grade



Free Fall



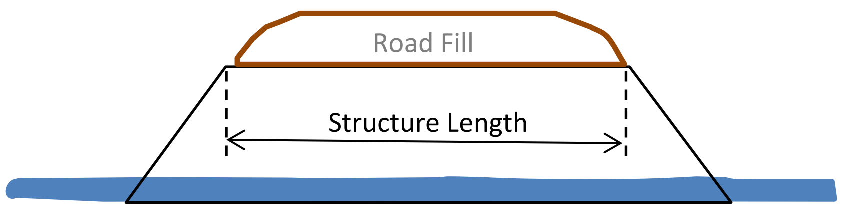
Cascade



Abutment Height, *Dimension E*: This measurement is taken <u>only</u> when surveying a *Bridge with Side Slopes and Abutments* (#7 structure**)**. To the nearest foot, measure the height of the vertical abutments from the top of the side slopes up to the bottom of the bridge deck structure.

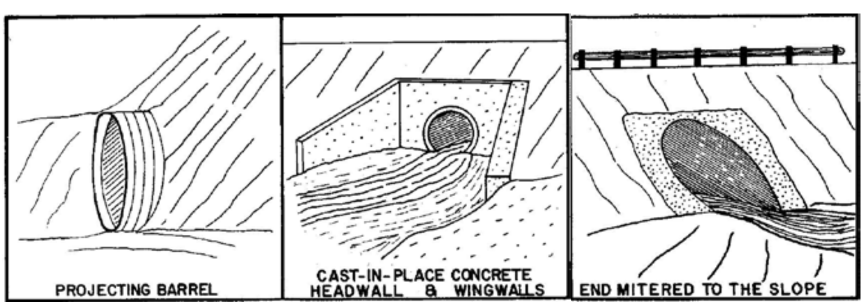


Structure Length, *Dimension L*: To the nearest foot, measure the length of the structure at its top.



Inlet Shape: Refer to the diagrams on the last page of the field data form, and record here the number that best matches the shape of the structure at its outlet. Refer to the instructions for **Outlet Shape** for examples and photos.

Inlet Type: <u>Choose only one option</u> for the style of a culvert inlet, which affects how water flows into the crossing, particularly at higher flows. The drawings here are meant as general guides, but refer to the photos below for more specific images of each type.



Projecting: The inlet of the culvert projects out from (is not flush with) the road embankment.

Headwall: The inlet is set flush in a vertical wall, often composed of concrete or stone.

Wingwalls: The inlet is set within angled walls meant to funnel water flow. These walls can be composed of the same material as the culvert, or different material. It is relatively rare to see wingwalls without a headwall.

Headwall & Wingwalls: The inlet is set flush in a vertical wall, and has angled walls to funnel flow.

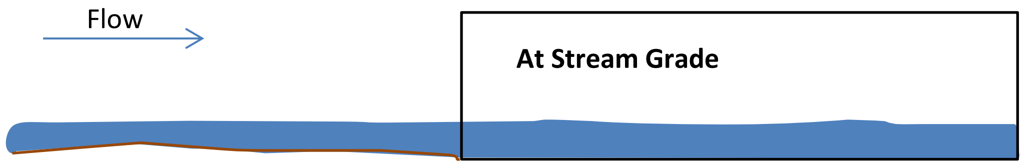
Mitered to Slope: The inlet is angled to fit **flush with the slope of the road embankment**. Note that many mitered culverts project out from the embankment, and should be recorded as *Projecting*.

Other: There may be some other inlet characteristics that do not match any of the above types and which may limit flow into the culvert (but are not *Physical Barriers*), in which case select *Other*, and explain in *Structure Comments*.

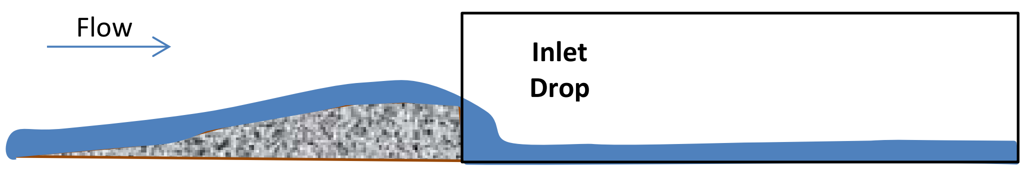
None: The inlet does not have any of the above features or characteristics.

Inlet Grade: An observation of the relative elevation of the stream bottom as it enters the structure. This is not an assessment of stream slope (gradient). Choose only one option.

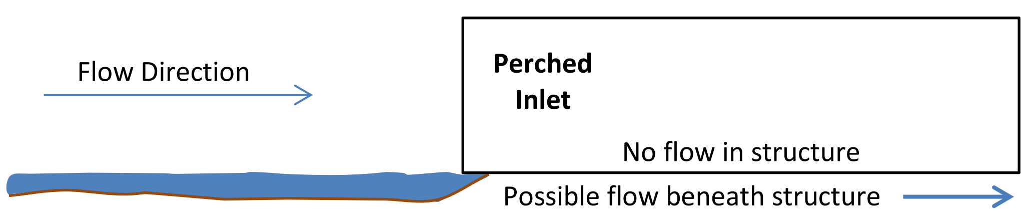
At Stream Grade: The inlet of the structure is at approximately the same elevation as the stream bottom upstream of the structure.



Inlet Drop: Water in the stream has a near-vertical drop from the stream channel down into the inlet of the structure. This usually occurs because sediment has accumulated above the inlet. The drop should be very obvious and not typical of natural drops in that stream. If there is a debris blockage or dam at the inlet, use **Physical** Barriers to record those features, and mark *At Stream Grade* here.

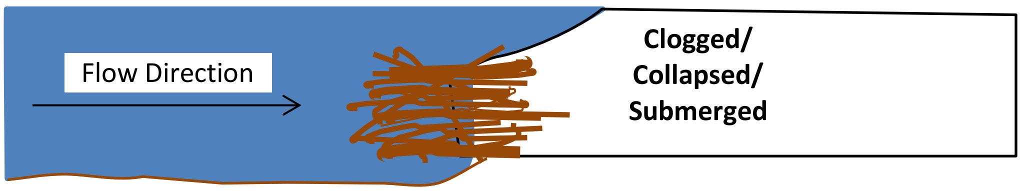


Perched: The inlet of the structure is set too high for the stream, and little water passes through the structure during normal low summer flows, though the stream has water upstream and downstream of the crossing. The structure inlet is above the surface of water in the stream. Water can enter the structure only at higher flows. This is a relatively rare condition, found mostly on very small streams. At such sites, there is generally water backed up above the inlet. In some cases water may be "piping" underneath the structure.






Clogged/Collapsed/Submerged: The structure inlet is either full of debris, collapsed, or completely underwater (not usually all three), making inlet measurements impossible. This may be found in places where beavers or debris have plugged a structure inlet so completely that water has backed up and covered the inlet, or where a crossing has collapsed to the point that it cannot be measured at its inlet. **Chose this option only if you are unable to collect data on inlet dimensions.**






Unknown: The inlet cannot be located or observed, or for some other reason you cannot determine the *Inlet Grade*, or take any inlet measurements.

Inlet Dimensions: There are four basic measurements to take at the inlet and outlet of each structure; these four measurements are to be made inside the structure. These are shown on the diagrams on the last page of the field data form.

Dimension A, ***Structure Width:*** To the nearest tenth of a foot, measure the full width of the structure inlet according to the location of the horizontal arrows labeled ***A*** in the diagrams. Take this measurement **<u>inside</u>** the structure.

Dimension B, ***Structure Height***: To the nearest tenth of a foot, measure the height of the structure inlet according to the location of the vertical arrows labeled ***B*** in the diagrams. Take this measurement **<u>inside</u>** the structure. This may be the full height of a culvert pipe if there is no substrate inside, or if there is substrate, it will be the height from the top surface of the substrate up to the inside top of the structure.

Dimension C, ***Substrate/Water Width***: To the nearest tenth of a foot, measure the width of **<u>either</u>** the substrate layer in the bottom of the structure, or the water surface, whichever is wider, according to the general location indicated by the arrows labeled ***C*** in the diagrams. Take this measurement **<u>inside</u>** the structure at the inlet. Some rules of thumb for Dimension C are below:

- When there is no substrate in a structure, measure the width of the water surface.
- When there is no water in a structure, but there is substrate, measure the width of substrate.
- When there is no substrate or water in a structure, C = 0.

Dimension D, ***Water Depth***: To the nearest tenth of a foot (except when < 0.1 foot, to the nearest *hundredth* of a foot), measure the average depth of water in the structure at the inlet according to the location of the vertical arrows labeled ***D*** in the diagrams. This measurement must be taken **<u>inside</u>** the structure. When there are many different water depths due to a very uneven structure bottom, take several measurements and record the average. For fords, measure the water depth at the upstream limit of the ford.

Slope %*:* (Optional) Calculate or estimate the percent slope of the crossing from inlet to outlet by using one of several optional methods described below. Note that this measurement or estimate can be important to calculating the hydraulic capacity of the crossing, and is difficult to measure accurately without the proper tools. In general, the ease and accuracy of these different methods relates directly to the cost of the tools needed, with the most easy-to-use and accurate measurement tools costing more.

1) The simplest accurate method for measuring slope is to use an accurate laser rangefinder/hypsometer with a slope function, and to measure from inlet to outlet at the same height in relation to each invert. For instance, a person with a known eye height of 5.0 feet sights from one end of a culvert by standing on top of the inlet to the 5.0 foot mark on a stadia rod on top of the outlet. You must take at least three measurements and average them, and be sure the instrument is set to read in percent, not degrees.
2) Another method for measuring slope is to use an auto level or other accurate survey instrument to measure the vertical difference between inlet and outlet invert elevations, then dividing this number by the length of the structure, and multiplying by 100.
3) The next best approach is to use a clinometer that measures slope to the nearest half percent, measuring from a fixed point above one invert (inlet or outlet) to the same height above the opposite invert such as described above under method 1. Many clinometers include both percent and degree scales; be sure to use the percent scale.
4) Another less accurate approach is to sight from a fixed elevation above the inlet invert with a hand level to a stadia rod at the outlet invert, to take the difference in height between the two points, divide by the structure length, and multiply by 100.

Slope Confidence: Rate the confidence you have in your slope measurement or estimate according to the criteria below:

High: Used method 1 above, taking multiple measurements and averaging them, or used method 2 above.

Low: Used methods 3 or 4 above, taking multiple measurements and averaging them.

Internal Structures: Indicate the presence of structures inside the crossing structure. These may include baffles or weirs used to slow flow velocities and help to pass fish, as well as trusses, rods, piers or other structures intended to support a crossing structure, but which may interfere with flow and aquatic organism passage. See photos below for examples of internal structures. Choose any option(s) that apply.

None: There are no apparent structures inside the crossing structure.

Baffles/Weirs: Baffles (partial width) or weirs (full width, notched or not) are incorporated into the structure, either inside or at its outlet, to help aquatic organisms move through the structure.

Supports: Some type of structural supports, such as bridge piers, vertical or horizontal beams, or rods apparently meant to support the structure, are observed inside the crossing structure.

Other: Structure(s) other than the categories above are present inside the crossing structure. Provide a very brief description of those structures here, or more fully describe them under **Structure Comments**. **Do not** include here items such as bedrock, material blockages, structural deformation, or inlet fencing to exclude beavers, which will be recorded below as **Physical Barriers**.

Structure Substrate Matches Stream: Choose only one option based on a comparison of the substrate (e.g., rock, gravel, sand) inside the structure and the substrate in the natural, undisturbed stream channel.

None: Select this option when there is very little (e.g., a thin layer of silt or a few pieces of rock) or no substrate inside the structure.

Comparable: The substrate inside the structure is similar in size to the substrate in the natural stream channel.

Contrasting: The substrate inside the structure is different in size from the substrate in the natural channel.

Not Appropriate: The substrate inside the structure is very different in size (usually much larger) than the substrate in the natural stream channel. Imagine turtles that typically move along a sandy stream trying to traverse an area of large cobbles, angular riprap or boulders (rarely observed).

Unknown: There is no way to observe if there is substrate inside the structure or what type it is. Select this option when deep, fast, or dark water or other factors do not allow direct observation.

Structure Substrate Type: Choose only one option from the table below to indicate the most common or dominant substrate type inside the structure. If you are certain that the structure contains substrate, but cannot assess the type, select *Unknown*. If there is no substrate in the structure, select *None*.

Substrate Type	Feet	Approximate Relative Size
Silt	< 0.002	Finer than salt
Sand	0.002 – 0.01	Salt to peppercorn
Gravel	0.01 – 0.2	Peppercorn to tennis ball
Cobble	0.2 – 0.8	Tennis ball to basketball
Boulder	> 0.8	Bigger than a basketball
Bedrock	Unmeasurable	Unknown - buried

Structure Substrate Coverage: Choose one option, based on the extent of the substrate inside the crossing structure as a ***continuous*** layer across the entire bottom of the structure from bank to bank (side to side).

None: Substrate covers less than 25% of the length of the structure, or there is no substrate inside the structure at all.

25%: Substrate covers *at least* 25% of the length of the structure.

50%: Substrate covers *at least* 50% of the length of the structure.

75%: Substrate covers *at least* 75% of the length of the structure.

100%: Substrate forms a ***continuous*** layer throughout the ***entire*** structure.

Unknown: It is not possible to directly observe whether substrate forms a continuous layer on the structure bottom.

Physical Barriers: Select any of these barrier types in or associated with the structure you are surveying, but do not include here information already captured in **Outlet Grade**. Note here additional barriers, including those associated with Inlet Grade or blockages, or Internal Structures. If a barrier feature affects more than one structure at a crossing (e.g., a beaver dam), include it for all affected structures. Refer to the photos below for examples of physical barriers.

Note that some structures have a combination of physical barriers. Check all that apply.

None: There are no physical barriers associated with this structure aside from any already noted in **Outlet Grade**.

Debris/Sediment/Rock: Woody debris or synthetic material, rock, or sediment blocks the flow of water into or through the structure. This can consist of wood or other vegetation, trash, sand, gravel, or rock. Do not check this option if you observe only very small amounts of debris that are likely to be washed away during the next rain event. Also, do not confuse sediment inside a structure that constitutes an appropriate stream bed with an accumulation that limits flow or passage of organisms.



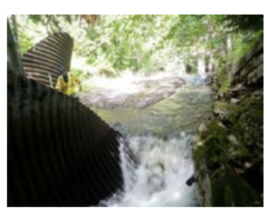


Deformation: The structure is deformed in such a way that it significantly limits flow or inhibits the passage of aquatic organisms. This does not include minor dents and slightly misshapen structures.




*Free Fall***:** In addition to its **Outlet Grade**, which may include a *Free Fall*, the structure has one or more **additional** vertical drops associated with it. These may include a dam at the inlet, a vertical drop over bedrock inside the structure, or some other feature likely to inhibit passage of aquatic organisms. Note that a *Free Fall* inside a structure is often more limiting than similar size drops found in an undisturbed natural reach of the same stream which occur where there may be multiple paths for organisms to follow. A *Free Fall* can exist because of a debris blockage, so both physical barriers would be recorded.






Fencing: The structure has some sort of fencing, often at the inlet to deter beavers. Depending on the mesh size of that fencing, it may directly block the movement of aquatic and terrestrial organisms, and it may become clogged with debris. If also blocked with debris, be sure to check *Debris/Sediment/Rock* as a **Physical Barrier** type as well.

Dry: There is no water in this structure, though water is flowing in the stream. Note that if you recorded *No Flow* for crossing Flow Condition, you should not select *Dry* here, as we expect a dry structure at a dry crossing; it is not in itself a physical barrier. This barrier type helps to identify passage problems associated with overflow or secondary crossing structures.

Other: There may be different situations that do not fit clearly into one of the above categories, but may still represent significant physical barriers to aquatic organism passage. Use this option to capture such situations, and add information in Structure Comments. Below are examples of some unusual physical barriers which may not fit under Physical Barrier categories listed above.

These are examples of structures with a combination of physical barriers. Multiple relevant barrier types should be selected.

Severity: Choose only one option for each surveyed structure, and rank the severity based on an assessment of *the cumulative effect of all physical barriers affecting that structure* according to the table that follows. Do not consider information already captured in **Outlet Grade**. Decide on an overall severity for each structure by considering all the different Physical Barriers present. If any barrier affects more than one structure at a crossing, it should be included in the severity rating for each structure affected. Refer to the table below for guidance in choosing the **Severity** rating.

Physical Barrier	Severity	Severity Definition
None	*None*	No physical barriers exist - **apart from** Outlet Grade
Debris/Sediment/Rock *Logs, branches, leaves, silt, sand, gravel, rock*	*None*	None beyond few leaves or twigs as may occur in stream
	Minor	< 10% of the open area of the structure is blocked
	Moderate	10% - 50% of open area blocked
	Severe	> 50% of open area of structure blocked
Deformation *Significant dents, crushed metal, collapsing structures*	*None*	Small dents and cracks – insignificant effect on flow
	Minor	Flow is limited < 10%
	Moderate	Flow is limited between 10% - 50%
	Severe	Flow is limited > 50%
Free Fall *Vertical or near-vertical drop*	*None*	No vertical drop exists - **apart from** Outlet Grade
	Minor	0.1 - 0.3 foot vertical drop - **apart from** Outlet Grade
	Moderate	0.3 - 0.5 foot vertical drop - **apart from** Outlet Grade
	Severe	> 0.5 foot vertical drop - **apart from** Outlet Grade
Fencing *Wire, metal grating, wood*	*None*	No fencing exists in any part of the structure
	Minor	Widely spaced wires or grating with > 0.5 foot (6 inch) gaps
	Moderate	Wires or grating with 0.2 - 0.5 foot (~ 2-6 inches)spacing
	Severe	Wires or grating with < 0.2 foot (~ 2 inch) spacing
Dry	*Minor*	May be passable at somewhat higher flows
	Moderate	Not likely passable at higher flows
	Severe	Impassable at higher flows
Other	*Minor*	Use best judgment based on above standards
	Moderate	Use best judgment based on above standards
	Severe	Use best judgment based on above standards

Water Depth Matches Stream: Compare the water depth inside the structure with the water depth in the natural stream channel away from the influence of the crossing. Choose only one option.

> *Yes*: The depth in the crossing falls within the range of depths naturally occurring in that reach of the stream and **for comparable distances** along the length of the stream. For example, if a structure has a water depth of 0.2 feet through the entire structure's length of 60 feet, and there comparable sections of the stream with a 0.2 foot water depth for approximately 60 feet of the channel, select *Yes*.

No-Shallower: This means that the water depth in the crossing is less than depths that occur naturally in a similar length of the undisturbed stream, or the shallower depth through the structure covers a greater length than occurs in the natural stream.

No-Deeper: This means that the water depth in the crossing is greater than depths that occur naturally in a similar length of the undisturbed stream. This is rarely observed.

Unknown: A comparison of structure depth to natural stream depth is not possible.

Water Velocity Matches Stream*:* Compare the water velocity inside the structure with the velocity in the natural stream channel away from the influence of the crossing. Choose only one option.

Yes: The water velocity in the crossing falls within the range of velocities naturally occurring in that reach of the stream **for comparable distances**. If velocities in the crossing are observed in the natural stream channel, and those velocities persist over the same distance as the structure length, select *Yes.*

No-Faster: This means that the water velocity in the structure is greater than velocities that occur naturally in a similar length of the undisturbed stream, or the velocity through the structure persists over a longer distance than occurs in the natural stream.

No-Slower: This means that the velocity in the crossing is less than velocities that occur naturally in a similar length of the undisturbed stream. This is rarely observed.

Unknown: A comparison of structure velocity to natural stream velocity is not possible.

Dry Passage Through Structure? Consider this question two different ways, depending on whether water is flowing through the structure. Choose only one option.

If there is water flowing in the structure: Is there a continuous dry stream bank through at least one side of the structure that allows the safe movement of terrestrial or semi-aquatic animals, and does this dry pathway connect to the stream banks upstream and downstream of the structure?

If there is no water flowing in the structure: then there is continuous dry passage through the structure.

Yes: A continuous bank connects upstream, through the structure, and downstream, or there is otherwise continuous dry passage through the structure.

No: There is no dry passage, the dry passage is not continuous, or the dry passage through the structure does not connect with stream banks upstream or downstream.

Unknown: It is not possible to determine if continuous dry passage exists through this structure.

Height Above Dry Passage: If there is dry passage through the structure, measure the average height from the dry stream bank to the top of the structure directly above (i.e., the clearance) to the nearest tenth of a foot. If both stream banks are dry and connected, record the higher measurement. If the structure has no water flow, measure the average height above the bottom of the structure or dry stream bed to the top of the structure.

Comments: Use this area to briefly comment on any aspects of the structure needing more information. Enter comments about the overall crossing in the **Crossing Comments** box.

Introduction:

While chemistry is an indication of water quality at a particular moment, aquatic organisms are excellent indicators of longer-term waterbody health. Because macroinvertebrates (macros) have adapted to survive in a variety of conditions, all habitats can be sampled (Semi-Quantitative Method). However, it is possible to get a representative sample from the most diverse habitat (Single Habitat Approach). Where possible, two samples from the most diverse habitats listed below need to be collected. The total site will be counted as one composite sample.

Most Diverse Stream Habitat	Riffles
	Leaf packs
	Tree roots, snags, and submerged logs
	Undercut banks (overhanging vegetation)
	Submerged macrophytes (aquatic plants)
Least Diverse Stream Habitat	Sediments

For ponds and wetlands, the highest diversity of macros is found within 3 meters of the outflow.

EPCAMR does not typically preserve macroinvertebrate samples in a jar with rubbing alcohol unless it is a special circumstance where we are required to do so. We catch, identify and release. Crayfish, live clams, and live snails need only be counted and released, especially**.** Empty shells tell us nothing about the current stream condition (we don't know when they died), so they are not counted.

Methods:

Season – The season you sample in is important. Try to pick a time of the year with typical or average flows and mild temperatures. This minimize stress on the macro population and will help your gear be most effective as opposed to freezing conditions and extreme low or high flow conditions.

Equipment – Typically, D-frame dip nets or kick screen nets are used for macro collection. For best operation, position the D net handle straight up or angle the kick net handles slightly backward from flow to allow a slight pouch to form in the kick net. Certain nets work better for certain habitats. Use a Meter square for ponds and wetlands. A sample bottle and forceps should be carried in the stream to collect fast moving organisms. Be careful of the pressure you put on the forceps as you could kill the macro. A small craft paint brush can be used to pick up smaller macros from the net, a magnifying glass and several segmented trays are useful for the identification process.

Site selection – Survey a 300-foot stream stretch. Sample upstream of a road crossing, or major tributary. Determine a plan of attack for collection sites based upon the above habitat chart. For ponds and wetlands, calculate the surface acreage from aerial photography, locate the outflow and measure water depth at sampling point (must be 1 meter or less). A "picker" decides on one or several location(s) on shore to setup a sorting station(s) for identification. A team consisting of a "netter" and a "kicker" will start at the downstream-most point and work upstream so you always work into undisturbed water.

Draw a map of the sampling reach. This map should include in-stream attributes (e.g., riffles, falls, fallen trees, pools, bends, etc.) or pond/wetland attributes (e.g. open water, vegetated areas, outlet, etc.) and structures, plants, and attributes of the bank and near wetted edge areas. Use an arrow to indicate the direction of flow. Indicate the areas that were sampled for macroinvertebrates on the map. Use a Global Positioning System (GPS) for latitude and longitude determination taken at the furthest downstream point of the sampling reach.

"Kicking"

Single Stream Habitat Approach: 1 Meter Kick Net (EPA Rapid Bioassessment Protocol):
The sampling of a single habitat, in particular riffles or runs, because macroinvertebrate diversity and abundance are usually highest in cobble substrate (riffle/run) habitats and provides a representative sample of the stream reach.

1. Select the fastest and slowest moving areas of the riffle (minimum of 2 sites). Organisms collected from both these sites will constitute one riffle sample. Begin at the downstream end of the reach to be sampled and work upstream. This keeps the working area undisturbed.
2. With the net opening facing upstream, place the bottom of the net flush on the stream bottom immediately downstream from the riffle.
3. While the first person ("netter") holds the net, the second ("kicker") disturbs the upper layer of gravel within a 3-foot by 3-foot area directly in front of the net opening. Using the toe or heel of the boot, dislodge the upper layer of cobble or gravel and scrape the underlying bed.
4. Pick up large rocks (2 inch or greater diameter) gently rub them under the water in the net opening to remove any clinging organisms. Gently place the cleaned rocks behind the "kicker" as the "kicker" moves forward to the net. Step 3-4 should be done for 2 minutes per site.
5. When done kicking, the "netter" sweeps the net in an upward fashion to collect the organisms.
6. Carry the net to the shoreline to the "picker" follow Picking instructions below.

For ponds and wetlands use the Dip Net Measured Sweep Method (adapted from Maine DEP Protocols for Sampling Aquatic Macroinvertebrates in Freshwater Wetlands):

1. Conduct sweep in an area where the bottom has not yet been disturbed and approach selected area slowly, to minimize accidental disturbance. Lay down the meter square to indicate the area boundaries.
2. Using a D-frame net, sweep through the water column within the meter square. Bump the net against the bottom substrate three times (at the beginning, the middle, and the end of the sweep) to dislodge and collect organisms from the sediment. The net should remain submerged during the entire sweep.
3. At the end of the sweep, turn the net so the opening is facing the surface of the water and lift the net out of the water, so no organisms are lost out of the opening.
4. Perform the measured sweep as quickly as possible to prevent aquatic organisms from escaping out of the net. The sweep should be completed within approximately 3 seconds.
5. If the net becomes significantly clogged or if branches, rocks, or other obstructions prevent the net from properly contacting the wetland substrate, discard the sample and resample in an undisturbed location.
6. Carry the net to the shoreline and deliver macros to the "picker". Transfer all material collected in the net into a kick screen net by turning the D-frame net inside out on the kick screen net. Visually inspect both nets and remove any clinging organisms.

Semi-Quantitative Stream Method (PA DEP Instream Comprehensive Evaluation Protocol):
Typically, a "D" net is used for this method. To make collection easier, the order of sampling sites may be mixed and collected in the same net load. For example: undercut bank, riffle, macrophyte, empty net, riffle, etc. Remember that everything is going into the same batch, so order doesn't matter. Do what is easiest for you.

If the net is empty after sampling at the first habitat station, identification may be skipped and the net emptied only as necessary.

Riffle Instream Habitat

1. Select the fastest and slowest moving areas of the riffle. Organisms collected from both these sites will constitute one riffle sample. Begin at the downstream end of the reach to be sampled and work upstream. This keeps the working area undisturbed.
2. With the net opening facing upstream, place the bottom of the net flush on the stream bottom immediately downstream from the riffle.
3. While the "netter" holds the net, the "kicker" picks up large rocks (2 inch or greater diameter) within a 1-foot by 1-foot area directly in front of the net opening under the water and gently rubs them in the net opening to remove any clinging organisms.
4. Gently place the cleaned rocks outside the sampling area.
5. When all the stones (or as many as possible) are removed from the sample area, the "kicker" stands approximately one foot upstream of the net opening and kicks the stream bed vigorously to dislodge any remaining organisms into the net.
6. Kick down approximately two inches for one to two minutes while moving toward the net.
7. When done kicking, the "netter" sweeps the net in an upward fashion to collect the organisms.
8. Carry the net to the shoreline to the "picker" follow Picking instructions below.

Collect a total of three riffle samples by repeating steps 1 – 8 to identify on shore together.

Leaf Pack Instream Habitat

1. Look for leaves that are about four to six months old. These old leaf packs are dark brown and slightly decomposed. Only a handful of leaves is necessary.
2. Begin at the downstream end of the reach to be sampled and work upstream. This keeps the working area undisturbed.
3. With the net opening facing upstream, place the bottom of the net flush on the stream bottom immediately downstream from the leaf pack.
4. Gently shake the leaf pack in the water to release some of the organisms, then quickly scoop up the net, capturing both organisms and the leaf pack in the net.
5. Carry the net to the shoreline to the "picker" follow Picking instructions below.

Collect a total of three leaf pack samples by repeating steps 1 – 5 to identify on shore together.

Tree Roots, Snags, and Submerged Logs Instream Habitat

Snags are accumulations of debris caught by logs or boulders lodged in the stream current. Caddisflies, stoneflies, riffle beetles, and midges commonly inhabit these areas.

1. Select an area on the tree roots, snag, or submerged logs which is approximately 3-feet by 3-feet.
2. Begin at the downstream end of the reach to be sampled and work upstream. This keeps the working area undisturbed.
3. Scrape the surface of the tree roots, logs, or other debris with a D net while on the downstream side of the snag. You can also disturb such surfaces by scraping them with your foot or large stick. Try pulling off some of the bark to get at the organisms hiding underneath. In all cases, be sure that the net is positioned downstream from the snag, so that dislodged material floats into the net.
4. You may remove log from the water to better sample from it but be sure to replace it when done.
5. Carry the net to the shoreline to the "picker" follow Picking instructions below.

Collect a total of three root samples by repeating steps 1 – 5 and identify them on shore together.

Undercut Bank and Overhanging Vegetation Instream Habitat

Undercut banks are areas where moving water has cut out vertical or nearly vertical banks, just below the surface of the water. In such areas you will find overhanging vegetation and submerged root mats that harbor dragonflies, damselflies, and crayfish.

1. Place the net below the surface under the overhanging vegetation.
2. Move the net in a bottom - up motion, jabbing at the bank five times in a row to loosen organisms.
3. Carry the net to the shoreline to the “picker” follow Picking instructions below.

Collect a total of three bank samples by repeating steps 1 – 3 and identify them on shore together.

Sediments Instream Habitat

Areas of mostly sand and/or mud can usually be found on the edges of the stream, where water flows more slowly.

1. A “netter” stands downstream of the sediment area with the net resting on the bottom. A “kicker” disturbs the sediment to a depth of about two inches moving toward the net.
2. The “netter” sweeps the net upward to collect the organisms as the “kicker” approaches.
3. Keeping the opening of the net at least an inch or two above the surface of the water, wash out the sediment from the net by gently moving the net back and forth in the water of the stream.
4. Carry the net to the shoreline to the “picker” follow Picking instructions below.

Collect a total of three sediment samples by repeating steps 1 – 4 to identify them on shore together.

“Picking”, Identification and Counting

Follow directions to collect macros from each instream habitat. Once collected the “netter” & “kicker” will:

1. Carry the net to the shoreline and deliver macros to the “picker”.
2. While the "kicker" holds the sampling pan, the "netter" empties the net's contents into a tray.
3. Using the squirt bottle filled with stream water, rinse the inside of the net into the tray to collect all the organisms.
4. Examine, wash and discard large pieces of vegetation, woody debris, stones, etc., making sure to remove and retain any aquatic invertebrates observed. Remove any clinging organisms and place them directly into segmented tray (ice cube tray works well) for individual identification. Recommended tool is a small paint brush to trap the organism in the bristles and release them with a swish in water.
5. The “kicker” and “netter” go for the next sample while the “picker” remains to continue sorting and counting macros as quickly as possible. Make sure to add enough cold stream water to keep them alive while they are waiting to be counted. Return counted macros back to the stream.

<u>Keys to easier "picking" are:</u>
- Patience!
- Look for movement

It is ok to group like organisms for identification. Remember some macros are predatory and should be kept separate from others they are visibly attacking. Also try to do this identification as accurately and quickly as possible and preferably out of the direct sun. The goal is to return the macros to the stream section near where you found them, but they will make their way back to suitable habitat. If there are macros you simply cannot identify, take detailed photos of them or place them in a sample bottle for more detailed analysis under a microscope later.

Keep a tally of different macroinvertebrate orders and number of different kinds (family, genus, or species) as you identify. Record order abundance as follows - > 50 Abundant (A), 5 – 50 Common (C) and < 5 Rare (R) the Section 1A: Stream Quality & Quantity Field Sampling Datasheets. You may use the visual references on the datasheet or another reference such as:

- PA Fish and Boat Commission Key to Macroinvertebrate Life in the River
- Stroud Water Research Center Keys to the Families of Aquatic Insects
- University of Wisconsin-Extension Wonderful, Wacky, Water Critters
- Isaac Walton League of America Volunteer Guide to Aquatic Macroinvertebrates
- And many more….

After sampling has been completed at a given site, all nets, pans, etc. that have come in contact with the sample should be rinsed thoroughly, examined carefully, and picked free of organisms or debris. Any additional organisms found should be placed into the sample containers. The equipment should be examined again prior to use at the next sampling site to prevent cross stream contamination and invasive species introduction.

Calculating Metrics

Take your sampling datasheet back to the office for evaluation. A number of different metrics are available to evaluate stream conditions based on benthic macroinvertebrate sampling. In most cases (except the Hilsnenhoff Biotic Index) the metrics are expected to decrease in value with increasing anthropogenic stress to a stream ecosystem reflecting a loss of pollution sensitive taxa and increasing dominance of a few pollution tolerant taxa.

Total Taxa Richness

Count the total number of taxa (kinds of organisms) that were identified for a stream. If less than 8, then stream conditions are poor. If between 8 and 15, then conditions are moderate, and if greater than 15, then conditions are good.

Hilsenhoff Biotic Index

Based on an organism's relative sensitivity to stream-quality conditions. The HBI uses assigned tolerance values that range from 0 to 10. A 0 is assigned to organisms least tolerant of organic pollution, and a 10 is assigned to organisms most tolerant of organic pollution. Species intermediate in their tolerance of organic pollution were assigned intermediate values (Hilsenhoff, 1982). Tolerance values are from the genus and species-level biotic index developed by the State of New York (Bode, 1991). HBI values from 0 to 4.5 are associated with nonimpacted sites, 4.51 to 6.50 with slightly impacted sites, 6.51 to 8.50 with moderately impacted sites, and 8.51 to 10 with severely impacted sites (Bode, 1993).

EPT Taxa Richness

The total number of taxa within the "pollution sensitive" orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These macroinvertebrate orders are the least tolerant of organic pollution with HBI from 0-4. Taxa richness and EPT taxa richness will decrease with decreasing water quality (Weber, 1973). Percent EPT is the total number of EPT individuals divided by the total number of individuals in the sample.

Shannon Diversity Index

An information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. In the Shannon index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

Shannon Diversity Index = $-\Sigma(n_i/N)\ \ln(n_i/N)$

The Simpson Index

A dominance index which gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity. In the Simpson index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), Σ is still the sum of the calculations, and s is the number of species.

Simpson Index = $\Sigma N(N-1)\ /n(n-1)$

SOURCE: RAPID BIOASSESSMENT PROTOCOLS FOR USE IN STREAMS AND WADABLE RIVERS: PERIPHYTON, BENTHIC MACROINVERTEBRATES AND FISH, SECOND EDITION (344 PP, 11 MB, JULY 1999, EPA-841-B-99-002)

William E. Sharpe, William G. Kimmel, and Anthony R. Buda

The Biotic Index was developed by William M. Beck, Jr. in response to the need for a simple biological measure of stream pollution. This method is based on the classification of selected aquatic invertebrates into categories depending on their response to organic pollution (sewage and other oxygen demanding wastes). General experience has indicated that the Biotic Index is also useful in classifying other types of pollution. Extensive study of the distribution of invertebrates in relation to water quality enabled Beck to divide these organisms into three groups on the basis of their ability to tolerate organic pollution:

Class I – pollution sensitive ***Class II – moderately tolerant*** ***Class III – pollution tolerant***

Invertebrates collected during stream surveys are identified and assigned to the appropriate Class and the following computation performed:

Biotic Index = 2(n Class I) + (n Class II)
where n = number of taxa (different organisms based on appearance)

EXAMPLE OF BIOTIC INDEX CALCULATION:

A sample of bottom fauna from stream X reveals the following different kinds of invertebrates –

Organism	# Taxa	Class	Organism	#Taxa	Class
Mayfly	4*	I	Net Spinning Caddisfly	2	II
Stonefly	3	I	Aquatic Sowbug	1	II
Case building caddisfly	2	I	Dragonfly nymph	1	II
Crayfish	1	I	True flies (Diptera)	5	III
			Snail	1	III

RESULT:

Biotic Index = 2(n Class I) + (n Class II)
= 2(10) + (4)
= 24 = Clean Stream

*Note: This number represents the different kinds (taxa) of mayflies found not the number of individuals

BIOTIC INDEX RANGES

Clean Streams	*Moderate Pollution*	*Gross Pollution*
10 or greater	3 – 9	0 – 2

The Biotic Index becomes more powerful as the investigator increases his proficiency in the identification of the individual organism to its lowest taxonomic group (species if possible). It also has built-in flexibility as it allows a given species to be classified to the appropriate category as information becomes available on its tolerance to organic pollution. The following scheme groups the commonly encountered aquatic invertebrates into their respective classes:

Class I – Pollution Sensitive Taxa

A. Mayflies (Ephemeroptera)
   1. Climbers and free rangers – body laterally compressed, platelike gills, usually three fringed tails, rapid movements.
   2. Clingers and bottom sprawlers – body broad and flat, two or three tails, clinging to underside of rocks or in vegetable matter
   3. Burrowers – usually two large forward – projecting tusks, three tails, gills dorsal, burrow in mud
B. Stoneflies (Plecoptera) – two tails, body color brown to yellow and dark areas on dorsal surface, active crawlers out of water.
C. Caddisflies (Trichoptera) – wormlike bodies, pair of prolegs at rear which bear hooks, live freely or in cases constructed of mineral and/or vegetable matter.
D. Crayfish (Decapoda)
E. Fingernail Clam (Pelecypoda) – tiny tan-colored or brown shells

Class II – Moderately Tolerant Taxa

A. Net-spinning caddisflies (Trichoptera) – as previously described, but without cases.
B. Water penny (Coleoptera) – body round or oval and strongly flattened, legs rarely visible from above.
C. Aquatic sow bug (Isopoda) – flattened grayish bodies, resemble pill bug often seen under rotting logs.
D. Scud (Amphipoda) – laterally compressed gray body, resembles miniature shrimp.
E. Hellgrammite (Megaloptera) – body wormlike with projections along sides, large pincer-like jaws.
F. Dragonfly nymph (Odonata)
G. Damselfly nymph (Odonata)

Class III – Pollution Tolerant Taxa

A. True flies (Diptera) – most belong in this class, but there are exceptions; wormlike bodies, legs absent, various forms and colors.
B. Snails (Gastropoda)
C. Flatworm (Tricladida) – small flat wormlike bodies, eyes on dorsal surface of "head".
D. Aquatic earthworms (Oligochaeta)
E. Leeches (Hirudinea)
F. Adult aquatic beetles (Coleoptera)
G. Surface film insects (Hemiptera)

**Note: Amphipoda, Decapoda, Gastropoda, Isopoda, Oligochaeta, Pelecypoda, Hirudinea, and Tricladida are not insects.*

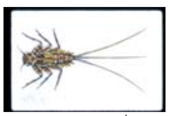
KEY TO ORDERS OF AQUATIC INSECTS

1a. Thorax with 3 pairs of segmented legs ***3***
1b. Thorax without segmented legs ***2***
2a. Mummy-like, in a case, often silk-cemented and containing vegetable or mineral matter….pupae (not keyed)
2b. Not in a case; mobile larvae, mostly with prolegs or pseudopods on one or more more segments……DIPTERA (true flies)
3a. With wings or external wing pads (may be inconspicuous) ***4***
3b. Wings or external wing pads absent ***10***
4a. With large, functional wings ***5***
4b. With wings pads or brachypterous wings ***7***
5a. Both pairs of wings completely membranous, with numerous veins…not aquatic, adults of Plecoptera or Trichoptera that may enter water to oviposit
5b. Front wings hardened, leather-like in basal half, or shell-like ***6***
6a. Front wings hard, opaque, shell-like, and without veination ……COLEOPTERA adults (beetles)
6b. Front wings hardened only in basal half, mostly membranous and with conspicuous veination near apex HEMIPTERA (true bugs)
7a. With 2 or 3 long, filamentous terminal appendages ***8***
7b. Terminal appendages absent or not filamentous ***9***
8a. Sides of abdomen with plate-like, feather-like, or leaf-like gills; usually with 3 tail filaments, occasionally only 2…… EPHEMEROPTERA (mayflies)
8b. Gills absent from middle abdominal segments; 2 tail filaments……….PLECOPTERA (stoneflies)
9a. Labium forming on elbowed, extensile grasping organ ODONATA (dragonflies)
9b. Mouthparts sucking, formed into a broad or narrow tube… HEMIPTERA
10a. Mouthparts sucking, formed into a narrow tube ***11***
10b. Mouthparts not formed into a narrow tube ***12***
11a. Parasitic on sponges; all tarsi with one claw ……………NEUROPTERA
11b. Free-living, walking on surface of water or swimming mesotarsi with two claws……….HEMIPTERA
12a. Ventral abdominal prolegs each with a ring of fine hooks (crochets)…………..LEPIDOPTERA (moths)
12b. Abdomen without ventral prolegs, except on terminal segment ***13***
13a. Antennae extremely small, inconspicuous, one-segmented ……………………TRICHOPTERA (caddisflies)
13b. Antennae elongate, with 3 or more segments ***14***
14a. A single claw on each tarsus……COLEOPTERA larvae
14b. Each tarsus with 2 claws ***15***
15a. With conspicuous lateral filaments ***16***
15b. Without conspicuous lateral filaments…COLEOPTERA larvae
16a. Abdomen terminating in 2 slender filaments or a median proleg with 4 hooks ………COLEOPTERA larvae
16b. Abdomen terminating in a single slender filament or in 2 prolegs, each with 2 hooks………MEGALOPTERA (hellgrammites)

Hilsenhoff, W.L. 1975. Aquatic Insects of Wisconsin. Tech. Bull. 89. Department of Natural Resources. Madison, Wisconsin. 52pp.

Some Class I Organisms

EPHEMEROPTERA


Mayfly+


Mayfly (burrowing)


Mayfly (climbing)

PLECOPTERA


Stonefly+


Stonefly

TRICHOPTERA


Caddisfly (case building)


Caddisfly (case building)


Caddisfly (case building)

TRICHOPTERA


Caddisfly (case building)


Caddisfly (case building)


Caddisfly (case building)


Caddisfly (net spinning)


Caddisfly (net spinning)

DECAPODA


Crayfish

PELEYCYPODA


Fingernail Clams

Some Class II Organisms

COLEOPTERA


Water Penny

ISOPODA


Aquatic Sowbug

AMPHIPODA


Scud

ODONATA


Dragonfly


Dragonfly


Damselfly

MEGALOPTERA


Hellgrammite

Some Class III Organisms

DIPTERA


Black Fly


Midge Fly


Tabanus


Cranefly

GASTROPODA


Snails

TRICLADIDA


Flatworms

HEMIPTERA


Water Strider

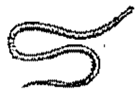
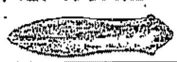
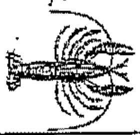
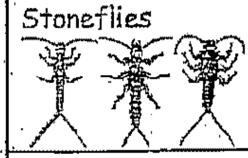
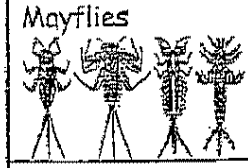
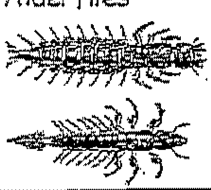

Water Boatman

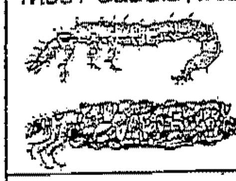
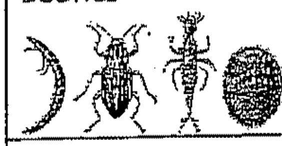
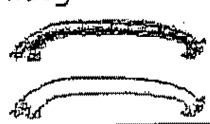
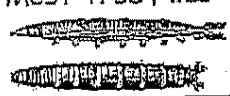
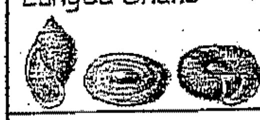
+Drawings by Stan Crilly

Funding for the Biotic Index Card provided by the Center for Watershed Stewardship, The Pennsylvania State University

(A)

Virginia Save Our Streams Macroinvertebrate Tally Sheet

Macroinvertebrates	Tally	Count
Worms 		
Flat-Worms 		
Leeches 		
Crayfishes 		
Sowbugs 		
Scuds 		
Stoneflies 		
Mayflies 		
Dragonflies and Damselflies 		
Hellgrammites, Fishflies, and Alderflies 		

Macroinvertebrates	Tally	Count
Common Netspinners 		
Most Caddisflies 		
Beetles 		
Midges 		
Black Flies 		
Most True Flies 		
Gilled Snails 		
Lunged Snails 		
Clams 		
Other		
Total number of organisms in the sample		

Illustrations from: Voshell, J. R., Jr. 2002. *A Guide to Common Freshwater Invertebrates of North America*. MacDonald and Woodward Publishing Co. With permission of the author.

Fig. 3. New field sheets developed for use in the modified Virginia Save-Our-Streams protocol. (A) Sheet for identifying macroinvertebrates and recording counts.

(B)

Individual Metrics

Metric	Number		Total number of organisms in the sample		Percent
Mayflies + Stoneflies + Most Caddisflies		Divide by		Multiply by 100	
Common Netspinners		Divide by		Multiply by 100	
Lunged Snails		Divide by		Multiply by 100	
Beetles		Divide by		Multiply by 100	

% Tolerant

Taxon	Number
Worms	
Flatworms	
Leeches	
Sowbugs	
Scuds	
Dragonflies and Damselflies	
Midges	
Black Flies	
Lunged Snails	
Clams	
Total Tolerant	
Total Tolerant divided by the total number of organisms in the sample	
Multiply by 100	

% Non-Insects

Taxon	Number
Worms	
Flatworms	
Leeches	
Crayfish	
Sowbugs	
Scuds	
Gilled Snails	
Lunged Snails	
Clams	
Total Non-Insects	
Total Non-Insects divided by the total number of organisms in the sample	
Multiply by 100	

Fig. 3. (B) Sheet for calculating individual metrics.

(C)

Save Our Streams Multimetric Index

Determine whether each metric should get a score of 2,1, or 0. Write your metric value from the previous page in the 2nd column (Your Metric Value). Put a check in the appropriate boxes for 2,1, or 0. Then calculate the subtotals and Save Our Streams Multimetric Index score and determine whether the site has acceptable or unacceptable ecological condition.

Metric	Your Metric Value	2	1	0
% Mayflies + Stoneflies + Most Caddisflies		Greater than 32.2	16.1 – 32.2	Less than 16.1
% Common Netspinners		Less than 19.7	19.7 – 34.5	Greater than 34.5
% Lunged Snails		Less than 0.3	0.3 – 1.5	Greater than 1.5
% Beetles		Greater then 6.4	3.2 – 6.4	Less than 3.2
% Tolerant		Less than 46.7	46.7 – 61.5	Greater than 61.5
% Non-Insects		Less than 5.4	5.4 – 20.8	Greater than 20.8
		Total # of 2s:	Total # of 1s:	Total # of 0s:
Subtotals:		Multiply by 2:	Multiply by 1:	Multiply by 0:

Now add the 3 subtotals to get the Save Our Streams Multimetric Index score:______________

_____Acceptable ecological condition (7 to 12)

_____Unacceptable ecological condition (0 to 6)

Fig. 3. (C) Sheet for calculating new Virginia (USA) Save-Our-Streams multimetric index and determining the category of ecological condition.

STROUD
WATER RESEARCH CENTER

KEYS TO THE FAMILIES OF AQUATIC INSECTS

Keys extracted from

Aquatic Entomology

Written by
W.P. McCafferty

Illustrations by
A.V. Provonsha

970 Spencer Road • Avondale, Pennsylvania • 19311-9514
Phone 610 268 2153 • Fax 610 268 0490
www.stroudcenter.org

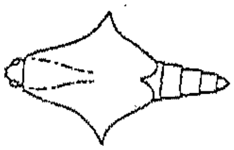
MAYFLIES

Figure 7.5. MATURE EPHEMEROPTERA LARVAE

THORAX ROBUST WITH NOTUM FUSED BETWEEN FORE WING PADS FOR AT LEAST HALF LENGTH OF PADS; GILLS ON ABDOMINAL SEGMENT 2 EITHER ABSENT, CONCEALED, OR OPERCULATE

FORE WING PADS FREE, SEPARATE FOR HALF THEIR LENGTH OR MORE; GILLS ON ABDOMINAL SEGMENT 2 PRESENT, VARIABLE, BUT NEVER OPERCULATE

THORACIC NOTUM CARAPACELIKE AND COVERING MUCH OF ABDOMEN



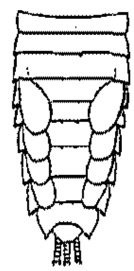
Baetiscidae
(p. 122)

THORACIC NOTUM NOT COVERING MOST OF ABDOMEN

ABDOMINAL GILLS 2–7 DOUBLE, ELONGATE, WITH FRINGED MARGINS

ABDOMINAL GILLS 2–7 NEVER DOUBLE, ELONGATE, AND FRINGED IN COMBINATION —— a

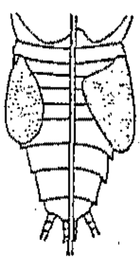
GILLS ON ABDOMINAL SEGMENT 2 ABSENT



Ephemerellidae
(p. 118)

GILLS ON ABDOMINAL SEGMENT 2 PRESENT AND OPERCULATE

GILLS ON ABDOMINAL SEGMENT 2 ROUNDED OR TRIANGULAR



Tricorythidae
(p. 119)

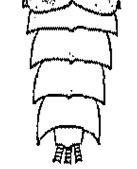
GILLS ON ABDOMINAL SEGMENT 2 QUADRATE

HEAD WITHOUT TUSKS

Behningiidae
(p. 112)

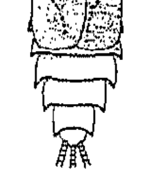
HEAD WITH ANTERIORLY PROJECTING TUSKS

GILLS ON ABDOMINAL SEGMENT 2 FUSED ALONG MIDLINE



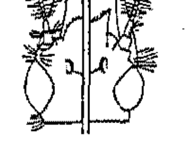
Neoephemeridae
(p. 121)

GILLS ON ABDOMINAL SEGMENT 2 NOT FUSED BUT OVERLAPPING



Caenidae
(p. 121)

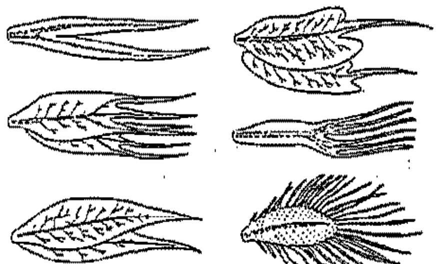
TUSK WITH NO SPINES IN DISTAL HALF



Ephemeridae
(p. 115)

TUSKS WITH DISTAL SPINES —— b

GILLS ON ABDOMINAL SEGMENTS 2–5 FORKED OR DOUBLE AND ELONGATE OR WITH FINGERLIKE PROJECTIONS OR IN CLUSTERS OF FILAMENTS, AND NEVER VENTRAL



Leptophlebiidae
(p. 110)

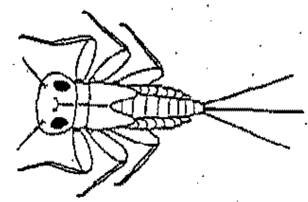
GILLS ON ABDOMINAL SEGMENTS 2–5 USUALLY PLATELIKE AND OFTEN WITH BASAL GILL TUFTS OR FLAPS, ONLY RARELY POINTED

FORE LEGS WITH 2 ROWS OF LONG HAIRS

Oligoneuriidae
(p. 105)

FORE LEGS WITHOUT 2 ROWS OF LONG HAIRS

DISTINCTLY FLATTENED BODIES WITH HORIZONTAL HEADS AND OUTSPREAD LEGS



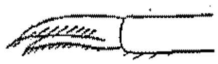
Heptageniidae
(p. 106)

BODY ELONGATE, STREAMLINED; HEAD VERTICAL

a

FORE LEG CLAWS DIFFERENT FROM MIDDLE AND HIND LEG CLAWS

FORE LEG CLAWS CLEFT



Metretopodidae
(p. 101)

FORE LEG CLAWS SIMPLE, WITH BRISTLES

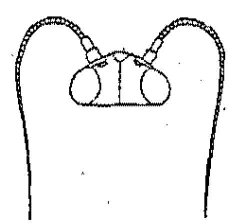
Ametropodidae
(p. 102)

CLAWS ON ALL LEGS SIMILAR

WITH 3 WELL-DEVELOPED TAILS; ANTENNAE SHORTER THAN 2× HEAD WIDTH

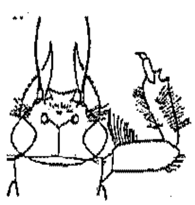
Siphlonuridae
(p. 100)

WITH 2 OR 3 WELL-DEVELOPED TAILS; IF 3 TAILS PRESENT, THEN ANTENNAE 2× TO 3× HEAD WIDTH



Baetidae
(p. 102)

TUSKS WITH OUTER KEEL AND OUTCURVED TIPS

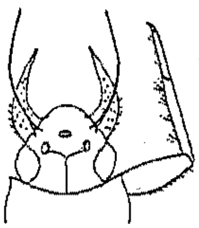


Palingeniidae
(p. 116)

TUSKS WITH SCATTERED OR INNER SPINES AND DOWNWARD-INWARD CURVED TIPS

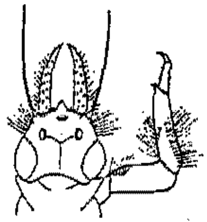
b

LEGS AND GILLS OUTSPREAD LATERALLY



Potamanthidae
(p. 112)

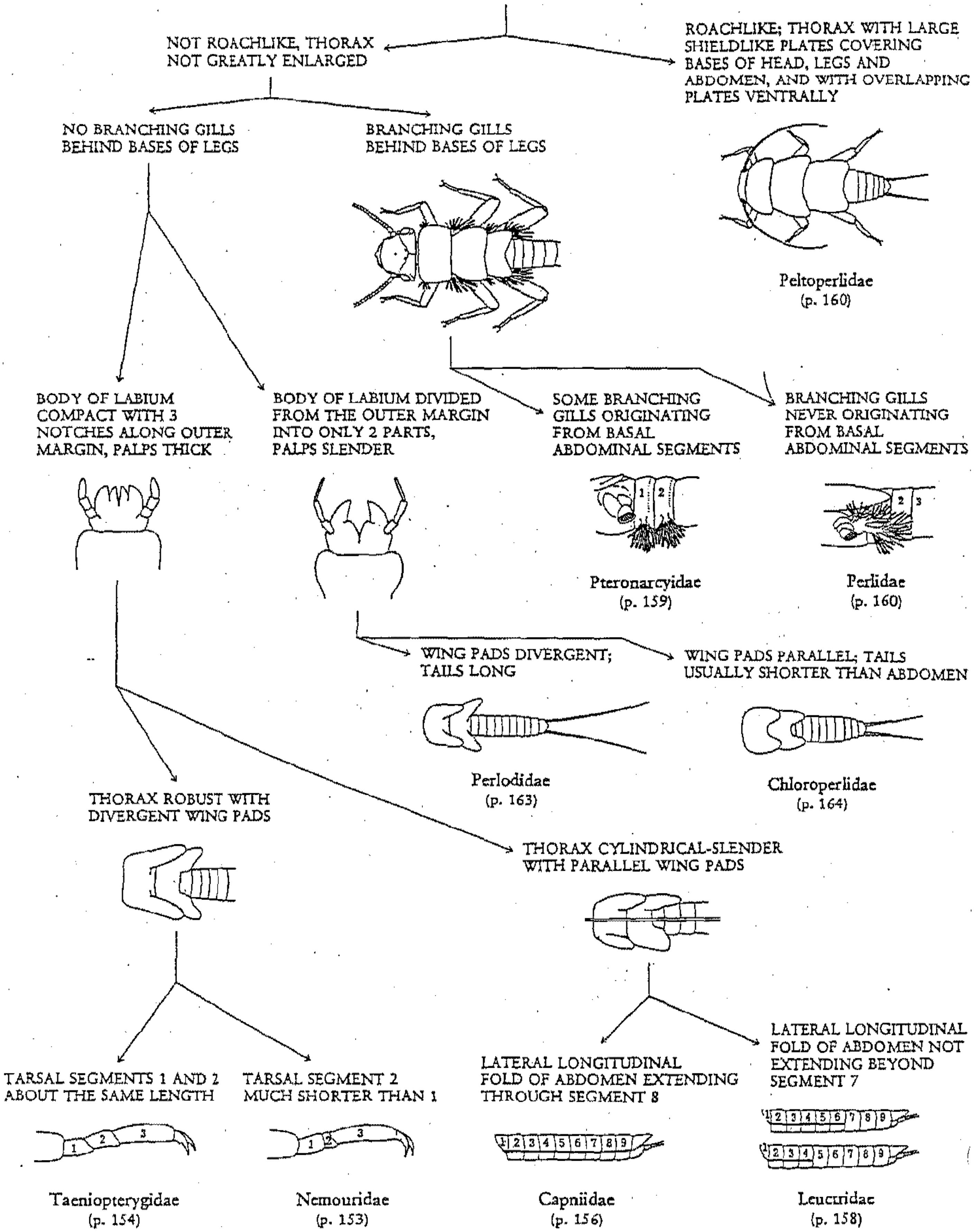
LEGS ROBUST; GILLS DORSAL



Polymitarcyidae
(p. 113)

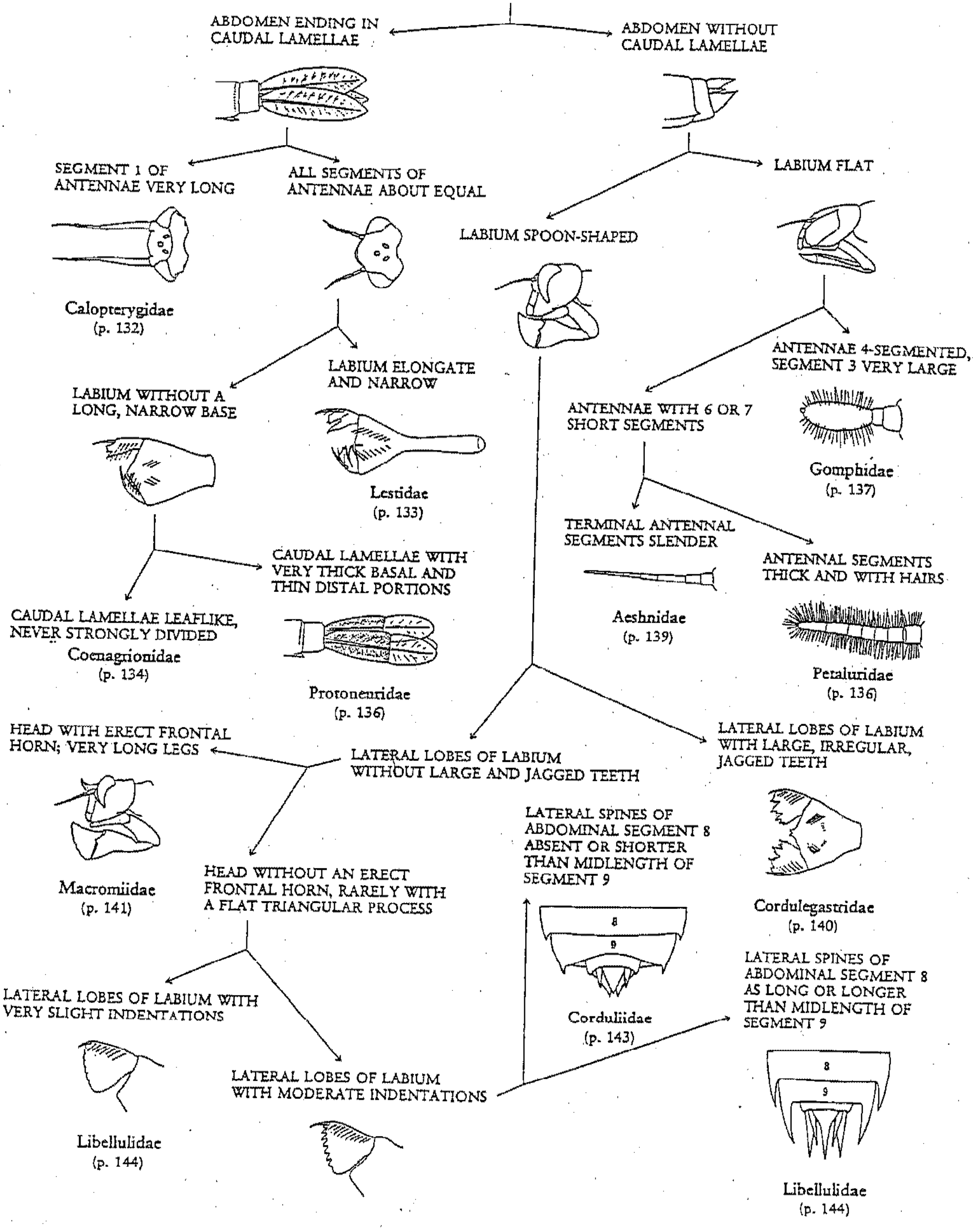
STONEFLIES

Figure 9.2. MATURE PLECOPTERA LARVAE



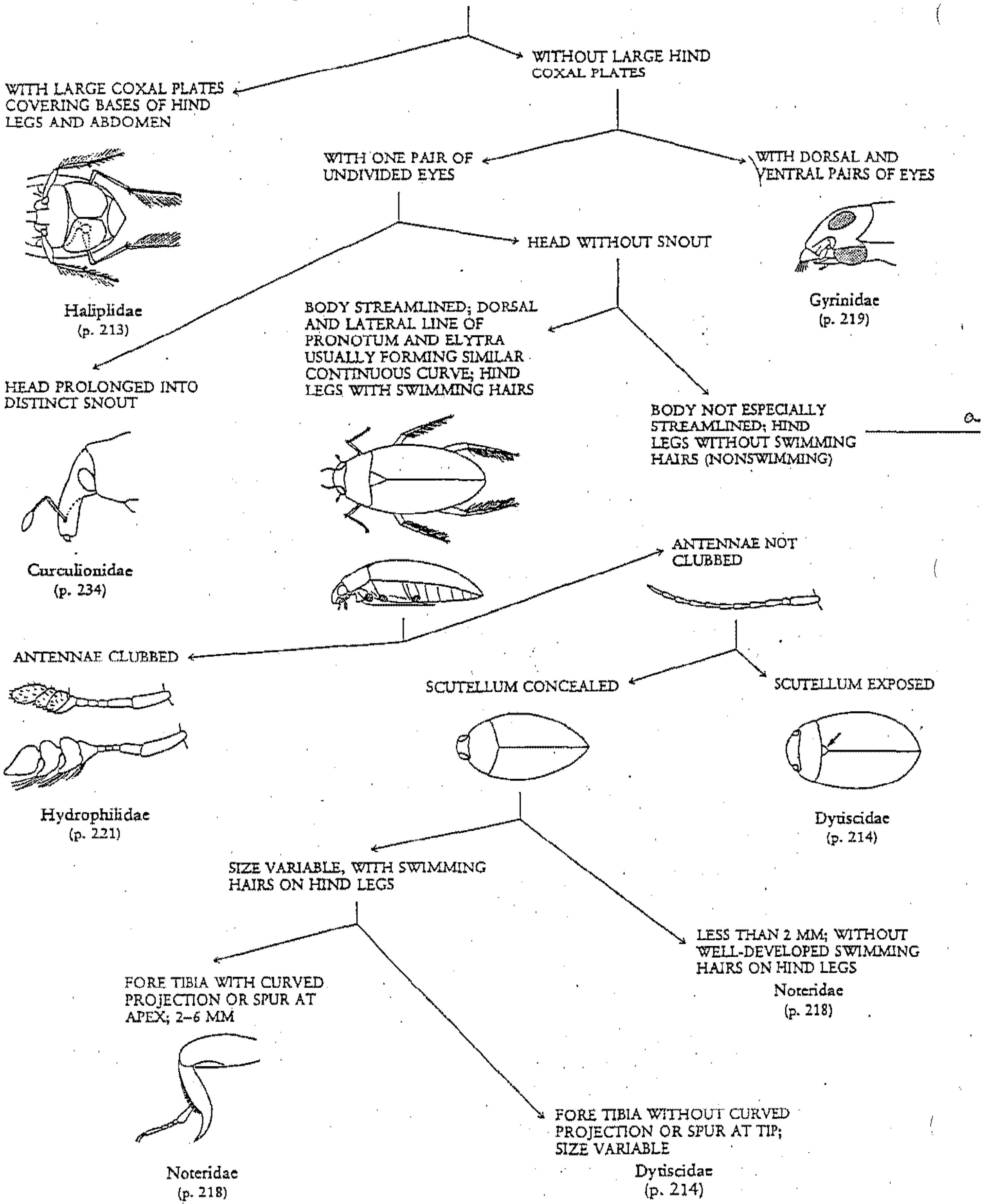
DRAGONFLIES AND DAMSELFLIES

Figure 8.2. MATURE ODONATA LARVAE



BEETLES

Figure 13.1. AQUATIC COLEOPTERA ADULTS

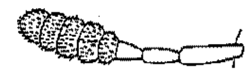


a

- ANTENNAE CLUBBED WITH CUPLIKE SEGMENT AT BASE OF CLUB
  - ANTENNAL CLUB 3-SEGMENTED; USUALLY OVER 2.5 MM

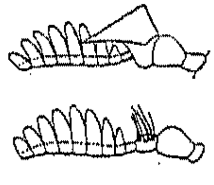
    Hydrophilidae
    (p. 221)
  - ANTENNAL CLUB 5-SEGMENTED; NOT OVER 2.5 MM

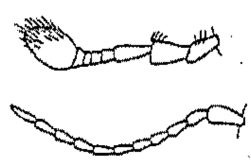
    Hydraenidae
    (p. 224)
- ANTENNAE VARIABLE BUT NEVER WITH A CUPLIKE SEGMENT AT THE BASE OF A CLUB; IF CLUBBED, THEN WITH LONG TARSI AND CLAWS
  - ALL TARSI 3-SEGMENTED; NOT OVER 2 MM
    Hydroscaphidae
    (p. 220)
  - ALL TARSI WITH MORE THAN 3 SEGMENTS; SIZE VARIABLE
    - ALL TARSI APPARENTLY 4-SEGMENTED, ACTUALLY 5

      Chrysomelidae
      (p. 232)
    - ALL TARSI DISTINCTLY 5-SEGMENTED
      - LONG LEGS WITH LONG CLAWS, AND TARSAL SEGMENT 5 USUALLY ABOUT AS LONG AS BASAL 4 SEGMENTS COMBINED; 1–9 MM.
        - ANTENNAE WITH PECTINATE CLUB

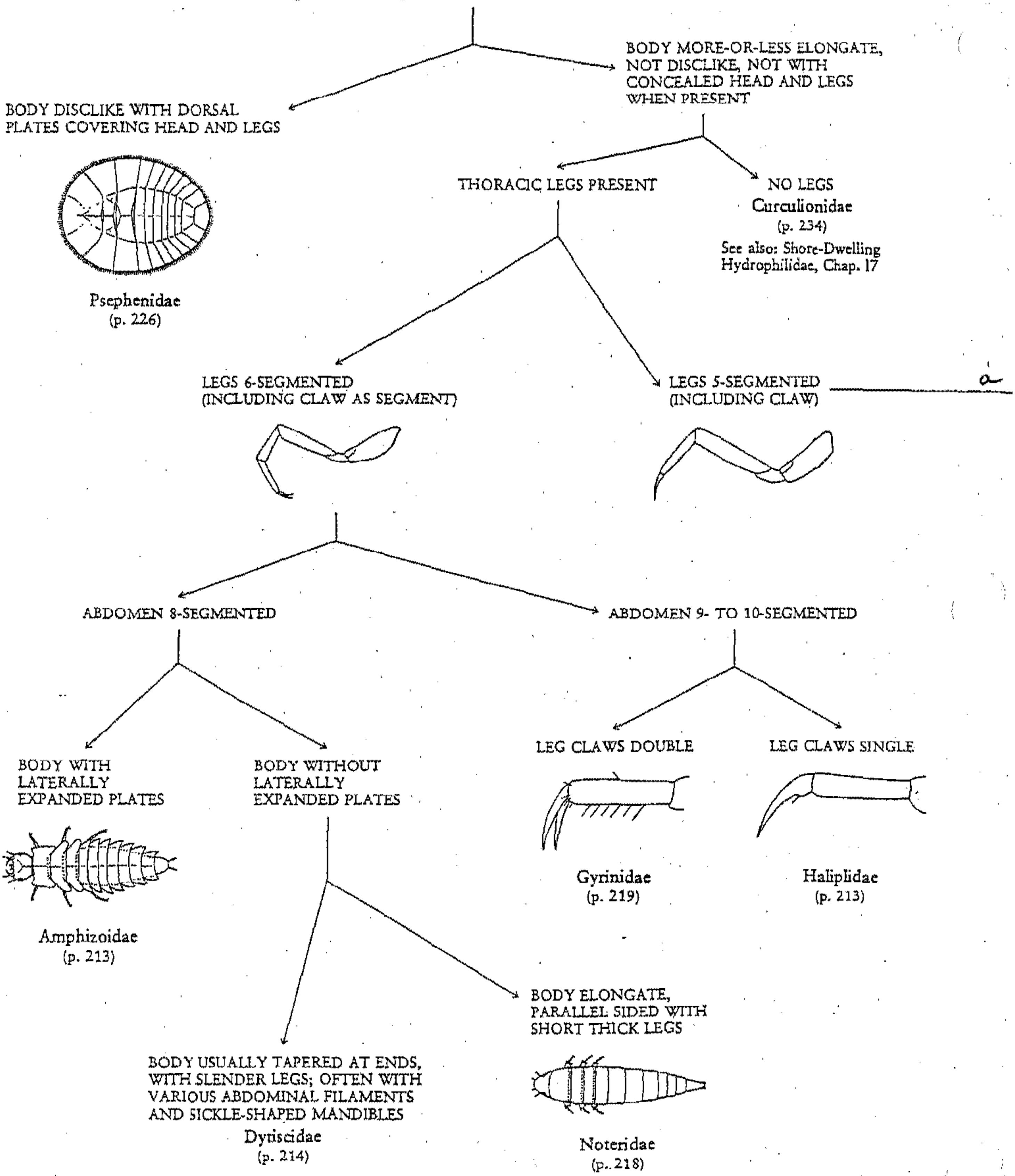
          

          Dryopidae
          (p. 229)
        - ANTENNAE VARIABLE, NOT WITH PECTINATE CLUB

          Elmidae
          (p. 231)
      - LEGS, CLAWS, AND TARSAL SEGMENT 5 NOT ESPECIALLY ELONGATE; LESS THAN 2 OR MORE THAN 10 MM
        - 11–16 MM
          Amphizoidae
          (p. 213)
        - LESS THAN 2 MM
          Noteridae
          (p. 218)

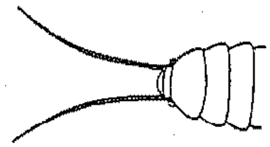
Figure 13.2. AQUATIC COLEOPTERA LARVAE



2

ABDOMEN 8-SEGMENTED;
USUALLY SOFT BODIED

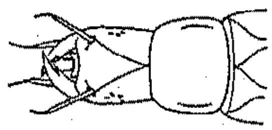
WITH VERY LONG
MULTISEGMENTED ANTENNAE



Helodidae
(p. 225)

ANTENNAE SHORTER THAN HEAD
AND PRONOTUM COMBINED

HEAD WITH WELL-DEVELOPED,
TOOTHED MANDIBLES PROTRUDING
FORWARD; NO SHARP SPURS
AT END OF ABDOMEN



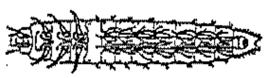
Hydrophilidae
(p. 221)

HEAD SMALL WITH
MANDIBLES INCONSPICUOUS
FROM ABOVE; PAIR OF
SHARP SPURS AT END
OF ABDOMEN

Chrysomelidae
(p. 232)

ABDOMEN 9-SEGMENTED;
USUALLY HARD BODIED

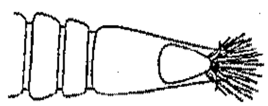
SEGMENT 9 WITHOUT
VENTRAL GILLS



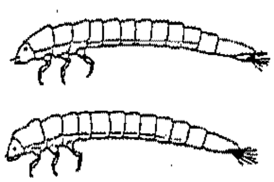
Ptilodactylidae
(p. 227)

ABDOMINAL SEGMENT 9 WITH
GILLS (SOMETIMES RETRACTED
INTO CAUDAL CHAMBER)

ABDOMINAL SEGMENT 9
WITH VENTRAL OPERCULUM



ABDOMEN WITH SUTURE LINES
ON SEGMENTS 1–6 TO 1–8 OR
SUTURE LINES INDISTINCT

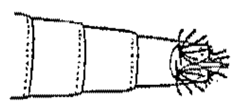


Elmidae
(p. 231)

ABDOMEN WITH SUTURE
LINES ON SEGMENTS 1–4

Limnichidae
(p. 228)

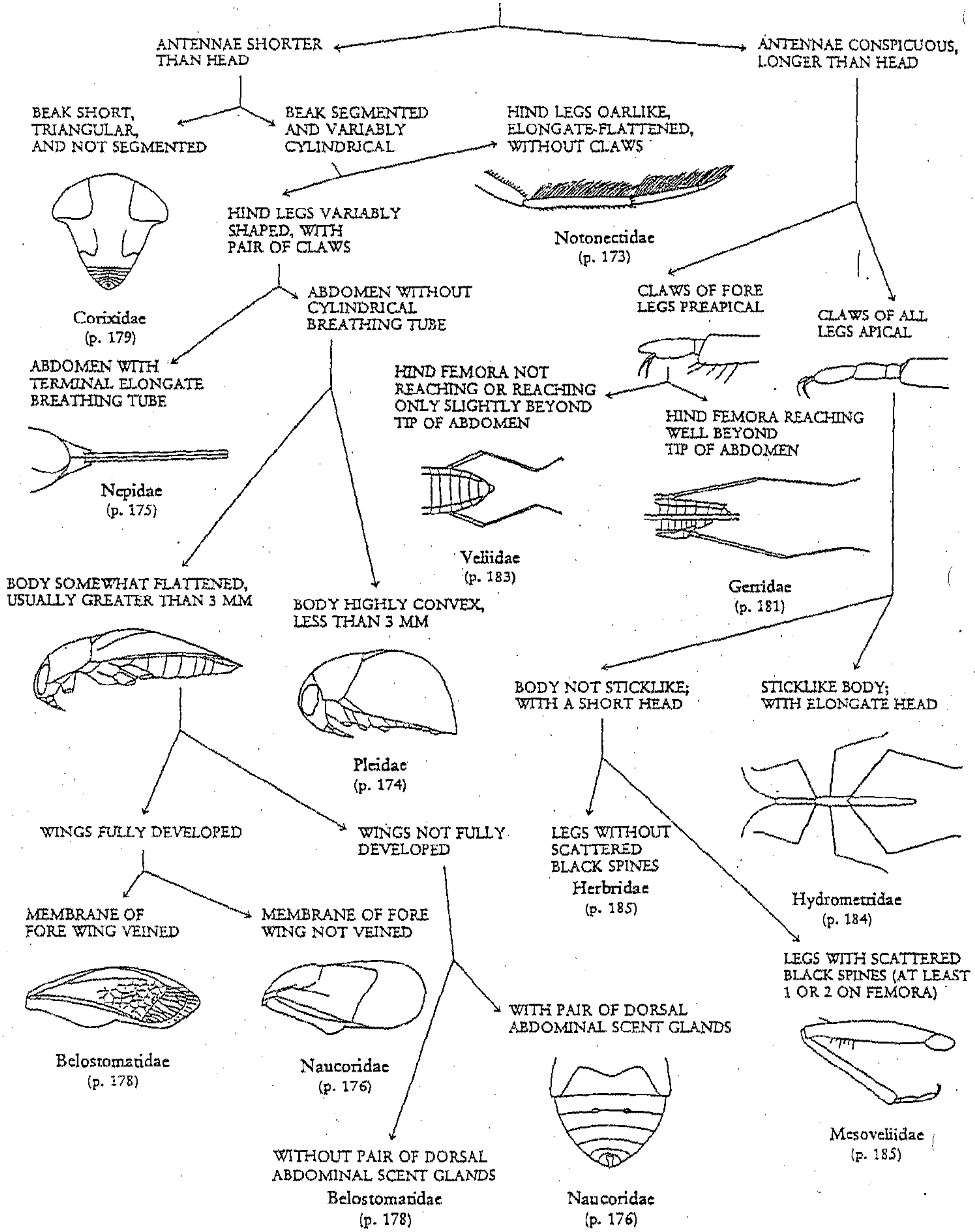
ABDOMINAL SEGMENT 9
WITHOUT VENTRAL OPERCULUM



Ptilodactylidae
(p. 227)

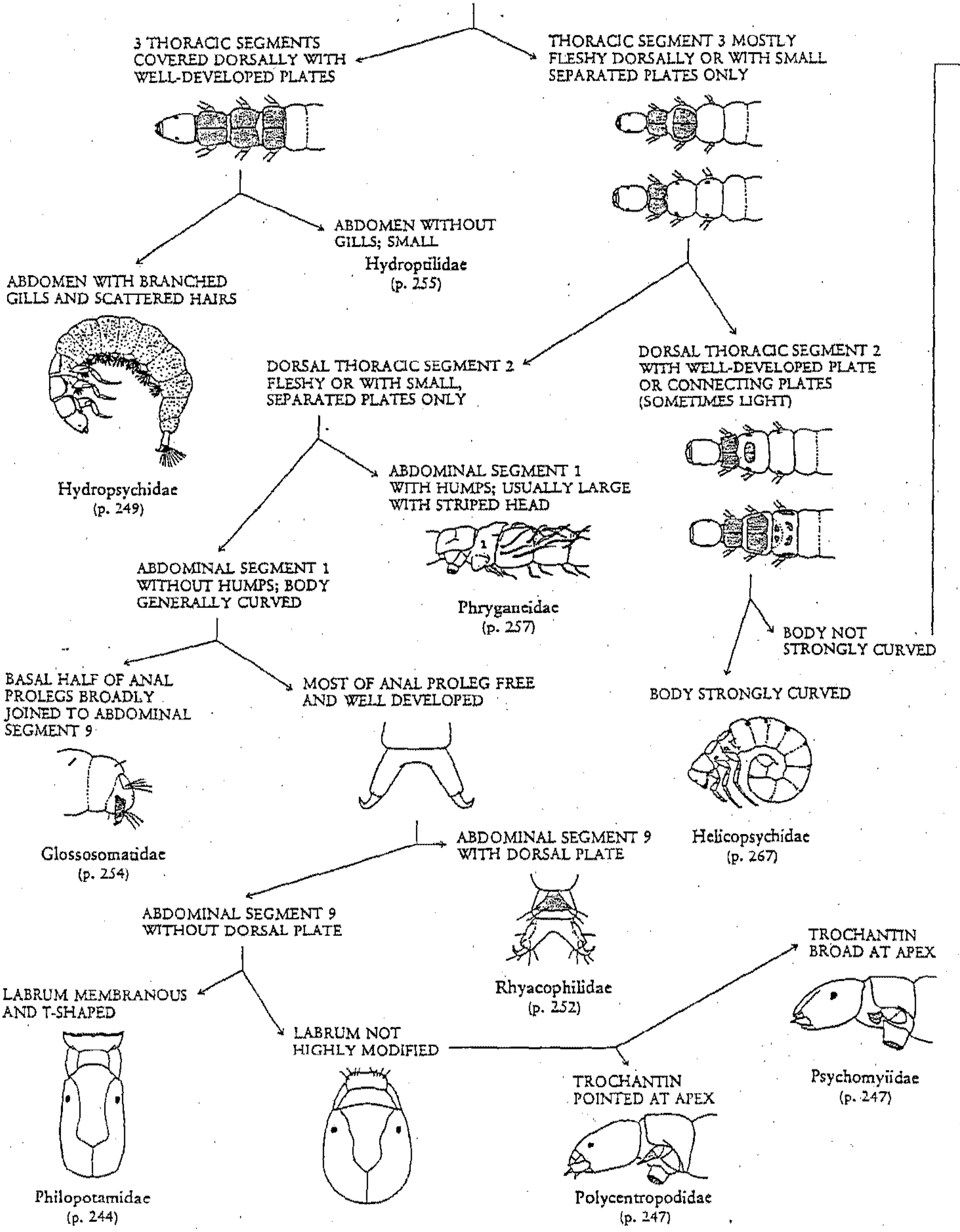
TRUE BUGS

Figure 10.1. UNDERWATER AND SURFACE HEMIPTERA



CADDISFLIES

Figure 14.1. MATURE TRICHOPTERA LARVAE



ANTENNAE SHORT AND INCONSPICUOUS

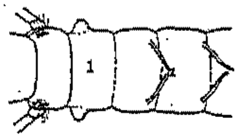
ABDOMINAL SEGMENT 1 WITH DORSAL HUMP AND DORSOLATERAL BRISTLES VARIABLE

ABDOMINAL SEGMENT 1 WITH NO DORSAL HUMP AND NEVER WITH MANY DORSOLATERAL BRISTLES

ANTENNAE RELATIVELY LONG AND CONSPICUOUS, AT LEAST 6× WIDTH

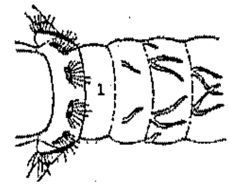
Leptoceridae
(p. 269)

LATERAL HUMPS PRESENT ON SEGMENT 1



Lepidostomatidae
(p. 264)

NO LATERAL HUMPS ON ABDOMINAL SEGMENT 1

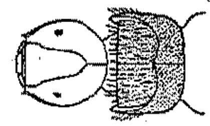


Brachycentridae
(p. 259)

ABDOMINAL SEGMENT 1 WITH SEVERAL DORSOLATERAL BRISTLES

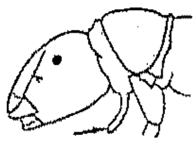
ABDOMINAL SEGMENT 1 WITH FEWER THAN 5 DORSOLATERAL BRISTLES

PRONOTUM WITH HIGHLY CURVED RIDGE



Beraeidae
(p. 265)

PROSTERNAL HORN PRESENT (SOMETIMES SMALL); ANTENNAE HALFWAY BETWEEN EYE AND ANTERIOR MARGIN OF HEAD



Limnephilidae
(p. 260)

PROSTERNAL HORN ABSENT
Odontoceridae
(p. 266)

PRONOTUM WITHOUT HIGHLY CURVED RIDGE

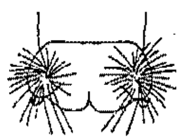
CLAW OF HIND LEG NOT HIGHLY MODIFIED

CLAW OF HIND LEG STOUT WITH SHORT BRISTLES, OR LONG AND FILAMENTLIKE

Molannidae
(p. 267)

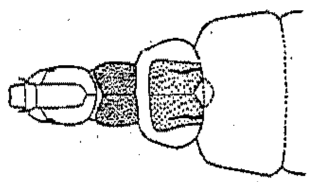
EACH ANAL PROLEG WITH LESS THAN 10 LONG HAIRS

EACH ANAL PROLEG WITH ABOUT 30 LONG HAIRS



Sericostomatidae
(p. 265)

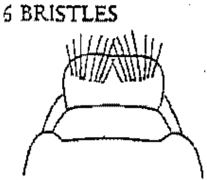
DORSAL THORACIC SEGMENT 2 WITH PAIR OF DARK, CURVED LINES



Leptoceridae
(p. 269)

DORSAL THORACIC SEGMENT 2 WITHOUT PAIRED DARK LINES

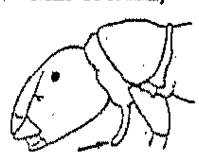
LABRUM WITH ABOUT 16 BRISTLES



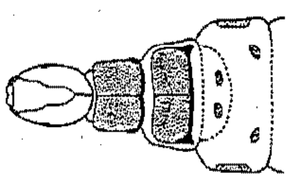
Calamoceratidae
(p. 268)

LABRUM WITH FEW BRISTLES

PROSTERNAL HORN PRESENT (SOMETIMES SMALL)



SOME SMALL MEDIAL PLATES ON DORSAL THORACIC SEGMENT 3

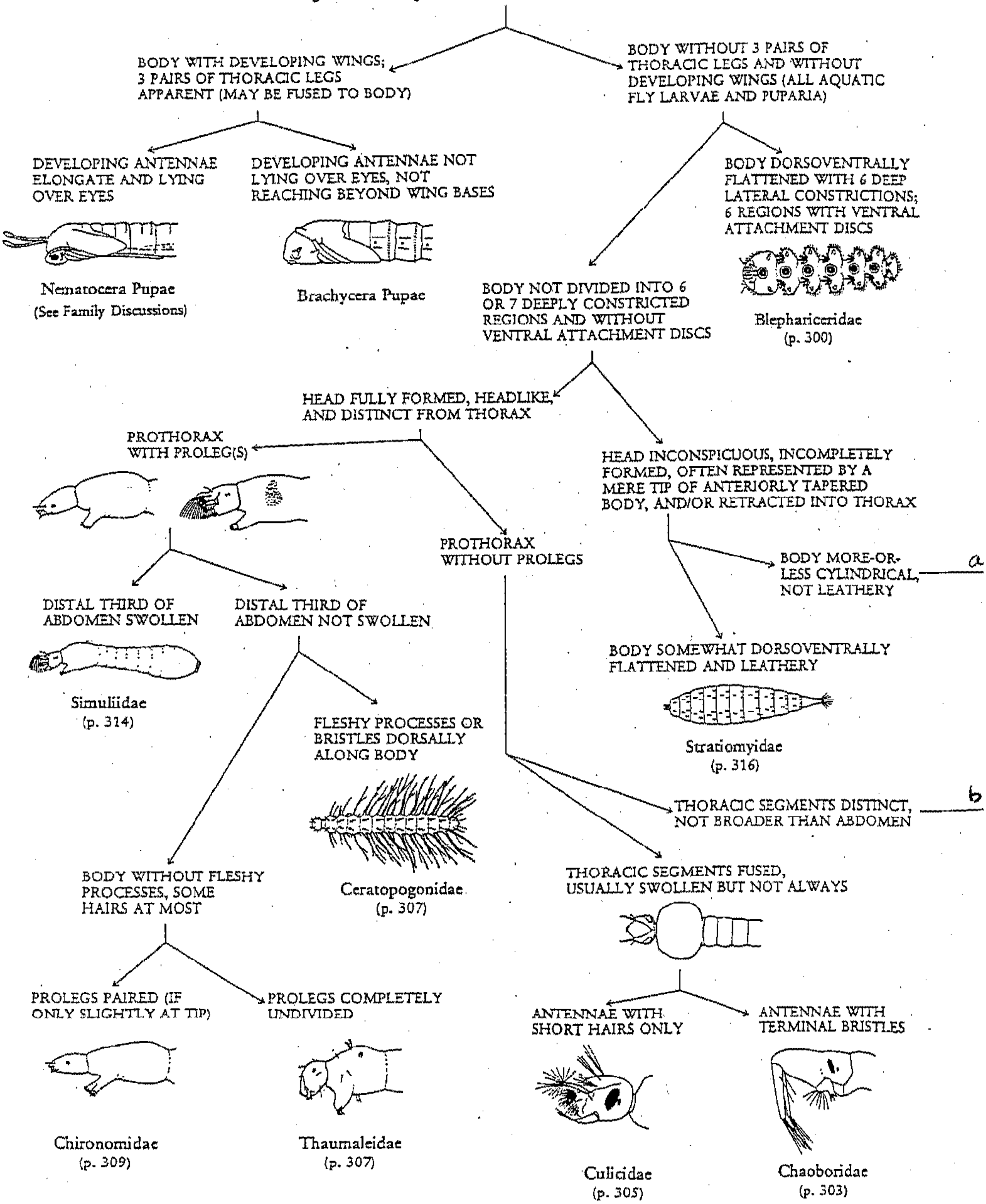


Limnephilidae
(p. 260)

NO MEDIAL PLATES ON DORSAL THORACIC SEGMENT 3
Phryganeidae
(p. 257)

PROSTERNAL HORN ABSENT
Odontoceridae
(p. 266)

Figure 16.1. AQUATIC DIPTERA IMMATURES



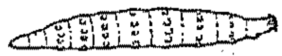
BODY WITH TAIL-LIKE PROCESSES, ELONGATE TERMINAL SEGMENT, TERMINAL PROLEGS, BLUNT OR BULBOUS ENDS, OR ANY COMBINATION OF THE ABOVE CHARACTERS

BODY NOT ENDING POSTERIORLY IN A SINGLE BREATHING TUBE, NEVER TAIL-LIKE AT END (a)

cont. p. 292

BODY ENDING POSTERIORLY IN A SINGLE BREATHING TUBE

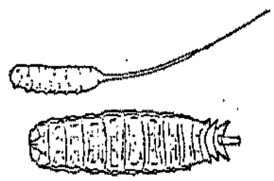
BREATHING TUBE SHORT, NOT MUCH NARROWER THAN PRECEDING SEGMENT, WITH MINUTE TERMINAL LOBES



Sciomyzidae
(p. 323)

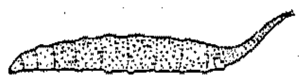
BREATHING TUBE TAIL-LIKE, ALTHOUGH SOMETIMES SHORT

BODY STRONGLY BLUNTED ANTERIORLY; TAIL NEVER DIVIDED



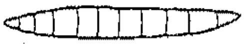
Syrphidae
(p. 322)

BODY NOT STRONGLY BLUNTED AT ANTERIOR END; TAIL SOMETIMES WITH 2 EXTENSIBLE BREATHING TUBES WITHIN IT

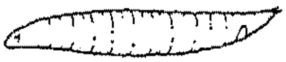


Ephydridae
(p. 324)

BODY SPINDLE-SHAPED, TAPERING AT BOTH ENDS; WITHOUT TAIL-LIKE PROCESSES OR TERMINAL PROLEGS



BODY WITH 2 MINUTE SPINES POSTERIORLY



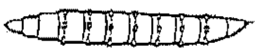
Ephydridae
(p. 324)

BODY WITHOUT 2 MINUTE SHARP SPINES POSTERIORLY

BODY HAIRY, WITH RINGS OF TUBERCLES; POSTERIOR END NARROW WITH SMALL TUBERCLES, BUT NOT POINTED

Sciomyzidae
(p. 323)

BODY WITH SERIES OF FLESHY RINGS ENCIRCLING BODY; POSTERIOR END POINTED



Tabanidae
(p. 317)

BASAL ABDOMINAL SEGMENTS WITHOUT PROLEGS

BODY SEGMENTS WITH 2 OR 3 SECONDARY DIVISIONS

Psychodidae
(p. 247)

BODY SEGMENTS NOT SUBDIVIDED

TERMINAL PROLEGS PRESENT

BODY TERMINATING IN SEVERAL LONG PROCESSES

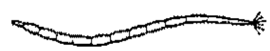
Tanyderidae
(p. 297)

TERMINAL PROCESSES SHORT OR ABSENT

Ceratopogonidae
(p. 307)

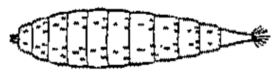
TERMINAL PROLEGS ABSENT

BODY VERY SLENDER



Ceratopogonidae
(p. 307)

BODY BROAD, BROADER THAN HEAD



Stratiomyidae
(p. 316)

AT LEAST ABDOMINAL SEGMENT 1 WITH PROLEGS (b)

cont. p. 292

(a)
cont. from p. 291

WITHOUT DISTINCTIVE TERMINAL PROLEGS (SOMETIMES WITH WELTLIKE PROLEGS)

ABDOMEN NOT PITLIKE POSTERIORLY a

ABDOMEN CONCAVE POSTERIORLY, AND THIS PIT IS SURROUNDED BY SHORT POSTERIORLY DIRECTED LOBES

Dolichopodidae
(p. 319)

WITH DISTINCTIVE TERMINAL PROLEGS

ABDOMEN ENDING IN LONG TUBE DIVIDED AT END OR WITH PAIR OF RETRACTILE TUBES AT END; TERMINAL PROLEGS USUALLY HOOK-SHAPED

Ephydridae
(p. 324)

ABDOMEN NOT ENDING IN ELONGATE SHEATH OR ELONGATE PAIR OF BREATHING TUBES

ABDOMEN ENDING IN PAIR OF CILIATED PROCESSES THAT ARE LONGER THAN TERMINAL PROLEGS

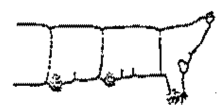
Athericidae
(p. 318)

PROCESSES OR BREATHING TUBES AT END OF ABDOMEN USUALLY NOT LONGER THAN TERMINAL PROLEGS

ABDOMEN ENDING IN VARIOUS PROCESSES OR LOBES; MINUTE HEAD DISCERNIBLE

Empididae
(p. 319)

ABDOMEN ENDING IN PAIR OF SHORT, SOMETIMES POINTED BREATHING TUBES; NO HEAD DISCERNIBLE

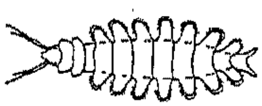


Muscidae–Anthomyiidae
(p. 327)

(b)
cont. from p. 291

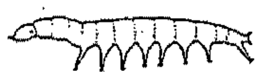
6 OR MORE PAIRS OF WELL-DEVELOPED PROLEGS PRESENT

ABDOMINAL PROLEGS BROAD AND LATERAL



Deuterophlebiidae
(p. 301)

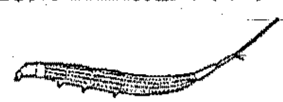
ABDOMINAL PROLEGS SLENDER AND VENTRAL



Nymphomyiidae
(p. 300)

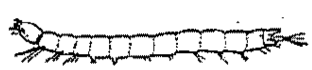
WEAK ABDOMINAL PROLEGS ON NO MORE THAN FIRST 3 ABDOMINAL SEGMENTS

ABDOMEN TERMINATING IN LONG BREATHING TUBE



Ptychopteridae
(p. 299)

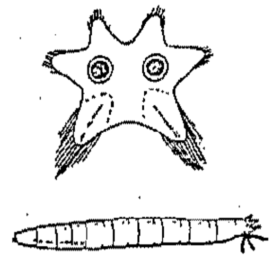
ABDOMEN NOT TERMINATING IN LONG BREATHING TUBE



Dixidae
(p. 302)

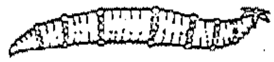
SMALL TO LARGE LOBES RIMMING AT LEAST PART OF END OF ABDOMEN

END OF ABDOMEN WITH CIRCLET OF 5–8 LOBES AND OFTEN SEVERAL ELONGATE FLESHY PROCESSES; PARTIALLY HARDENED HEAD RETRACTED



Tipulidae
(p. 294)

TERMINAL LOBES VERY SMALL; HEAD NOT DISCERNIBLE

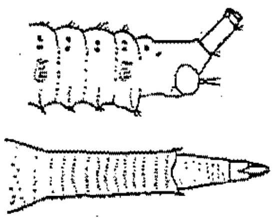


Sciomyzidae
(p. 323)

ABDOMEN NOT ENDING IN DISC OF LOBES

ABDOMEN ENDING IN PAIR OF BREATHING TUBES

BREATHING TUBES WELL DEVELOPED (SOMETIMES RETRACTED WITHIN ELONGATE SHEATH); PROLEGS ABSENT OR WELTLIKE



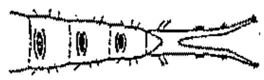
Ephydridae
(p. 324)

BREATHING TUBES SHORT TO MINUTE; TERMINAL PROLEGS SHORT, OFTEN WELTLIKE

Muscidae–Anthomyiidae
(p. 327)

ABDOMEN NOT ENDING IN PAIR OF BREATHING TUBES

ABDOMEN WITH VARIOUS TERMINAL PROCESSES AND/OR ELONGATED TERMINAL SEGMENT OFTEN SPLIT AT END



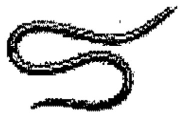
Tipulidae
(p. 294)

TERMINAL SEGMENT OF ABDOMEN SOMEWHAT BULBOUS WITHOUT WELL-DEVELOPED PROCESSES

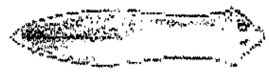
Empididae
(p. 319)

Stream Insects and Crustaceans ID Card

Lines under picture indicate the relative size of organisms

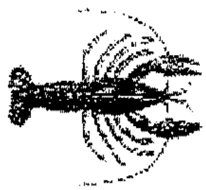


Aquatic Worm:
Class Oligocheata
¼" - 2", can be very tiny;
thin, wormlike body, tolerant of impairment

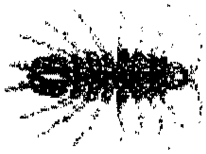


Flat Worm:
Family Planaridae
Up to ¼", soft body,
may have distinct head with eyespots, tolerant of impairment

Leech:
Order Hirudinea
¼" - 2", segmented body,
suction cups on both ends,
tolerant of impairment

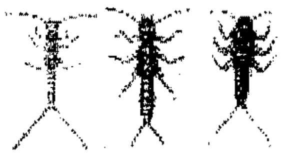


Crayfish: **Order Decapoda**
Up to 6", 2 large claws, 8 legs, resembles a small lobster, somewhat tolerant of impairment

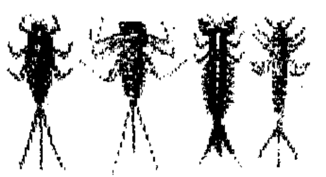


Sowbug: **Order Isopoda**
¼" - ¾", gray oblong body wider than it is high, more than 6 legs, long antennae, somewhat tolerant of impairment

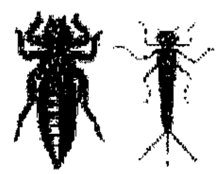
Scud: **Order Amphipoda**
¼", white to gray, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp, somewhat tolerant of impairment



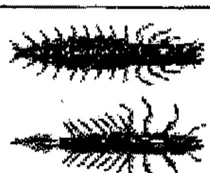
Stonefly: **Order Plecoptera**
½" - 1 ½", 6 legs with hooked tips, antennae, 2 hair-like tails, no gills on abdomen, very intolerant of impairment



Mayfly:
Order Emphemeroptera
¼" - 1", plate-like or feathery gills on abdomen, 6 hooked legs, 2 or 3 long hair-like tails, tails may be webbed together, very intolerant of impairment

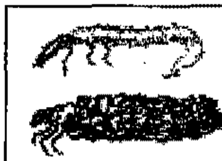


Dragonfly and Damselfly:
Order Odonata
½" - 2", large eyes, 6 hooked legs, large protracting lower jaw, 3 broad oar-shaped tails OR wide oval to round abdomen, somewhat tolerant of impairment



Hellgrammite, Fishfly, and Alderfly:
Order Megaloptera
¾" - 4", 6 legs, large pinching jaws, 8 pairs of feelers along abdomen, 2 hooks on tail end OR 1 single spiky tail, somewhat tolerant of impairment

Common Netspinners:
Family Hydropsychidae
Up to ¾", 6 hooked legs on upper 1/3 of body, 2 hooks at back end, underside of abdomen with white tufts of gills, somewhat tolerant of impairment



Most Caddisfly:
Order Trichoptera
Up to 1", 6 hooked legs on upper 1/3 of body, may be in stick, rock or leaf case, no gill tufts on abdomen, intolerant of impairment

Illustrations from: Voshell, J. R., Jr. 2001. Guide to the Common Freshwater Invertebrates of North America. MacDonald and Woodward Publishing Co. With permission of the author.

Stream Insects and Crustaceans ID Card

Lines under picture indicate the relative size of organisms

Beetles: ***Order Coleoptera***
¼" – 1", disk-like oval body with 6 small legs and gill tufts on underside OR small black beetle crawling on streambed OR comma-like brown "crunchy" body with 6 legs on upper 1/3 and possibly gill tuft on back end, OR (miscellaneous body form – rare), somewhat tolerant of impairment

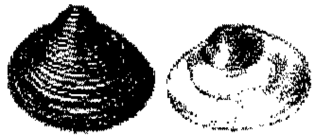
Midges:
Family *Chironomidae*
Up to ¼", distinct head, worm-like segmented body, 2 leg-like projections on each side, often whitish to clear, occasionally bright red, tolerant of impairment

Black Fly: Family *Simuliidae*
Up to ¼", end of body wider (like bowling pin), distinctive head, sucker on end, tolerant of impairment

Most True Flies:
Order Diptera
¼" – 2", bodies plump and maggot-like, may have caterpillar like "legs" along body, may have lobes or conical tails on end, tolerant of impairment

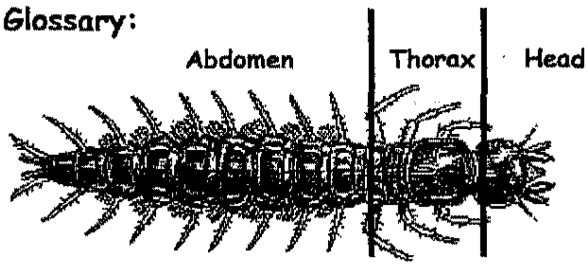
Gilled Snails:
Class Gastropoda
Up to ¾", shell opening covered by a thin plate called an operculum, with helix pointed up shell opens to the right, intolerant of impairment

Lunged Snails:
Class Gastropoda
Up to ¾", no operculum, with helix pointed up shell opens to the left, tolerant of impairment



Clams:
Class Bivalvia
Up to ¾", fleshy body enclosed between two clamped together shells (if clam is alive, shells cannot be pried apart without harming clam), somewhat tolerant of impairment

Glossary:



Tails: There are many different kinds of macroinvertebrate tails. The thin thread-like tails found on stoneflies and mayflies are called *cerci*. The oar-shaped tails found on a damselfly are not really tails – they are actually gills called caudal lamellae!

VA Save Our Streams Program
VA Division of the Izaak Walton League of America
7598 North Lee Highway
Raphine, VA 24472
(540) 377-6179 www.sosva.com

These sheets are modified from the National Izaak Walton League of America SOS Program Stream Insects & Crustaceans ID Card.
http://www.iwla.org/SOS/index.html

Illustrations from: Voshell, J. R., Jr. 2001. *Guide to the Common Freshwater Invertebrates of North America*. MacDonald and Woodward Publishing Co. With permission of the author.

Wonderful, Wacky,

Water Critters

WONDERFUL WACKY WATER CRITTERS

HOW TO USE THIS BOOK

1. The "KEY TO MACROINVERTEBRATE LIFE IN THE RIVER" or "KEY TO LIFE IN THE POND" identification sheets will help you 'unlock' the name of your animal.

2. Look up the animal's name in the index in the back of this book and turn to the appropriate page.

3. Try to find out:

   a. What your animal eats.

   b. What tools it has to get food.

   c. How it is adapted to the water current or how it gets oxygen.

   d. How it protects itself.

4. Draw your animal's adaptations in the circles on your adaptation worksheet on the following page.

GWQ023 Wonderful Wacky Water Critters DNR: WT-513-98

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Printed on Recycled Paper

Illustrations by Carolyn Pochert and Lynne Bergschultz

CRITTER ADAPTATION CHART

How does it get its food?
What is its food?

How does it get away
from enemies?

Draw your "critter" here

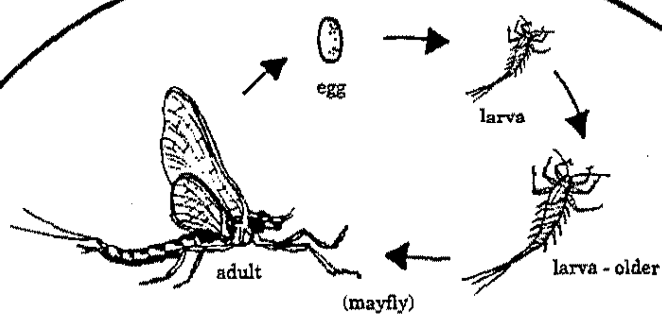
____
NAME OF "CRITTER"

How does it get oxygen?

Other unique adaptations.

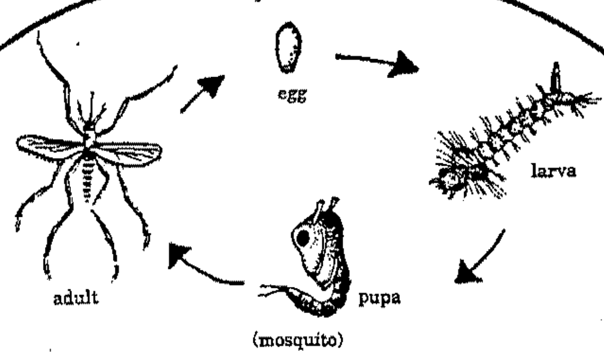
Two Common Life Cycles:

WHICH METHOD OF GROWING UP DOES
YOUR ANIMAL HAVE?



WITHOUT A PUPAL STAGE?

THESE ANIMALS GROW GRADUALLY, CHANGING ONLY SLIGHTLY AS THEY GROW UP. THE LARVA LIVE IN WATER, THEN EMERGE AS FLYING ADULTS.

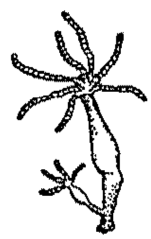


WITH A PUPAL STAGE?

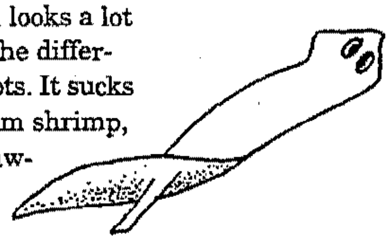
THESE ANIMALS GO THROUGH FOUR STAGES AND LOOK DIFFERENT IN EACH. BEETLES, FLIES, MOSQUITOES AND MOTHS GROW IN THIS WAY.

Wonderful Wacky Water Critters

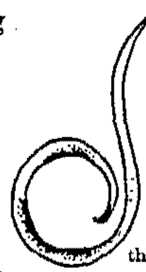
(Note: sizes of illustrations are not proportional.)



1. **HYDRA:** The amazing hydra is related to the jellyfish. Living only in clean, unpolluted waters, it likes to just "hang around," but can either move slowly on its "foot" or somersault end over end like a gymnast. Long tentacles surround an opening that is used for both eating and going to the bathroom! The hydra dines on meals of one-celled animals, water fleas, and seed or clam shrimp. It paralyzes its food by injecting poison into the prey before eating. It gets oxygen right through its skin. Its "ears" are used as both fingers to feel surroundings, and as a nose, to smell!



2. **PLANARIA:** The planaria or flatworm looks a lot like a small flattened slug. You can tell the difference by its triangular head and two eyespots. It sucks up its favorite meal of seed shrimp or clam shrimp, water fleas and dead animals with a straw-like mouth. Don't look for the mouth on its head – the mouth comes right out of the planaria's *belly*. A planaria finds dead decaying animals not only a tasty meal but also a good place to crawl into and hide. It doesn't need gills or lungs. It gets oxygen right through its skin! It is interesting that if you cut a planaria in two from head to tail, both halves will live and grow new, complete bodies.

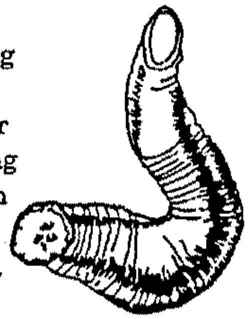


threadworm

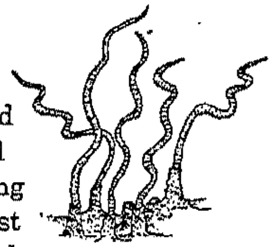
horsehair worm

3. **NEMATODE:** This tiny worm, also known as the threadworm or roundworm, is commonly found in bottom muck or on bottom plants throughout the world. You can tell it from other worms by its S-shaped swimming motion. Most roundworms prefer a quiet life eating tiny plants and animals, both dead and alive. Some nematodes live as parasites on clams, snails or fish. The threadworm gets oxygen right through its skin. This wiry hairlike animal finds quiet water a comforting home. Don't confuse it with the long, tan **horsehair worm**.

4. LEECH: Can you imagine one of your friends clinging onto you, sucking your blood and increasing in weight by five times? That's what some leeches do! A leech can cling onto sticks, stones, an animal or even you by means of a suction cup. After attaching to an animal, the leech scrapes open a little hole in the skin of its host and releases an anticoagulant, which is a chemical that keeps blood from clotting. This leech's strange feeding habit puts it into a special category called a parasite. Some leeches eat a more "civilized" diet of dead plants and animal matter. The presence of a lot of leeches is a sign of mucky bottoms. The leech does not have gills or lungs. It gets oxygen through its skin. Many fishes find leeches great food – they're an important part of a pond's food web.



5. TUBIFEX WORM: This aquatic angleworm is right at home in mucky water. Sometimes called a sludge worm, it will even live in grossly polluted waters. It buries its head in the bottom mud, eating away while letting its tail wave in the current. Just like a land worm, an aquatic worm eats mostly dead plants. If a particularly juicy dead animal is nearby it will munch on that too, just as long as it doesn't have to travel too far. Amazingly, this worm can live where there is hardly any oxygen. But it doesn't seem to like it. It thrashes its tail wildly when this happens. This worm breathes right through its skin. It is also both male and female at the same time. Thus, when two worms mate both worms are fertilized.



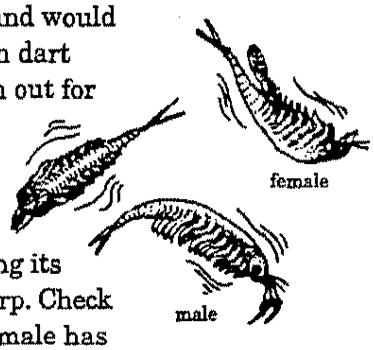
6. BRISTLE WORM: These tiny, uncommon animals can be told from midge larvae and other worms by the pairs of bristles on each segment. Like most worms the bristle worm breathes through its skin and eats dead plants. It lives quite comfortably in bottom debris and plants.

7. **CYCLOPS or COPEPOD:** The copepod is a small crustacean that looks like a swimming apostrophe mark ('). It is sometimes called a cyclops because its single eyespot reminds people of the one-eyed monster in Greek mythology. The quiet waters of ponds, lakes and rivers are its home, since faster waters would wash it away. A copepod clings onto plants and feeds on algae, bacteria and organic debris that pass its way. When a female has egg sacs on the sides of its "tail," it looks something like a teeny, tiny Mickey Mouse balloon. Copepods are part of the many microscopic plants and animals that all together are called *plankton*. Plankton are important links in the food chain. They eat algae and are food for insects and small fishes. Other common plankton include water fleas, seed shrimp and clam shrimp.

8. **SEED SHRIMP and CLAM SHRIMP:** These tiny, almost microscopic members of the freshwater plankton are scavengers, living on dead plants and animals. If you watch one carefully with a hand lens or microscope you can see its shell opening and closing. You might even see its legs bringing its favorite meal of dead, decaying matter into the shell. Since many insects and fish find these small animals a wonderful meal, it's a good thing there are so many of them. You might find hundreds in one teaspoon of water.

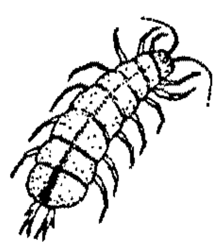
9. **WATER FLEA or DAPHNIA:** Did you ever itch to catch a water flea? The name water flea is a nickname; it is also called cladocera or daphnia. These tiny critters are part of the freshwater plankton. A daphnia swims jerkily, using branched antennae, while eating algae, microscopic animals and organic debris. Watch its legs swirl food to its mouth. Its tiny size and transparent body help it hide from hungry insects and fish.

10. **FAIRY SHRIMP:** This graceful animal lives only in *temporary* ponds, never in ponds with fish. That's because it generally swims slowly and would make easy fish food. When disturbed it can dart quickly out of the way. It still has to watch out for hungry predaceous diving beetles, young salamanders and ducks. The fairy shrimp gets its dinner of microscopic animals and bits of organic debris to its mouth by waving its gill-legs. It also swims by moving its gills in waves – looking like it's playing a harp. Check to see if you have a male or a female. The male has large mouth claspers to hold the female. Sometimes the female will have two egg sacs attached behind her gills. The eggs have to go through both drying and freezing before they can hatch!

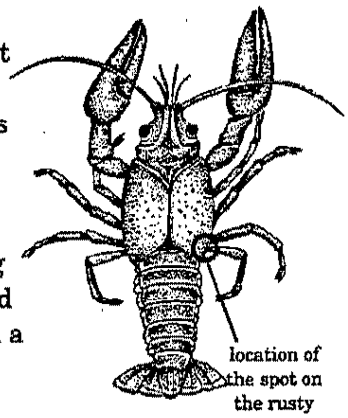


11. **SCUD or AMPHIPOD:** Can you tell why the scud is often called the sideswimmer? Its shape helps it cut through the river current without being washed downstream. Its shape also allows it to swim fast to get away from predators. Scuds are active mostly at night as they look for a tasty dinner of decaying plants and animals. The scud has an excellent sense of touch which helps it find food in the dark. This sideswimmer has gills for breathing. Can you find them? (Hint, look on its legs.) A young scud looks just like an adult, only smaller.

12. **AQUATIC SOWBUG or ISOPOD:** The isopod is a scavenger that uses its seven pairs of legs to scamper around the bottom of streams and ponds while feeding on dead plants. It breathes through gills located on its belly. The isopod's eyes are very sensitive to light; therefore, it is usually active only at night. The darkness also helps it hide from the watchful eyes of its enemies. An isopod can live in water with low oxygen, typical of water polluted with sewage or farm runoff. If you find many of these animals, what does that tell you about the quality of the water?

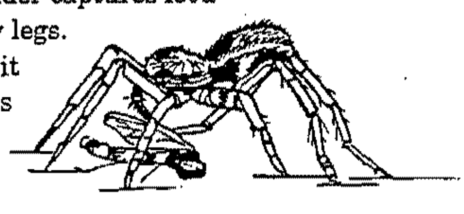


13. **CRAYFISH:** The crayfish (also known as crawfish) is one of the most interesting of the aquatic animals because of its large size and impressive pincers. These claws are important tools for catching food and for defense. Watch how it moves sideways or shoots backwards as if jet propelled. Its periscope eyes help it hunt for food and see danger in all directions. Its gills can't be seen – they are under the hard body shell. The crayfish is an omnivore, hunting mostly at night. It prefers a meal of plants and dead animals but will catch its dinner if given a chance. In the spring look for eggs or young attached under the female's tail.



If your crayfish has a rusty spot on its shell, it is an exotic. This rusty crayfish was accidentally introduced into Wisconsin. Wherever it is introduced, it causes problems. In some northern Wisconsin lakes it has eaten most of the aquatic plants, hurting the quality of the lakes. Fish that normally eat crayfish don't like the feisty, aggressive "Rusty." It takes over the homes of native crayfish and has been known to eat fish eggs. It is illegal to transport live crayfish from one place to another or to use live crayfish for fishing bait.

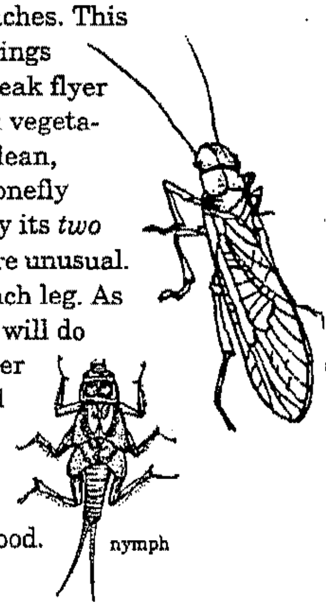
14. **FISHING SPIDER:** This water spider has eight legs, no wings and a body which is divided into two sections. The similar water strider (see #22) has wings and six legs. The water spider captures food by running it down with its hairy legs. After catching it the spider bites it and injects a poison that dissolves the body. The spider then sucks out its body juices – a type of "animal slurpy." When it takes a rare trip below water, it carries a bubble of air along like a scuba diver does. The spider's favorite foods are insects, small fish and tadpoles. Don't worry, they are too small to hurt you.



15. **WATER MITE:** The water mite is a round critter with eight legs and one eye. It is usually red in color, but it can be blue, green or spotted. Its small legs make it hard for it to swim. It does just fine in quiet water, but in fast water its round body makes it tumble through the current. The mite's favorite pastime is to crawl into a juicy dead animal and eat away. It also likes a dinner of tiny microscopic animals. Because it is so small it can get all the oxygen it needs right through its skin.

16. **SPRINGTAIL:** Just like people at a mall, these tiny wingless insects mill around in huge numbers right on the water's surface. When disturbed, the springtail will jump away quicker than your eye can follow. Under its back end it has a special trigger or spring that snaps with great force when it needs to escape an enemy. The springtail never goes into the water, preferring to live on the surface eating dead, decaying plant matter. Young springtails look just like adult springtails, only smaller.

17. **STONEFLY:** Stoneflies are one of the oldest insects and are a close relative to cockroaches. This large insect has transparent, brownish wings which fold over its back. The adult is a weak flyer and is often found hiding on stream bank vegetation. The young or larva lives mostly in clean, flowing water with lots of oxygen. The stonefly larva can be told from the mayfly larva by its *two* "tail" filaments. The stonefly larva's gills are unusual. You will find them as tufts attached to each leg. As oxygen decreases in the water, stoneflies will do "push-ups" to increase the amount of water going over their gills. A meal of algae and dead plants is relished by some stonefly larva while others feed on animals, especially on mayfly and blackfly larva. Stoneflies are one of the trout's favorite food.



adult

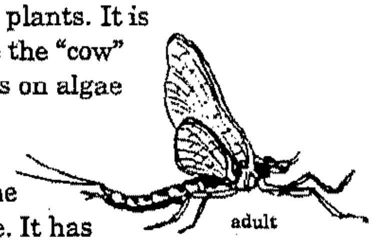
nymph

18. **FISHFLY, DOBSONFLY and ALDERFLY:** The young of these insects are commonly called hellgrammites (hellgrammites sold as bait are usually dragonfly nymphs). Trout and other fish find them a delicacy. To avoid becoming trout food, the larvae hide under rocks and come out mostly at night. Fishflies and dobsonflies have little hooks at the end of their "tails" that help them hang onto rocks and sticks in fast-moving water. Fishfly and alderfly larvae are carnivores and sometimes cannibals, feeding on other smaller insects and each other! Don't worry about those strange spines on their side; those are gills. But do watch out for their strong jaws. Large alderflies and dobsonflies can give a painful bite.

alderfly larva

dobsonfly larva

19. **MAYFLY**: The mayfly and damselfly larvae look almost like twins, but the damselfly is much larger! Damselflies swim by moving back and forth; mayflies move up and down. The mayfly has rows of feathery gills along its side between the legs and its three "tails." The mayfly is one of the most common insects found in coldwater streams. Its young feed mostly on small plants. It is sometimes considered to be the "cow" of the stream since it grazes on algae on rocks. There are many different kinds of mayflies. How many did you find? The burrowing mayfly is unique. It has a large humped back, digging front legs and beautiful feathery gills. It gets its name from its habit of digging into the soft mud and silt at the edges of streams. The adult mayfly doesn't eat anything during its short life of a few hours to a few days. As an adult, it mates, lays eggs and dies. Mayflies often swarm in huge numbers near water.



adult

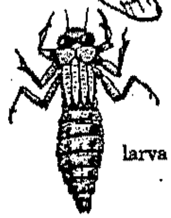
flathead mayfly larva

burrowing mayfly larva

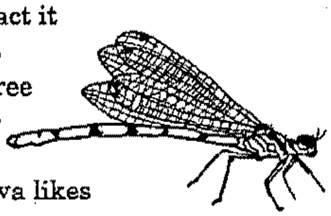
minnow mayfly larva

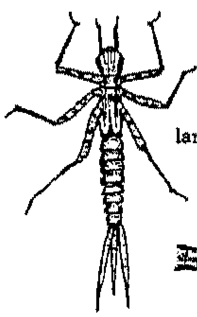
20. **DRAGONFLY**: It is interesting to watch a dragonfly larva catch its dinner of small insects and tadpoles. It uses a scoop-like lower lip called a labium (lay bee um) to reach out and grab its food. The larva breathes through gills located inside the tip of its abdomen. It can move as if jet-propelled with these gills. The adult is a swift, graceful insect that resembles a helicopter as it hunts for mosquitoes and other tasty, flying insects. Some adult dragonflies can eat over 100 mosquitoes a day. When it lands, it holds its wings out like an airplane. Old folk tales call them "Darning Needles," but they can't sew your mouth shut!


adult


larva

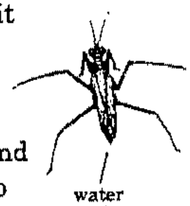
21. **DAMSELFLY:** The damselfly is closely related to the dragonfly. The damselfly larva is much slimmer than the dragonfly larva; in fact it looks a lot like a mayfly larva, but it is usually much larger. The larva has three platelike "tails" (which are really gills) at the tip of its abdomen. Be careful because these break off easily. The larva likes to feed on any aquatic animal it can overcome. It can be found in ponds, streams and rivers. The adult damselfly cannot fly as fast as the dragonfly, but it is more graceful. When it rests on a handy leaf, stick or rock, it folds its wings over its back. The adult feeds on flying insects and loves to be out on sunny days.


adult

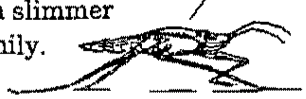

larva


side view of "tail"

22. **WATER STRIDER:** The water strider is sometimes called the "Jesus Bug" because it can walk on water. Hair on the tips of its legs keeps it from breaking through the water's surface. This nervous critter escapes its enemies by scurrying across the surface. The water strider's front legs are used for grasping its food. It is a scavenger and hunter, eating plants and insects that come up to get air. Most water striders will drown if caught under water. The **marsh treader** is a slimmer light brown member of the strider family.

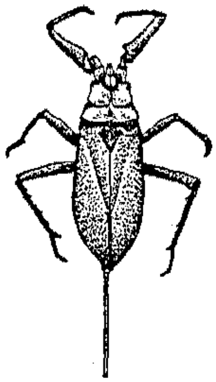

water strider


marsh treader

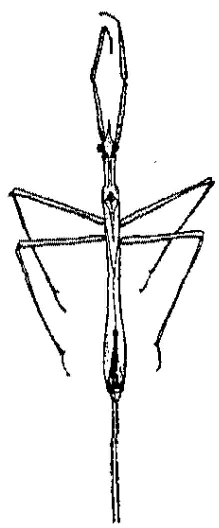


23. **WATER BOATMAN:** This insect's body is shaped like a boat, perfect for swimming. Its long, flattened hind legs make excellent paddles. The bug is actually dark colored, but an envelope of air used as its oxygen supply sometimes makes it appear silvery. This air also makes it hard for the insect to stay submerged. It has to grab onto plants or other objects to stay underwater. The water boatman feeds on oozy algae or dead plants and animals, which it scrapes toward its sucking beak with its front feet. The male attracts a female with a chirping sound made by rubbing his front feet against his beak and opposite leg. Aren't you glad we don't do that?

24. **WATER SCORPIONS:** How long can you stand without moving? A water scorpion can hang upside down perfectly still for hours. When an unsuspecting tadpole, fairy shrimp, or insect comes along, the water scorpion lunges forward and grabs it with razor-sharp front legs. Its long, thin mouth is inserted into the prey, and it gradually sucks out the insides and leaves an empty shell behind. The long "tail" isn't a stinger. It is a snorkel used for breathing. Watch how the tip is held right at the water surface, allowing the water scorpion to breathe and hunt at the same time.



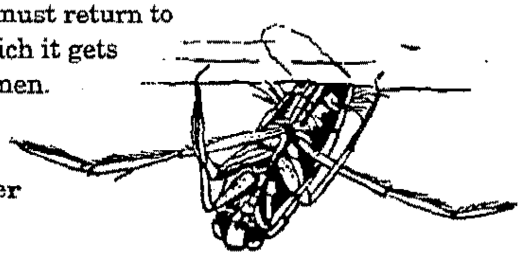
'Nepa'



'Ranatra'

25. **GIANT WATER BUG:** This huge insect sometimes grows to be two or more inches in length. The giant water bug is a superb predator, attacking and eating animals three times larger than itself, including tadpoles, fishes, frogs, very young ducks and other insects. It uses its strong front legs to grasp its prey while its beak is used to pierce, inject a poison and suck the victim's body juices. This true bug lives among plants at the bottom of the pond. It is a strong flyer and can often be found around lights at night. It does not have gills so it must make trips to the surface to get air. It breathes through the tip of its abdomen. The giant water bug is cooked in China and is considered to be a delicacy. Hold it from behind or the giant water bug might find you a delicacy too.

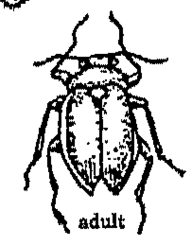
26. **BACKSWIMMER:** The name of this critter describes it perfectly. The backswimmer's keel-shaped back and powerful legs help it swim after its prey of small aquatic animals and escape its enemies. Its colorful body would help it play "hide and go seek," because it is camouflaged from both directions. The white back, when seen from underneath blends into the sky; the dark bottom, when seen from the air, blends in with the color of the water. The backswimmer must return to the surface for oxygen, which it gets through the tip if its abdomen. The backswimmer's bite can hurt, so be careful. The **pygmy backswimmer** is a smaller relative.



27. **WATER PENNY**: The water penny adult is a land-loving beetle. The young or larva stage has a streamlined body that allows it to live on rocks in very fast water, where it is protected from predators by the swift current. It looks like a suction cup, but it's alive! The slow-moving larva munches on algae that grow on the rocks. A silvery sheen on its belly is caused by air trapped in a coat of fine hairs. This is where its gills are too. The water penny can only live in streams or rivers that are clean and have lots of oxygen. The presence of water pennies indicates that the stream or river has year-round, pollution-free water.


larva (bottom)


larva (top)


adult

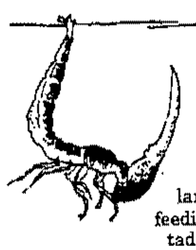
28. **RIFFLE BEETLE:** Guess where this small black beetle likes to live? That's right, in riffles, the part of a stream where the water flows quickly over a rocky bottom. You'll never find the riffle beetle in calm lakes or dirty rivers. It's part of the clean stream team. Amazingly, it cannot swim. Instead, it crawls through the rocks eating algae. A riffle beetle larva is small, brown, and hard. The riffle beetle exchanges oxygen with the water across a thin layer of air attached to its hairy underside. What could you do to improve rivers for riffle beetles?


adult


larva

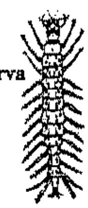
29. **PREDACEOUS DIVING BEETLE:** This beetle is one of the most common of all aquatic beetles. The diving beetle larva is sometimes called the "water tiger" or "dragon of the pond" because of its immense appetite. It will even eat its own kind. Both the adult and the larva wait in ambush for their favorite meal of insects, leeches, snails, tadpoles and fishes. (They're not very picky!) The diving beetle has strong, sharp jaws that are used for defense and to catch prey. Its hollow jaws are like hypodermic needles. The beetle can shoot digestive enzymes into its victim, predigesting the food before sucking it up. Since the beetle does not have gills, it has to come to the surface for air.


adult


larva feeding on tadpole

30. **CRAWLING WATER BEETLE:** This beetle lives among plants in shallow water. It especially likes a home made of algae, which is also its dinner. The round shape of the crawling water beetle makes it difficult for it to swim in swift water. It would be like trying to row a barrel; you would be sent spinning and bobbing downstream. (Keeping this in mind, where in the river would you look for this critter?) Can you see how it breathes? Look carefully at the tip of its abdomen and you will find a bubble of air. It carries its oxygen like a scuba diver. This animal is easily studied in an aquarium; just give it some algae to eat.

31. **WHIRLIGIG BEETLE:** This beetle zips in wild patterns all around the surface of quiet water. When disturbed it dives to the bottom. It also protects itself by giving off a strong smell like apple seeds. Look at its unusual eyes. It seems to have four eyes, two above the water and two below the water. It really has two eyes that are split in half. Why do you think this would be a good adaptation? This beetle is a scavenger, which means it eats dead plants and animals. Though it prefers swimming, it can fly to a new home if the old one dries up. This beetle is harmless, so don't be afraid the next time you are around it.



larva

adult

view of "four eyes" at water's surface

32. **WATER SCAVENGER BEETLE:** Unlike its "scavenger" name suggests, this beetle's larva is a predator which searches for and eats live food. The adult is an *omnivore,* eating both living and dead plant and animal matter. It has a special love for algae. The larva is a slow, clumsy swimmer, so it likes to lie still and wait for its prey to go by. The adult is a good swimmer. It is sometimes called the silver beetle. Hair on its body traps air, which shines silvery in the sun. It uses this layer of trapped air for breathing.

larva

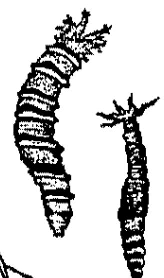
adult

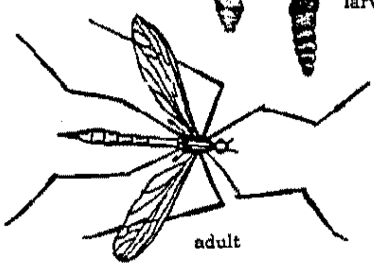
33. **BLACKFLY:** The blackfly larva moves like an inchworm, first spinning small loops of silk with its mouth, then attaching itself to the loops with tiny hooks on its back end. It is the original Velcro®! It also uses the silk as a safety line to reel itself back if knocked off its rock. It eats whatever the river brings to it, mostly bits of dead plants. (Talk about a life of ease!) It gets its oxygen through gills located on its back end. The adult blackfly has a short body with a humped back. This critter can be a real pest in the summer. Its bite is not very painful ... until later. Some blackflies can only live in clean streams; other kinds are very tolerant of pollution. The female lays eggs on rocks in streams and rivers. The blackfly is food for many other animals.


adult

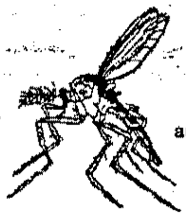

larva

34. **CRANEFLY:** The big, wormlike, cranefly larva has tentacles around its back end. It shoves the tentacles through the surface of the water for breathing. The cranefly larva is very important to life in the river. It chews on large leaves that fall from trees. Since it's a sloppy eater, tiny bits of leaves float away and become dinner for many other insects. Each type of cranefly is very specific about where it lives. Some species will only live in clean, flowing waters, others in wet meadows, and others in mud flats. The adult looks like a gigantic, long-legged mosquito. But it doesn't bite – it doesn't even have a mouth. It flies slowly and awkwardly. Keep an eye out for the delicate adults the next time you're around a light at night.


larva


adult

35. MIDGE or BLOODWORM: Young midges can be found in all sorts of water; some live in hot springs at temperatures of 124°F! The larva likes to snack on tiny bits of dead plants floating in the water and tiny microscopic animals. It eats by straining its food through brushes surrounding its mouth. Some midge larvae are bright red and are called bloodworms. The chemical that makes them red helps them get oxygen when levels are low. The chemical is hemoglobin, just like in our blood. The midge larva may seem pretty tiny to us but it is an important food source for fish, even the largest fish in Wisconsin – the sturgeon. So, indirectly, that little larva may be part of your dinner some day.

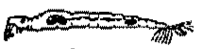


adult

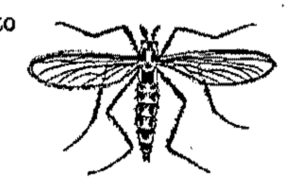
larva

Most adult midges are harmless even though they look like a miniature mosquito. Some, the "no-see-ums," are nasty biters. They dance over the water in great flocks or swarm around making a humming sound. Even the non-biting midges can be annoying at certain times of the year because of their huge numbers. Swarms of midges and mayflies near Lake Winnebago and the Mississippi River can completely cover houses, bridges and roads. They can create traffic problems by making roads slippery.

36. PHANTOM MIDGE: The phantom midge larva is so clear it's nearly invisible. What a great disguise for playing "hide and go seek!" It hunts tiny crustaceans by grabbing them with its antennae. The phantom midge breathes right through its body. The pupa of a phantom midge can swim with jerky movements. The adult looks similar to a mosquito but does not bite; it probably doesn't eat anything in its short adult life.

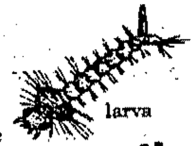


larva

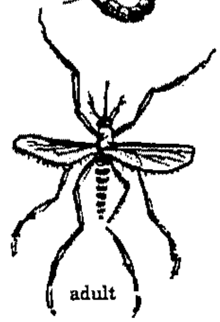


phantom midge adult

37. **MOSQUITO:** This interesting insect goes through four distinct stages: an egg stage which can spend the winter in dry soil and hatch when spring rains fill the puddles and small ponds; a larva stage which spends its life upside down breathing through a tube on its rear end; a pupa stage which swims but does not eat; and an adult stage that we are all too familiar with. Watch the larva move; when it is disturbed it races to the bottom of the pond. The mosquito larva eats microscopic plants, animals or organic debris with brushes surrounding its mouth. The pupal stage is called a "tumbler" and is almost all head. The adult female requires a blood meal to develop her eggs. No large animal is free from these pests. Some females make life miserable for animals such as deer, people or squirrels, while others torment frogs and turtles. The adult male lives on plant juices and flower nectar. Next time you swat at them remember, these critters are important food for fishes, frogs and birds.


larva


pupa

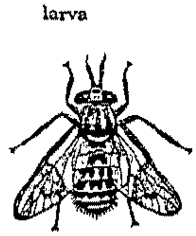

adult

38. **SOLDIER FLY:** It is ALIVE! The soldier fly larva may look dead but it eats, breathes, grows and moves (although rarely). Talk about the ultimate couch potato. You don't have to move much when you eat tiny plants floating right past your mouth. The tuft of bristles on its back end is where it breathes. What do you think would happen if oil was spilled on the pond? Would it cover the soldier fly's breathing disc?


larva

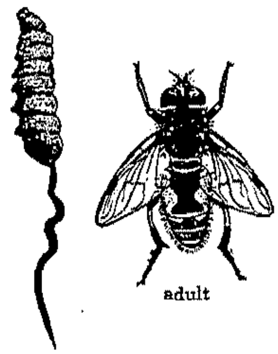
39. **HORSEFLY and DEERFLY:** The seldom found larvae of these flies hunt for worms and snails to eat. They don't look like ferocious predators, being almost headless, legless, wormlike animals, but that doesn't seem to stop them. They're usually found in swamps, small ponds and weedy places away from big carnivores like fish. These flies breathe through a small disc on their "tails" which they push up through the water's surface into the air.


larva

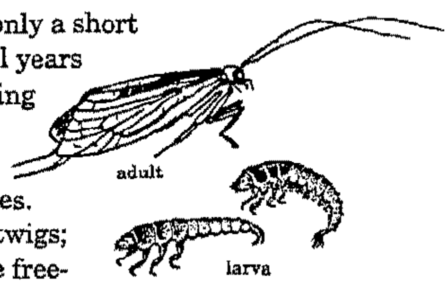

adult

40. WATER SNIPEFLY OR ATHERIX: This small fly larva looks like a cross between a maggot and a caterpillar. It doesn't look like it could hunt down and eat other small critters, but it does. It breathes through a small opening near its two "tails" called a spiracle. The adult snipefly feeds mostly on blood – maybe yours, but usually other animals! The prescence of water snipefly larva is a sign of clean, fast water.

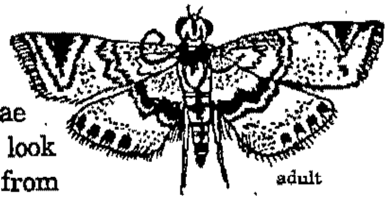
41. RAT-TAILED MAGGOT or "MOUSIE": You might find the type of home that this larva likes very yucky. It prefers very mucky, smelly, highly polluted waterways where it munches away at the organic matter in the sediment. In fact, it can even live in manure storage pits! The larva breathes through the end of its long breathing tube. It can extend this several inches through the sediment right up to the surface of the water. The adult is one of the common 'flower flies' that mimic bees and feed on nectar and pollen.



42. CADDISFLY: The caddisfly lives only a short time as an adult but may spend several years as a larva. Many larvae can do something few aquatic insects can – they build their own shelter. Different kinds of caddisflies build different types of homes. Some species build homes of leaves or twigs; others use tiny stones, while others are free-living. A few types of caddisfies build a pebble house attached to a larger rock. Some caddisflies like to live in temporary stagnant ponds while other types will only live in swift streams. All caddisflies eat plants but some catch tiny bits of plants by building a net to trap food as it drifts past. The caddisflies are very important food for fish, especially trout.



43. CATERPILLAR or PYRALID MOTH: A few species of moths have caterpillars or larvae that live in the water. These aquatic caterpillars look similar to land-loving caterpillars. They hide from enemies by either building a silk-lined case sandwiched between two pieces of leaves, or by weaving a thick web of silk over small pits in rocks. Aquatic caterpillars feed on a variety of plants and breathe through their skin and with gills. A young caterpillar changes into a pupa and then into a small, brownish gray moth.



adult

caterpillar

44. SNAIL: Think how hard it would be to carry your house on your back! That's what a snail does. Each kind of snail has a unique shape or color to its shell. How many kinds did you find? There are two major types of snails. The *lunged* and the *gilled* snails. The pouch snail, one of the lunged snails, lives in ponds and pools where oxygen is low. It can be found in slow, polluted rivers too. The orb snail, also one of the lunged snails, lives in clean, quiet waters. Gilled snails have a shell "door" (operculum) which they can close. This type of snail is typically found in clean rivers. They need more oxygen than the pouch snails. The snail's shell provides protection from enemies. It also is a handy oxygen container. When a snail is seen crawling upside down on the surface of the pond it is gathering fresh air into its shell. When a snail is threatened it pulls its "foot" into its shell and is safe from most predators. A snail has both its eyes and mouth on its "foot!" Watch how it uses its eyes like periscopes as it moves along, scraping and feeding on algae. The snail is very sensitive to acid in the water which can dissolve its limey shell. Where do you think the acid might come from?

orb snail

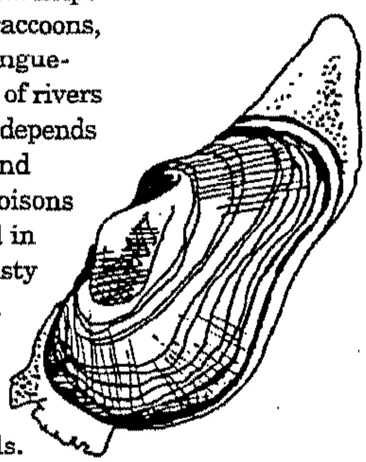
snail upside-down underwater on the pond surface

right opening gilled snail

left opening pouch snail

45. LIMPET: The limpet is a special type of snail. Its tiny shell is shaped like a flattened cone or tent. When a limpet is disturbed it clamps firmly to an object. It is almost impossible to remove without damage. It breathes with gills. The limpet is a harmless plant eater, so be kind the next time you see one.

46. **FRESHWATER MUSSEL:** How would you like to have a shell, no eyes and catch your food with your nose? No? Well, that's what a mussel does. Freshwater mussels have a hard and strong shell that helps protect them from predators such as birds, raccoons, and turtles. Between its shell halves is a tongue-shaped "foot" used to pull it along the bottom of rivers and lakes. It breathes through gills. A mussel depends on the river to bring it microscopic plants and animals, which it filters out of the water. Poisons in the water are also filtered out and stored in the mussel's body. Some mussels can be a tasty treat for people, although tough and chewy. Would you eat any mussels from areas where waste and chemicals from farms or towns wash into the water? Interestingly, the first buttons were cut from mussel shells. One of the first important fishing industries in Wisconsin was mussel fishing to make mother-of-pearl buttons. The mussel trade is still important in Wisconsin. Small pieces of freshwater mussel shells are sent overseas where they are inserted into oysters as the 'seeds' that will become cultured pearls.

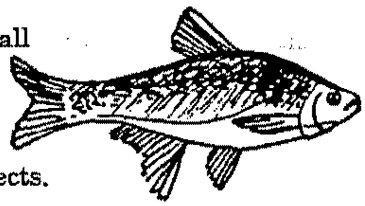


In the Mississippi River, native mussel populations have declined greatly due to harvesting, loss of habitat, and the introduction of exotic zebra mussels. The zebra mussel is fingernail-size, and is black, white and tan striped. They usually live in clusters called "colonies." If you think you have found a zebra mussel in inland waters other than the Mississippi River, contact your local Department of Natural Resources office.

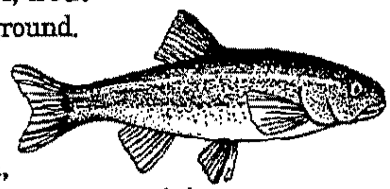
zebra mussel

47. **PILL CLAM:** This pale tiny clam never gets bigger than a fingernail. It's even commonly called a fingernail clam. It likes to live on the bottom of many watery homes: ponds, brooks, rivers or lakes. Just like its bigger cousin, the pill clam filters bits of plants and organic debris out of water. All clams have two tubes on the top of the "foot." One sucks in water containing food and oxygen. The other shoots out the clam's waste.

48. **SHINERS AND CHUBS:** These small fish are common in streams and rivers. They are an important link in the food chain. A tasty meal for a shiner would consist of plankton, crustaceans and insects. It could become dinner for a giant water bug or a bass. All bodies of water – from swift, cool, trout streams, to warm, quiet lakes – are its playground. When it's time to mate, the male shiner builds a nest out of gravel. Many females will lay eggs in a single nest. The eggs are protected by the male but when they hatch, the young have to flee or the male will eat them. I'm glad he's not *my* father!

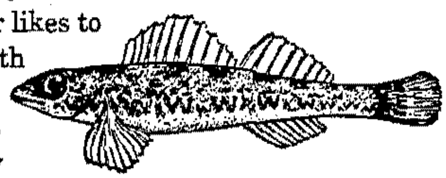


shiner

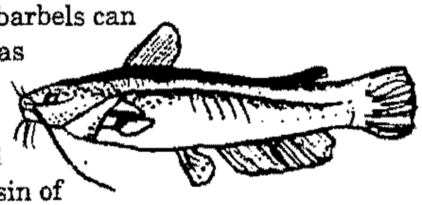


chub

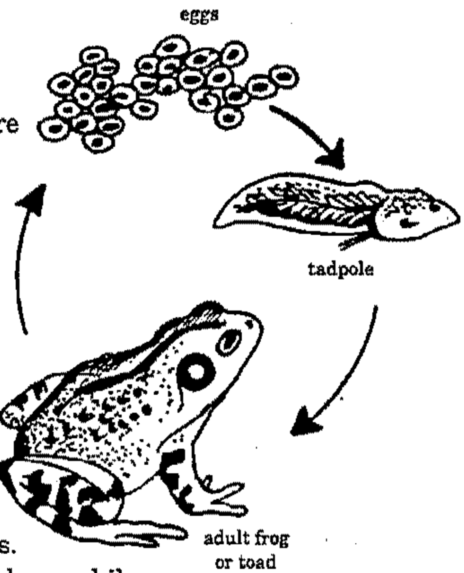
49. **JOHNNY DARTER:** Watch how this tiny member of the perch family moves and you can see how it got its name. The Johnny darter likes to sit quietly in one place and then zip with great speed after a dinner of small insects. Small black "W"-like markings on their sides make identifying Johnny darters easy. A male that is ready to mate will only build his nest under rocks in clear, unpolluted streams, so we must be careful to keep his home clean.



50. **BULLHEAD:** The bullhead is an interesting, smooth-skinned fish. It has a large mouth, and whiskers known as barbels. Watch how the barbels let the fish know what is nearby. The barbels, along with thousands of taste buds covering the entire body, help the fish locate food in muddy water and at night. Many people think that the barbels can sting, but that's false! The bullhead has another defense; a spine concealed in its top and side fins. The stinging sensation sometimes felt when jabbed by the spine of the "Mad Tom," (a cousin of the bullhead) is caused by an irritating chemical produced in glands at the base of the spine. The bullhead can be found scavenging the bottom of quiet, warm

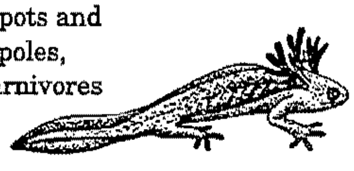


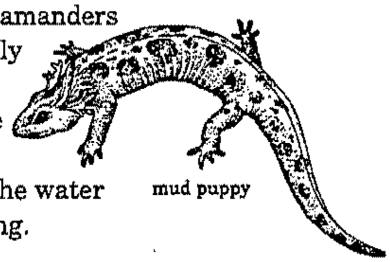
waters throughout North America looking for yummy dead stuff as well as insects, fish eggs and even young fish. Being a hardy animal, it can withstand polluted waters and very low oxygen levels. It gulps air at the surface if there's no oxygen in the water. A bullhead without the head and spines makes a fine dinner if you remove the skin before cooking.



51. **TADPOLE:** Baby frogs or toads are called tadpoles. Many different kinds are found in Wisconsin. Some kinds turn into adults in two weeks, while others take two to three years. If you find a large tadpole in the pond it is probably a young green frog. Small black tadpoles found swimming in large groups could be called "toadpoles," as they'll turn into toads. Only the bullfrog tadpole is found in rivers; other tadpoles are not strong enough swimmers to survive the river currents. A tadpole eats only plants, especially algae, while a frog eats insects and small animals, even tadpoles.

52. **SALAMANDER:** A tadpole with gills? No, its not a mutant; it's a salamander larva. In a few weeks, it will lose the gills, get flecks and spots and crawl out of the pond. Unlike frogs and tadpoles, salamanders have teeth. They're hungry carnivores so teeth help them catch their prey of fairy shrimp, mosquitoes and other insects. The adult salamander can be found under damp logs, in leaves and even deep underground where it feeds on worms and other soil invertebrates. Salamanders are active at night. Watch for them in early spring when they mate with much tail thrashing and rolling in the water. A type of salamander called the "mud puppy" is fully aquatic – it spends its entire life in the water and is occasionally caught by people fishing.





GLOSSARY

ABDOMEN – The third or rear section of an insect where digestion, reproduction and air exchange occur.

CAMOUFLAGE – A plant or animal's ability to hide itself by appearing similar to its surrounding.

CARNIVORE – An animal that gets its energy by eating other animals.

CRUSTACEAN – Segmented animals having an exoskeleton (or shell-like covering), two pairs of antennae and breathe by means of gills. Most are microscopic, occurring in huge numbers in lakes, streams and especially the ocean. Others are large, such as lobsters, shrimp or crayfish.

EXOTIC – A plant or animal that is not native. Many exotics have been introduced by people into places where they are causing problems.

FOOD WEB – The overall sharing of energy between plants and animals that produce food, are eaten by others, or receive food by eating others.

HERBIVORE – An animal that gets its energy by eating plants.

LARVA – The immature form of an insect.

INVERTEBRATE – An animal that does not have a backbone.

MICROSCOPIC – Something very small in size – so small that people need tools, such as a microscope, to make it appear larger to see it.

OMNIVORE – An animal that gets its energy by eating both plant and animal matter.

ORGANIC DEBRIS – Dead plants and animal matter usually already partially broken up.

PARASITE – An animal that lives on or in other living organisms (plants or animals) and obtains its food from them.

PLANKTON – Microscopic, or nearly so, plants and animals that float or swim in water in vast numbers.

PREY – Animals that are eaten by other animals.

VERTEBRATE – An animal with a backbone.

INDEX

to critters and the pages they are on.

Wonderful, Wacky, Water Critters

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Protocols for Sampling Aquatic Macroinvertebrates in Freshwater Wetlands

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Bureau of Land and Water Quality
Division of Environmental Assessment
Biomonitoring Program

Standard Operating Procedures
Protocols for Sampling Aquatic Macroinvertebrates in Freshwater Wetlands

1. **Applicability.** This standard operating procedure (SOP) applies to the collection of aquatic macroinvertebrate samples from inundated freshwater wetland habitats, including marshes, pools and other depressional wetlands, lacustrine and riverine fringe wetlands, low-gradient river and stream reaches, lakes and ponds. It describes the primary method to collect aquatic macroinvertebrate community composition data using a D-frame net. This method is required if data collected are to be used in the DEP wetland macroinvertebrate linear discriminant model to predict aquatic life use attainment. The use of a stovepipe sampler is also described as an alternative method to collect macroinvertebrate samples in areas where it may be difficult to use a D-frame net. In addition, this SOP describes how to collect qualitative macroinvertebrate data using a screening level multi-habitat method. This SOP also applies to the collection of related habitat and land use data. Protocols for completing the Wetland Human Disturbance Assessment are described in a separate Maine DEP SOP. Methods for collecting associated water samples, physical/chemical field measurements, and use of temperature logging devices are detailed in separate Maine DEP SOPs.

2. **Purpose.** The purpose of this SOP is to provide standardized methods for collecting aquatic macroinvertebrate samples and related data from wetlands in Maine.

3. **Definitions.**

   A. Aquatic Macroinvertebrates – aquatic animals without backbones that can be seen with the naked eye. Generally, this includes animals that are retained by a 500 - 600 micron mesh screen. Examples of aquatic macroinvertebrates include aquatic insects (such as mayfly, dragonfly and caddis fly larvae), aquatic worms, amphipods (scuds), leeches, clams and snails.

   B. Aquatic Macrophytes – aquatic plants that can be seen with the naked eye. Examples include water lilies, pond weeds, and bladderwort.

   C. Emergent Vegetation – rooted plants with lower portions typically growing beneath the surface of the water, but having aerial leaves, stems and reproductive structures. Emergent plants often grow in shallow waters including marshes, lake shores, and river and stream margins. Examples include cattails, sedges, rushes and pickerel weed.

4. Responsibilities.

A. The section leader of the Maine DEP Biomonitoring Program in the Division of Environmental Assessment has the following responsibilities:
   (1) Assist in procurement of programmatic funds.
   (2) Provide technical support related to biological assessment.
   (3) Participate as a member of a field team as time allows.

B. The Wetlands Subsection Leader has the following responsibilities:
   (1) Write proposals and manage grant funds.
   (2) Manage contracts for seasonal staff and assist with contracts for macroinvertebrate sample sorting and taxonomic identification.
   (3) Purchase and maintain supplies and equipment.
   (4) Update wetland SOPs.
   (5) Coordinate with other DEP programs and partners during selection of wetland sampling locations and scheduling of field teams.
   (6) Train and oversee wetland monitoring field teams.
   (7) Supervise seasonal wetland program staff.
   (8) Participate as a member of a field team.

C. The Rivers and Streams Subsection Leader has the following responsibilities:
   (1) Manage contracts for macroinvertebrate sample sorting and taxonomic identification.
   (2) Supervise macroinvertebrate sample sorting contractors.
   (3) Purchase and maintain supplies and equipment.
   (4) Provide technical support related to biological assessment.
   (5) Participate as a member of a field team as time allows.

D. The Stream Algae Subsection Leader has the following responsibilities:
   (1) Supervise macroinvertebrate sample sorting contractors.
   (2) Purchase and maintain supplies and equipment.
   (3) Provide technical support related to biological assessment.
   (4) Participate as a member of a field team as time allows.

5. Guidelines and Procedures.

A. Sampling Period
   (1) Sampling of wetland macroinvertebrates must occur during June and July, except for special studies that require sampling at other times (i.e. studies to identify seasonal variation, impact assessments from events occurring outside the normal sampling period, etc.). Scientific justification for departing from the normal

sampling period must be provided, and interpretation of results must include professional judgement to ensure that seasonal differences in macroinvertebrate assemblages are considered.

(2) This period was selected for the following reasons:
   (a) Aquatic invertebrate taxa of interest have developed sufficiently to be identified.
   (b) Wetlands are less likely to dry down during this period compared with later in the summer.
   (c) Overlap with stream algae and stream macroinvertebrate sampling is minimized.

B. Supplies (see supply list, Appendix 1)

C. Selecting Macroinvertebrate Sampling Locations

(1) Collect aquatic macroinvertebrates within one of the following preferred habitats if present at the site:
   (a) Areas having emergent vegetation
   (b) Aquatic macrophyte beds consisting of floating-leaved and/or submerged plants.
   (c) Sampling locations may include similar areas within or adjacent to other habitat types, for example pockets of emergent, floating-leaved or submerged vegetation occurring within a scrub-shrub wetland.

(2) Other representative inundated habitats may be sampled as appropriate for monitoring wetlands where emergent and aquatic bed vegetation do not occur, provided all other selection criteria are followed.

(3) Water depth in all locations sampled must be less than 1 meter.

(4) Locations selected for all replicate samples collected at a site must be as similar to each other as possible with regard to water depth, vegetative community structure and substrate type.

D. Recording Site Characterization, Habitat and Land Use Data

(1) Complete all applicable sections of Maine DEP Wetland Bioassessment Field Data Form.

(2) Complete the Biological Monitoring Wetland Human Disturbance Assessment form (refer to Protocols for Completing the Biological Monitoring Wetland Human Disturbance Assessment, DEPLW-1259).

(3) Take one to several representative digital photos of the site to be monitored. Record the photo number on the field data form.

(4) Record GPS waypoint for the sampling site, using the designated station number to name the waypoint. Follow manufacturer's directions in manual for GPS unit used.

E. Recording Physical/Chemical Measurements in the Field (Refer to Protocols for Using the Hanna Dissolved Oxygen and Specific Conductance/pH Meters in Rivers, Streams, and Freshwater Wetlands, DEPLW0636A-2014).

F. At some sites a water temperature logger may be deployed during the site visit and retrieved later in the sampling season. (Refer to Protocols for Measuring Continuous Water Temperature Using an Onset Data Logger, DEPLW0700A-2014).

G. Collecting Water Samples (Refer to Protocols for Collecting Water Grab Samples in Rivers, Streams, and Freshwater Wetlands, DEPLW0637A-2014).

H. Collecting and Preserving Algae Samples (Refer to Protocols for Sampling Algae in Wadeable Rivers, Streams, and Freshwater Wetlands, DEPLW-0634B-2014).

I. Manage all data collected in accordance with the Protocols for Managing Biomonitoring Data, DEPLW-1202A-2014.

J. Dip Net Measured Sweep
   (1) The dip net measured sweep is the primary method used to collect aquatic macroinvertebrates in wetlands. This method is required if data collected are to be used in the DEP wetland macroinvertebrate linear discriminant model to predict aquatic life use attainment.
   (2) Conduct dip net sweep in an area where the bottom has not yet been disturbed and approach selected area slowly, in order to minimize accidental disturbance.
   (3) Using a 500 - 600 micron D-frame net, sweep through the water column for a distance of one meter. Measure the sweep distance using a meter stick held slightly above the surface of the water by a second person to avoid disturbing aquatic organisms.
   (4) Bump the net against the bottom substrate three times (at the beginning, the middle, and the end of the one meter sweep) to dislodge and collect organisms from the sediment. The net should remain submerged during the entire sweep.
   (5) At the end of the sweep, turn the net so the opening is facing the surface of the water and lift the net out of the water, so no organisms are lost out of the opening.
   (6) If the net becomes significantly clogged or if branches, rocks, or other obstructions prevent the net from properly contacting the wetland substrate, discard the sample and resample in another undisturbed location.
   (7) Perform the measured sweep as quickly as possible to prevent aquatic organisms from escaping out of the net. The sweep should be completed within approximately 3 seconds.
   (8) Transfer all material collected in the net into a 500 - 600 micron sieve bucket by placing the bucket half way into the water and turning the net inside out inside the bucket. Place material in and on the net into the water in the bucket. Visually inspect the net and remove any clinging organisms.
   (9) Examine, wash and discard large pieces of vegetation, woody debris, stones, etc., making sure to remove and retain any aquatic invertebrates observed. Retain all finer plant and material and detritus.

(10) Drain water out of sieve bucket and transfer all material collected into a wide mouth quart sized canning jar. Use additional jars as needed for each sample so that none of the jars are more than approximately 1/2 full. Place sample material into each jar loosely (not packed), to ensure adequate space for alcohol.
(11) Collect three replicate samples in areas of emergent or aquatic bed vegetation, if present, or in other representative inundated habitats as appropriate for the wetland type sampled. Collect each replicate sample in an undisturbed location. Space replicate samples so that samples are spread out to the extent possible across each site (but generally within 100 meters of each other), to account for potential uneven spatial distribution of macroinvertebrate communities. For sites where appropriate available sampling habitat is limited or patchy, spacing of replicate samples may be adjusted as necessary based on professional judgement.
(12) Preserve samples in 95% ethyl alcohol for later sorting and taxonomic analysis in the laboratory.

K. Stovepipe Sampler

(1) The stovepipe sampler is an alternative method used to collect macroinvertebrate samples in areas where it may be difficult to use a standard D-frame net. This may include sites having particularly dense vegetation and/or little standing water.
(2) A stovepipe sampler is a five-gallon plastic bucket with the bottom removed. The bottom diameter is 25 cm. The sampler is used to enclose fixed-area plots to restrict the movement of organisms.
(3) One person will press the stovepipe sampler firmly into the wetland substrate and hold in place while a second person performs the remaining sample collection steps.
(4) Be sure to select a site where water depth does not overtop the stovepipe sampler.
(5) Using one hand, gently agitate the area within the sampler for approximately 10 seconds to dislodge organisms from vegetation and sediment. Shoulder length rubber gloves are recommended for this procedure.
(6) Remove vegetation, coarse woody debris, and approximately the top 1 cm of sediment enclosed within the sampler and place it into a 500 -600 micron sieve bucket.
(7) Sweep the area within the sampler 10 times with a small 500 micron mesh hand net, starting from the bottom of the sampler and moving up through the water column. Between sweeps, transfer all material collected in the hand net into the sieve bucket by placing the bucket half way into the water and turning the net inside out inside the bucket. Place material in and on the net into the water in the bucket. Visually inspect the net and remove any clinging organisms.
(8) Examine, wash and discard large pieces of vegetation, woody debris, stones, etc., making sure to remove and retain any aquatic invertebrates observed. Retain all finer plant material and detritus.
(9) Drain water out of sieve bucket and transfer all material collected into a wide mouth quart sized canning jar. Use additional jars as needed for each sample so that none

of the jars are more than approximately 1/2 full. Place sample material into each jar loosely (not packed), to ensure adequate space for alcohol.

(10) Collect three replicate samples in areas of emergent or aquatic bed vegetation, if present, or in other representative inundated habitats as appropriate for the wetland type sampled. Collect each replicate sample in an undisturbed location. Space replicate samples so that samples are spread out to the extent possible across each site (but generally within 100 meters of each other), to account for potential uneven spatial distribution of macroinvertebrate communities. For sites where appropriate available sampling habitat is limited or patchy, spacing of replicate samples may be adjusted as necessary based on professional judgement.

(11) Preserve samples in 95% ethyl alcohol for later sorting and taxonomic analysis in the laboratory.

L. Multi-Habitat Sampling

(1) Multihabitat sampling is a qualitative method that may be used as a screening tool for assessing aquatic invertebrates.

(2) Using a 500 - 600 micron D-frame net, sample all inundated microhabitats at each site by jabbing the net into the wetland substrate and quickly sweeping upward to the water's surface. Examples of habitats to be sampled include areas of emergent vegetation, aquatic macrophyte beds, pools, channels and areas between vegetation hummocks.

(3) Between jabs, transfer all material collected in the net into a 500 - 600 micron sieve bucket by placing the bucket half way into the water and turning the net inside out inside the bucket. Place material in and on the net into the water in the bucket. Visually inspect the net and remove any clinging organisms. All material collected at a given site is composited into a single sample.

(4) Examine, wash and discard large pieces of vegetation, woody debris, stones, etc., making sure to remove and retain any aquatic invertebrates observed. Retain all finer plant material and detritus.

(5) Transfer a small amount of the composite sample from the sieve bucket into a large white picking tray.

(6) Using a forceps, separate organisms from detritus and place one to several organisms representing each different taxon observed into a vial of alcohol. Continue until no different taxa are observed and discard remaining material contained in the picking tray.

(7) Repeat steps 5 and 6, working with small amounts of the composite sample at a time, until entire sample has been picked.

M. Labeling Macroinvertebrate Samples in the Field

(1) Label quart jars using opaque tape and a fine-tipped permanent marker. Required labeling information and format are described in paragraph 3 below.

(2) Label multihabitat sample vials by placing a strip of heavy paper inside each vial. Record required information using a number 2 or darker pencil only. Do not use

other types of writing utensils, as alcohol used to preserve the sample may cause ink to run.

(3) Include the following information on the label for each sample:
  (a) Sample collection date (day/month/year). Example: 6/10/2013
  (b) Sample identification number. Example: DN-2013-001
    1. The sample identification number is unique for each sample collected, and consists of the method abbreviation, 4-digit year (i.e. 2013), and 3 digit station number, separated by hyphens. Method abbreviations: DN = dip net measured sweep sample, SP = stovepipe sample, MH = multihabitat sample.
    2. Wetland invertebrate samples are generally collected only once per year at a given site for the ambient monitoring program. If a special project involves multiple samples collected in the same year at the same site, and the same collection method is used, an additional 2-digit sequential code must be included in the sample identification number based on the order in which samples were collected. Example: DN-2013-001-01, DN-2013-001-02, DN-2013-001-03, etc.
  (c) Station name. Example: Meadow Brook
  (d) Town. Example: New Gloucester
  (e) Replicate number. Example: DN#1
    1. The replicate number consists of the method abbreviation plus the number assigned to each replicate sample for a particular site (generally 1, 2, or 3).
    2. A replicate number is not required for multihabitat samples.
  (f) Container number. If a single sample must be divided between two or more sample containers, additional information must be recorded on the label to indicate the container number and the total number of containers for that sample. Examples: Jar 1 of 2, vial 2 of 3, etc.
  (g) The following is an example of a completed label:

6/10/13 DN-2013-001
Meadow Brook, New Gloucester
DN#1 Jar 2 of 3

N. Preserving Macroinvertebrate Samples in the Field
  (1) Wetland macroinvertebrate samples are preserved in 95% ethyl alcohol.

O. Decontaminating Sampling Gear
  (1) The DEP Division of Environmental Assessment (DEA) uses standardized methods for cleaning and disinfecting all sampling equipment to prevent the spread of invasive species and disease pathogens which threaten amphibians and other wildlife in Maine. These methods are described in Protocols for Decontaminating Biomonitoring Sampling Equipment, DEPLW0919A-2014.

P. Laboratory Procedures for Macroinvertebrate Samples

(1) Laboratory procedures for wetland macroinvertebrate sample sorting, preservation, labeling, subsampling and taxonomy follow methods described in Davies and Tsomides 2002.

6. References

Connors, B., 2014. *Protocols for Decontaminating Biomonitoring Sampling Equipment*. Maine Department of Environmental Protection, Augusta, ME. DEPLW0919A-2014.

Connors, B., 2014. *Protocols for Measuring Continuous Water Temperature Using an Onset Data Logger*. Maine Department of Environmental Protection, Portland, ME. DEPLW0700A-2014.

Connors, B., 2014. *Protocols for Managing Biomonitoring Data*. Maine Department of Environmental Protection, Portland, ME. DEPLW-1202A-2014.

Connors, B. and J. L. DiFranco, 2014. *Protocols for Completing the Biological Monitoring Wetland Human Disturbance Assessment*. Maine Department of Environmental Protection, Portland, ME. DEP-LW1259.

Danielson, T. J., 2014. *Protocols for Collecting Water Grab Samples in Rivers, Streams and Freshwater Wetlands.* Maine Department of Environmental Protection, Augusta, ME. DEPLW0637A-2014.

Danielson, T. J., 2014. *Protocols for Using the Hanna Dissolved Oxygen and Specific Conductance/pH Meters in Rivers, Streams, and Freshwater Wetlands*. Maine Department of Environmental Protection, Augusta, ME. DEPLW0636A-2014.

Danielson, T. J., 2014. *Protocols for Sampling Algae in Wadeable Rivers, Streams, and Freshwater Wetlands*. Maine Department of Environmental Protection, Augusta, ME. DEPLW-0634B-2014.

Davies, S.P., and L. Tsomides, 2002. *Methods for Biological Sampling and Analysis of Maine's Rivers and Streams*. Maine Department of Environmental Protection. Augusta, ME. DEP LW0387-B2002.

Appendix 1: Wetland Sampling Equipment List

Water Chemistry
D.O. meter
Conductivity/pH meter
extra batteries (AAA?)
extra probe solutions and buffers
extra heads
sample container kits
long handled dipper
1 gallon plastic mixing jugs (2)
cooler and ice

Macroinvertebrates
500 - 600 micron D-frame nets
500 – 600 micron sieve buckets
meter stick
canning jars/lids (wide mouth quarts)
extra lids/rings
extra label tape
alcohol/field alcohol container
multihabitat samples:
    vials/caps
    picking trays
    forceps
    paper labels
stovepipe samples:
    stovepipe sampler
    small hand net (500 micron)
    long rubber gloves

Algae/Diatoms
wide mouth Nalgene containers
M3 preservative
Nitrile gloves
Pipette and bulb or rolling controller
squirt bottles
tap water
plastic beaker
whirlpak bags
Epiphyte samples:
    hand pruner
    metric ruler
Sedimented alage/diatoms:
    small plastic petrie dishes
    spatula

Decontamination gear
garden sprayer
quaternary ammonia or household bleach
5 gallon water container for rinsing
scrub brush
liquid soap
measuring cup
rubber or nitrile gloves
goggles
apron

General Stuff
canoe
paddles
pfd's
pack baskets
boots/waders (non-felt bottomed)
wader repair kit
field sheets/clipboards
wetland maps
Gazateer
camera and spare batteries (AA)
GPS unit and spare batteries (AA)
sharpies / pencils
hand wipes
paper towels
flagging
extra rope
duct tape
packing tape
freezer bags
trash bags
utilty/work gloves
tarp
screw drivers (Philips and flathead)
bug shirts/head nets

First aid kit

Calculate Your Ecological Footprint

Each organism uses resources from the ecosystem to exist. We express this essential requirement as an area of the planet that annually supplies these requirements each year and define this as the organism's ecological footprint. For humans, we can record the consumption data and convert it into an area that supplies these ecosystem resources that are annually appropriated by each person. This is an example of a "systems analysis" that is very helpful for us to understand the connections between our behavior and our dependency on the mother nature. Our ecological footprint helps us to appreciate what we get for free from the environment. https://www.footprintcalculator.org/

Macroinvertebrate Links

Online Keys for Identification

Macroinvertebrate Resources of Stroud Water Research Center: Photo Gallery, Identification Key, Leaf Pack Network®, Rock Pack Experiment, Monitor My Watershed, Water Quality Mobile App, 3D Printable Designs, Taxonomic Certification Program and much more. https://stroudcenter.org/macros/gallery/

New York Department of Conservation: This key is a pictorial method of identifying aquatic macroinvertebrates. It is structured so the major groups of aquatic macroinvertebrates can be accurately identified primarily on the basis of photographs instead of traditional written keys that often require the knowledge of unfamiliar terminology.
http://www.dec.state.ny.us/website/dow/stream/index.htm

The Stream Study: The Stream Study is based on material developed by the Save Our Streams Program of the Izaak Walton League of America. The Stream Study provides a method to determine the water quality of a stream based on the collection and identification of stream-bottom macroinvertebrates.
http://www.people.virginia.edu/-sos-iwla/Stream-Study/StreamStudyHomePage/StreamStudy.html

Online Picture Sources

Atlas of Common Freshwater Macroinvertebrates of Eastern North America. Excellent pictorial tool to identify macroinvertebrates! Explore this resource for aquatic insect identification to support citizen science identification activities. https://www.macroinvertebrates.org/

Mayfly Central: Mayfly Central is a place, a program, and an information resource. It is located in the Department of Entomology at Purdue University, where it is associated with the Laboratory of Aquatic Entomology. The program is a multidimensional research and education program dedicated to the pursuit and dissemination of knowledge about mayflies, or the insect order Ephemeroptera.
https://www.entm.purdue.edu/mayfly/na-species-list.php

Welcome to the Aquatic Insect Collections of Brackenridge Field Laboratory, Department of Zoology, University of Texas at Austin. The lists on the following pages represent an attempt to catalog the aquatic insect species of Texas including those held in the collections at BFL and those from published records. http://www.utexas.edu/research/bfl/collections/aqinsects/aqinpage.htm

Books

A guide to common freshwater invertebrates of North America by J. Reese Voshell, 2002. The McDonald & Woodward Publishing Company, Blacksburg, Virginia.

Wonderful, Wacky, Water Critters. University of Wisconsin-Extension 2001. Suzanne Wade (Author)

An Introduction to the Aquatic Insects of North America by Richard W. Merritt (Editor), Kenneth W. Cummins (Editor)

Aquatic Entomology: The Fishermen's Guide and Ecologists' Illustrated Guide to Insects and Their Relatives by Richard W. Merritt, K. W. (Ed.) Cummins

Aquatic Insect Ecology: Biology and Habitat, Vol. 1 by J.V. V. Ward

How to Know the Aquatic Insects by Dennis M. Lehmkuhl, Edward T. Cawley and John Bamrick

Equipment Suppliers

Forestry Suppliers, Inc (formerly Ben Meadows) Quality Products for Forestry, Environmental Science, Surveying, Engineering. In Business Since 1949. Online Catalog at https://www.forestry-suppliers.com/

BioQuip Products (Entomological & Botanical equipment, books, software - the best!) Online Catalog at http://www.bioquip.com/

Carolina Biological Supply (full line of living and preserved biological materials, supplies, etc) Online Catalog at https://www.carolina.com/life-science/entomology/

Connecticut Valley Biological Supply Co.(Collecting & storage equipment; supplies etc) Online Catalog at https://www.connecticutvalleybiological.com/

Edmunds Scientific, a major supplier of optics and science products to high-tech industries, but we are also dedicated to making these same exciting items available to schools and to families. Online Catalog at http://www.scientificsonline.com/

Insect Lore (Educational materials, books, kits, etc!!) Online Catalog at https://www.insectlore.com/

Benz Microscope Optics Center (Excellent selection of low-cost microscopes for hobbyists, schools, and professionals) Online Catalog at https://benzmicroscope.com/

Ward's Natural Science Establishment (all kinds of supplies for biology/entomology) Online Catalog at http://www.wardsci.com/

Directory of North American Entomological Societies: This page provides the listing of entomological societies for North America. http://www.sciref.org/links/EntSoc/NorthAm.htm#USA