State of Ohio
Environmental Protection Agency

Ecological Assessment Section
Division of Water Quality
Planning & Assessment

Biological Criteria for the Protection of Aquatic Life: Volume III: Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities

First Update September 30, 1989)

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43266-0149

Volume III, pp. V-1-7 to V-1-9. Replaces Tables V-1-1 and V-1-2 with Table V-1.

Table V-1. Current taxonomic keys and the level of taxonomy routinely used by the Ohio EPA for various macroinvertebrate taxonomic classifications.

Porifera: Species (Pennak 1989)
Coelenterata: Genus (Pennak 1989)
Platyhelminthes: Class (Pennak 1989)
Nemertea: Phylum (Pennak 1989)
Nematomorpha: Phylum/genus (Pennak 1989)
Ectoprocta: Genus/species (Thorp and Covich 1991)
Entoprocta: Species (Thorp and Covich 1991)
Annelida
- Oligochaeta: Class (Pennak 1989)
- Hirudinea: Species (Klemm 1982)

Arthropoda
- Crustacea
  - Isopoda: Genus (Pennak 1989)
  - Amphipoda: Genus (Pennak 1989)
    - Gammarus: Species (Holsinger 1972)
  - Decapoda
    - Cambarus and Fallicambarus: Species (Jezerinac and Thoma 1984, Jezerinac 1993)
    - Palaemonetes: Species (Pennak 1989)
- Arachnoidea: Class (Pennak 1989)
- Insecta
  - Ephemeroptera: Genus (Edmunds *et al.* 1976, Merritt and Cummins 1996)
    - Baetidae: Genus/species (Morihara and McCafferty 1979, McCafferty and Waltz 1990, Lugo-Ortiz and McCafferty 1998)
      - Pseudocloeon: Species (McCafferty and Waltz 1995)
    - Heptageniidae
      - Stenonema: Species (Bednarik and McCafferty 1979)
    - Ephemerellidae
      - Dannella: Species (Allen and Edmunds 1962)
      - Ephemerella: Species (Allen and Edmunds 1965)
      - Eurylophella: Species (Funk and Sweeney 1994)
      - Serratella: Species (Allen and Edmunds 1963b)
    - Baetiscidae
      - Baetisca: Species (Burks 1953)
  - Ephemeroidea: Species (McCafferty 1975)
  - Odonata: Family/genus (Merritt and Cummins 1996)
    - Anisoptera: Genus/species (Needham and Westfall 1955, Walker 1958, Walker and Corbett 1975)
  - Plecoptera: Genus (Stewart and Stark 1988)
    - Perlidae
      - Acroneuria: Species (Hitchcock 1974)
      - Paragnetina: Species (Hitchcock 1974)
      - Perlinella: Species (Kondratieff *et al.* 1988)
    - Perlodidae: Species (Hitchcock 1974)
  - Hemiptera: Genus (Hilsenhoff 1995, Merritt and Cummins 1996)
  - Megaloptera: Genus (Merritt and Cummins 1996)
    - Nigronia: Species (Neunzig 1966)
  - Neuroptera: Genus (Merritt and Cummins 1996)
  - Trichoptera: Genus (Wiggins 1996, Merritt and Cummins 1996)
    - Philopotamidae: Species (Ross 1944)
    - Hydropsychidae
      - Hydropsyche and Ceratopsyche: Species (Schuster and Etnier 1978)
    - Rhyacophilidae
      - Rhyacophila: Species (Flint 1962, Weaver and Sykora 1979)
    - Leptoceridae
      - Ceraclea: Species (Resh 1976)
      - Mystacides: Species (Yamamoto and Wiggins 1964)
      - Nectopsyche: Species (Haddock 1977)
      - Oecetis: Species (Floyd 1995)
      - Triaenodes/Ylodes: Species (Glover 1996)
  - Lepidoptera: Genus (Merritt and Cummins 1996)
  - Coleoptera: Genus (Hilsenhoff 1995, Merritt and Cummins 1996)
    - Dryopoidea: Genus/species (Brown 1972)
  - Diptera: Family/genus (Merritt and Cummins 1996)
    - Ceratopogonidae
      - Atrichopogon: Species (Johannsen 1935)
    - Chironomidae: Genus/species groups (Wiederholm 1983)
      - Ablabesmyia: Species (Roback 1985)
      - Labrundinia: Species (Roback 1987)
      - Tanypus: Species (Roback 1977)
      - Corynoneura: Species (Simpson and Bode 1980, Bolton In Prep.)
      - Eukiefferiella and Tvetenia: Species groups (Bode 1983)
      - Nanocladius: Species (Saether 1977, Simpson and Bode 1980, Bolton In Prep.)
      - Parakiefferiella: Species (Bolton In Prep.)
      - Rheocricotopus: Species (Saether 1985)
      - Thienemanniella: Species (Hestenes and Saether 2000)
      - Chironomus: Species groups (Oliver and Roussel 1983)
      - Dicrotendipes: Species (Epler 1987)
      - Endochironomus and Tribelos: Species (Grodhaus 1987)
      - Parachironomus: Species (Simpson and Bode 1980, Bolton In Prep.)
      - Polypedilum: Species groups/species (Maschwitz 2000, Bolton In Prep.)
      - Tanytarsini: Genus/species groups/species (Simpson and Bode 1980, Bolton In Prep.)
    - Muscidae: Species (Johannsen 1935)

Mollusca
- Gastropoda: Genus/species (Burch 1982)
- Pelecypoda
  - Sphaeriidae: Genus (Burch 1972)
  - Unionidae: Species (Waters 1995)

Volume III, pp. V-1-11 to V-1-15. Add the following new citations to the References section.

Floyd, M.A. 1995. Larvae of the caddisfly genus Oecetis (Trichoptera: Leptoceridae) in North America. Bulletin of the Ohio Biological Survey Vol. 10, No. 3. 85 pp.

Funk, D.H. and B.W. Sweeney. 1994. The larvae of eastern North American Eurylophella Tiensuu (Ephemeroptera: Ephemerellidae). Transactions of the American Entomological Society 120(3):209-286.

Glover, J.B. 1996. Larvae of the caddisfly genera Triaenodes and Ylodes (Trichoptera: Leptoceridae) in North America. Bulletin of the Ohio Biological Survey Vol. 11, No. 2. 89 pp.

Hestenes, T.C. and O.A. Saether. 2000. Three new Nearctic Thienemanniella Kieffer species with a review of the Nearctic species. Late 20th Century Research on Chironomidae. An Anthology from the 13th International Symposium on Chironomidae: pp. 103-127. Shaker Verlag, Aachen.

Hilsenhoff, W.L. 1995. Aquatic insects of Wisconsin. Keys to Wisconsin genera and notes on biology, habitat, distribution and species. Publication Number 3 of the Natural History Museums Council. University of Wisconsin - Madison.

Jezerinac, R.F. 1993. A new subgenus and species of crayfish (Decapoda:Cambaridae) of the genus Cambarus, with an amended description of the subgenus Lacunicambarus. Proc. Biol. Soc. Wash. 106(3): pp. 532-544.

Kondratieff, B.C., R.F. Kirchner, and K.W. Stewart. 1988. A review of Perlinella Banks (Plecoptera: Perlidae). Annals of the Entomological Society of America 81(1):19-27.

Lugo-Ortiz, C.R. and W.P. McCafferty. 1998. A new North American genus of Baetidae (Ephemeroptera) and key to Baetis complex genera. Ent. News 109(5): 345-353.

Maschwitz, D.E. and E.F. Cook. 2000. Revision of the Nearctic species of the genus Polypedilum Kieffer (Diptera: Chironomidae) in the subgenera P. (Polypedilum) Kieffer and P. (Uresipedilum) Oyewo and Saether. Bulletin of the Ohio Biological Survey. New Series 12(3): 1-135.

McCafferty, W.P. and R.D. Waltz. 1995. Labiobaetis (Ephemeroptera: Baetidae): new status, new North American species, and related new genus. Ent. News 106(1): 19-28.

McCafferty, W.P. and R.D. Waltz. 1990. Revisionary synopsis of the Baetidae (Ephemeroptera) of North and Middle America. Transactions of the American Entomological Society 116(4):769-799.

Merritt, R.W. and K.W. Cummins (editors). 1996. An introduction to the aquatic insects of North America. 3rd edition. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Pennak, R.W. 1989. Fresh-water invertebrates of the United States. 3rd edition. John Wiley & Sons, New York, New York.

Saether, O.A. 1985. A review of the genus Rheocricotopus Thienemann & Harnisch, 1932, with the description of three new species (Diptera: Chironomidae). Spixiana Supplement 11:59-108.

Thorp, J.H. and A.P. Covich (editors). 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego, California.

Waters, G.T. 1995. A guide to the freshwater mussels of Ohio. 3rd edition. The Ohio Department of Natural Resources, Division of Wildlife, Columbus, Ohio.

New Citations (cont)

Weaver, J.S., III and J.L. Sykora. 1979. The Rhyacophila of Pennsylvania with larval descriptions of R. banksi and R. carpenteri (Trichoptera: Rhyacophilidae). Annals of Carnegie Museum. Carnegie Museum of Natural History 48(22): 403-423.

Wiggins, G.B. 1996. Larvae of the North American caddisfly genera (Trichoptera). 2nd edition. University of Toronto Press, Toronto, Canada.

Yamamoto, T. and G.B. Wiggins. 1964. A comparative study of the North American species in the caddisfly genus Mystacides (Trichoptera: Leptoceridae). Can. J. Zool. 42: 1105-1126.

NOTICE TO USERS

All methods and procedures for the use of biological criteria contained and/or referred to in these volumes supercede those described in any previous Ohio EPA manuals, reports, policies, and publications dealing with biological evaluation, designation of aquatic life uses, or the determination and evaluation of aquatic life use attainment. Users of these criteria and the supporting field methods, data analyses, and study design should conform to that presented or referenced in these volumes (and subsequent revisions) in order to be applicable under the Ohio Water Quality Standards (WQS; OAC 3745-1).

Three volumes comprise the supporting documentation for setting and using biological criteria in Ohio. All three volumes are needed to use the biological criteria, implement the field and laboratory procedures, and understand the principles behind their development, use, and application. These volumes are:

Ohio Environmental Protection Agency. 1987. *Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment.* Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987. *Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters.* Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989. *Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities.* Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

In addition, one other publication from the Stream Regionalization Project is recommended to all users:

Whittier, T.R., D.P. Larsen, R.M. Hughes, C.M. Rohm, A.L. Gallant, and J.M. Omernik. 1987. *The Ohio stream regionalization project: a compendium of results.* U.S. EPA - Environmental Res. Lab, Corvallis, OR. EPA/600/3-87/025. 66 pp.

These documents can be obtained by writing:

Ohio Environmental Protection Agency
Division of Water Quality Monitoring and Assessment
1800 WaterMark Drive, P.O. Box 1049
Columbus, Ohio 43266-0149

Other recommended and helpful literature is listed in the references of each volume.

FOREWARD

This volume is excerpted from the Ohio EPA Manual of Surveillance Methods and Quality Assurance Practices (6th Update). The macroinvertebrate methods are from section V, subsection 1 and the fish methods are from section V, subsection 4 of this manual. They are produced here to accompany the supporting technical documentation for the establishment and use of biological criteria in Ohio.

Acknowledgements

Jeff DeShon, Jack Freda, and Mike Bolton provided the primary input to the macroinvertebrate section. Chris Yoder, Marc Smith, Roger Thoma, Randy Sanders, and Ed Rankin were responsible for the fish section. Ed Rankin was the primary originator of the Qualitative Habitat Evaluation Index (QHEI) which is described in the fish section. Pam Jacques provided typing support.

Subsection 1. Macroinvertebrates

J.E. DeShon, J.T. Freda , M. J. Bolton

Part A) Field Methods - Quantitative Sampling
Part B) Field Methods - Qualitative Sampling
Part C) Laboratory Methods - Quantitative Sampling
1) Macroinvertebrate Counts and Identifications
2) Macroinvertebrate Data Analysis
a) Invertebrate Community Index
b) Community Similarity Index
c) Rank Correlation Coefficient
d) Coefficient of Variation
Part D) Laboratory and Data Analysis Methods - Qualitative Sampling

Part A
Field Methods - Quantitative Sampling

The primary sampling equipment used for the collection of benthic macroinvertebrates is the modified Hester-Dendy multiple-plate artificial substrate sampler. The sampler is constructed of 1/8 inch tempered hardboard cut into three inch square plates and one inch square spacers. A total of eight plates and twelve spacers are used for each sampler. The plates and spacers are placed on a 1/4 inch eyebolt so that there are three single spaces, three double spaces, and one triple space between the plates. The total surface area of the sampler, excluding the eyebolt, is 145.6 square inches.

Samplers placed in streams are tied to a concrete construction block which anchors them in place and prevents the multiple- plates from coming into contact with the natural substrates. In water deeper than four feet, a float (1 qt. cubitainer) is attached to the samplers to keep them within four feet of the surface. Whenever possible, the samplers are placed in runs rather than pools or riffles and an attempt is made to establish stations in as similar an ecological situation as possible. All samplers are exposed for a six week period. A set of samplers consists of three multiple-plate samplers (three square feet) at National Ambient Water Quality Monitoring Network (NAWQMN) stations and five multiple-plate samplers at all other sampling locations. All NAWQMN stations and most routine monitoring stations are sampled during the time period of June 15 to September 30.

Retrieval of the samplers is accomplished by cutting them from the block and placing them in one quart plastic containers while still submersed. Care is taken to avoid disturbing the samplers and thereby dislodging any organisms. Enough formalin is added to each container to equal an approximate 10% solution. Qualitative samples of macroinvertebrates inhabiting the natural substrates are also collected at the time of sampler retrieval. In shallow water, samples are taken in a stream segment covering all available habitats in the near vicinity where the samplers were placed. Samples are collected using triangular ring frame 30-mesh dip nets and hand picking with forceps. Grab samplers (i.e., Ekman, Peterson, or Ponar) can also be used in deep water. The qualitative sampling continues until, by gross examination, no new taxa are being taken. A station description sheet (Figure V-1-1) is filled out by the collector at the time of sampler retrieval. The substrate is described using the categories for substrate characterization indicated in the USEPA biological field manual (Weber, 1973).

In those situations where quantitative biological samples are collected from the natural substrates using a Surber square foot sampler (30-mesh netting), the collector stands on the downstream side of the sampler and works the substrate using a hand cultivator with two inch tines. Large rocks are gently scrubbed with a brush. The material collected is placed in sealed containers, preserved in 10% formalin, and transported to the laboratory. Three to five Surber samples are taken at each site.

Figure V-1-1. Station description sheet used by macroinvertebrate field crews (Front).

Ohio EPA Surface Water Section
Macroinvertebrate Field Sheet

Stream_____ Stream Code_____ RM____ Date Collected_____

Location_____ Date Set_____

_____ Collected By_____

Sampling Method: HD(No.____) - DN/HP - Surber - Grab (Type_____) - Other_____

HD Sampler Site: Depth_____ Canopy_____ Current (Set)_____ Current (Ret)_____

HD Condition: Disturbed Yes/No Comment:_____
Debris Yes/No Comment:_____
Silt/Solids None - Slight - Moderate - Heavy

DN/HP Sampling: Total Time____ Habitats: Pool - Riffle - Run - Margin - Backwater

Physical Characteristics

Flow Condition: High - Moderate - Low - Interstitial - Intermittent - Dry
Current Velocity: Fast - Moderate - Slow - ND
Channel Morphology: Natural - Channelized - Channelized (Recovered) - Impounded
Bank Erosion: Extensive - Moderate - Slight - None
Riffle Development: Extensive - Moderate - Sparse - Absent
Riffle Quality: Good - Fair - Poor Embedded: Yes/No
Clarity: Clear - Murky - Turbid
Color: None - Green - Brown - Grey - Other( )
Canopy: Open - 75% - 50% - 25% - Closed

Substrate Characteristics

Percent of:	Pool	Riffle	Run
Bedrock( )	____	____	____
Boulder( )	____	____	____
Rubble( )	____	____	____
Coarse Gravel	____	____	____
Fine Gravel	____	____	____
Sand	____	____	____
Silt	____	____	____
Clay/Hardpan	____	____	____
Detritus	____	____	____
Peat	____	____	____
Muck	____	____	____
Other( )	____	____	____
Macrophytes( )	____	____	____
Algae( )	____	____	____
Artifacts( )	____	____	____
Compaction(F,M,S)	____	____	____
Depth (Average)	____	____	____
Width (Average)	____	____	____

Predominant Land Use (L,R,B)

Forest	Open Pasture	Wetland
Shrub	Closed Pasture	Other
Old Field	Urban	( )
Rowcrop	Residential/Park	
Industrial	Mining/Construction	

Riparian Vegetation

Left	Width	Right	Width	Type
____	____	____	____	Large trees
____	____	____	____	Small trees
____	____	____	____	Shrubs
____	____	____	____	Grass/Weeds
____	____	____	____	None

Margin Habitat

Undercut Banks	Root Mats
Grass	Water Willow
Shallows	Clay/Hardpan
Rip Rap	Bulkhead
Other( )	

Margin Quality: Good - Fair - Poor

Figure V-1-1 (Continued). Station description sheet used by macroinvertebrate field crews (Back).

Biological Characteristics

Riffle

Predominant Organisms: _____

Other Common Organisms: _____

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Run

Predominant Organisms: _____

Other Common Organisms: _____

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Pool

Predominant Organisms: _____

Other Common Organisms: _____

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Margin

Predominant Organisms: _____

Other Common Organisms: _____

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Other Notable Collections: _____

Potential Pollution Sources: _____

Evidence of Pollution: _____

Photo Numbers: _____

Comments: _____

In those situations where Ekman, Peterson, or Ponar grab samples are used for quantitative purposes, three to five samples are collected and then treated in essentially the same manner as the Surber samples. The material collected with the grab is washed through a bucket with a 30-mesh screen bottom, placed in sealed containers, preserved in 10% formalin, and returned to the laboratory.

Part B
Field Methods - Qualitative Sampling

When only qualitative samples are collected the methods are similar to those employed when collecting qualitative samples in conjunction with artificial substrate samples except that:

a) A more intensive sampling effort is required.

b) The sampling area is more rigidly defined.

c) More extensive field notes concerning the biological and physical condition of each station are required.

d) A preliminary biological community assessment is made on site.

Each station is sampled at least once between June 15 and September 30. Organisms are collected from the natural substrates using triangular ring frame 30-mesh dip nets and forceps, and are preserved in 70% alcohol. Collections are made for a minimum of 30 minutes, then continue until no new taxa are evident in gross examinations. Whenever possible, a riffle, run, margin, and pool habitat are sampled at each station and an attempt is made to sample areas which are physically similar from site to site. Stations should be sampled in order, moving from upstream to downstream, to detect any changes between sites.

As in quantitative sampling, the station description sheet (Figure V-1-1) is filled out at each station at the time of collection. In addition, the length of sampling time and the presence of riffle, run, margin, and pool habitats are noted. Predominant populations and estimates of community density and diversity in each habitat type are noted on the sheet. A preliminary biological community assessment is made after each station is sampled.

Part C
Laboratory Methods - Quantitative Sampling

Samples are coded and sample numbers are immediately entered into a log book upon arrival at the laboratory. Samples are given a log number derived from the date, e.g., 871108-10, where 87 represents the year, 11 represents the month, and 08 the day. The number following this six digit date, i.e., the number 10 in the previous example, indicates that this was the 10th sampled logged that day. Other information in the log book includes the name(s) of field personnel that collected the sample, date, stream or lake name, basin name, entity (where applicable), general location, sample type, sampling method(s) used, the person who conducted the analyses, and any other comments considered pertinent to the collection and analysis of the sample.

1) *Macroinvertebrate Counts and Identifications*

Composite samples consisting of five multiple-plate samplers are used in station evaluations for routine monitoring. However, replicate samples (three multiple-plate samplers) are reported to the USEPA for NAWQMN stations. Replicate sets of five multiple-plate samplers can be used if deemed necessary in those cases where sampling is for litigation purposes. In all cases, the multiple-

plate(s) is (are) disassembled in a bucket of water, cleaned of organisms and debris, and discarded. The organism/debris mixture is then passed through U.S. Standard Testing Sieves number 30 (0.589 mm openings) and number 40 (0.425 mm openings). The material retained in each sieve is preserved in properly labeled and coded jars of 70% alcohol.

The following procedures are used during the course of analyzing an artificial substrate, Surber, or grab sample:

a) Sorting of the sample is done in a white enamel pan followed by scanning under the dissecting microscope (10x magnification). Subsamples are produced using the following guidelines:

1) The Folsom sample splitter is used for all subsampling. (In an effort to determine the accuracy of the Folsom sample splitter, a sample composed of 200 individuals of five frequently collected organisms was prepared and repeatedly split. Statistical analysis of the data yielded a chi- square value of 2.56, df=4, which was not significant at the 95% probability level.)

2) After an entire sample has been sorted, subsampling within families containing unmanageable numbers is acceptable.

3) Very large samples may be subsampled prior to sorting - but only after examination in a white enamel pan to remove obvious rare taxa, e.g., crayfish, hellgramites, non-hydropsychid caddisflies.

4) A minimum of 250 organisms is identified, with at least 50-100 midges, 70 caddisflies, 70 mayflies.

b) Dipterans of the family Chironomidae are prepared for identification by clearing the larvae in hot 10% KOH for 30 minutes and then mounting in water on microscope slides. Permanent slides for the voucher collection are mounted in Euparol mounting medium.

c) Material retained in the # 40 screen is counted and identified or counted and extrapolated when identification is impossible or impractical. (Artificial substrate sample only.)

d) Organisms determined to be dead before the time of collection are discarded.

e) When only one sex or life stage can be identified it is assumed that the other sex or stage is the same species.

f) Sections of bryozoan colonies are removed from the plates and saved for identification. Only colonies, not individuals, are counted. (Artificial substrate sample only.)

g) Early instars that cannot be identified are extrapolated where possible.

h) Species level identifications are made where possible and practical. Generic or higher level classifications are made if specimens are damaged beyond identification, in those cases where taxonomy is incomplete or laborious and time-consuming, or where the specimen is an unidentifiable early instar.

i) Organisms are listed in tables following the laboratory table format (Table V-1-1).

j) Two end fragments of an oligochaete are counted as one individual. Fragments without ends are not counted.

k) Any taxonomic key in the laboratory may be used as an aid in the identification of an organism. However, the final identification and name used are taken from the asterisked references in Table V-1-2. Also indicated is the level of taxonomy attainable with the keys listed.

Table V-1-1. Phylogenetic order for macroinvertebrate listing including level of taxonomy generally used.

Porifera:	Species
Coelenterata:	Genus
Platyhelminthes:	Class
Nematomorpha:	Genus
Bryozoa:	Species
Entoprocta:	Species
Annelida	
Oligochaeta:	Class
Hirudinea:	Species
Arthropoda	
Crustacea	
Isopoda:	Genus
Amphipoda:	Genus/Species
Decapoda:	Species
Arachnoidea	
Hydracarina:	Class
Insecta	
Ephemeroptera	
Siphlonuridae:	Genus
Baetidae:	Genus
Oligoneuriidae:	Genus
Heptageniidae:	Genus/Species
Leptophlebiidae	Genus
Ephemerellidae:	Species
Tricorythidae:	Genus
Caenidae:	Genus
Baetiscidae:	Species
Potamanthidae:	Genus
Ephemeridae:	Genus
Polymitarcyidae:	Species
Odonata	
Zygoptera	
Calopterygidae:	Genus
Lestidae:	Species
Coenagrionidae:	Family/Genus
Anisoptera	
Aeshnidae:	Species
Gomphidae:	Species
Cordulegastridae:	Species
Macromiidae:	Species
Corduliidae:	Species
Libellulidae:	Species
Plecoptera	
Pteronarcyidae:	Genus
Peltoperlidae:	Genus
Taeniopterygidae:	Genus
Nemouridae:	Species
Leuctridae:	Genus
Capniidae:	Genus
Perlidae:	Species
Perlodidae:	Species
Chloroperlidae:	Genus
Hemiptera	
Belostomatidae:	Genus
Nepidae:	Genus
Pleidae:	Genus
Naucoridae:	Genus
Corixidae:	Genus
Notonectidae:	Genus
Megaloptera	
Sialidae:	Genus
Corydalidae:	Species
Neuroptera:	Genus
Trichoptera	
Philopotamidae:	Genus/Species
Psychomyiidae:	Species
Polycentropodidae:	Genus
Hydropsychidae:	Genus/Species
Rhyacophilidae:	Genus/Species
Glossosomatidae:	Genus
Hydroptilidae:	Genus/Species
Phryganeidae:	Genus
Brachycentridae:	Genus
Limnephilidae:	Genus
Lepidostomatidae:	Genus
Beraeidae:	Genus
Sericostomatidae:	Genus
Odontoceridae:	Genus
Molannidae:	Genus
Helicopsychidae:	Species
Calamoceratidae:	Genus
Leptoceridae:	Genus/Species
Lepidoptera:	Genus

Coleoptera	
Gyrinidae:	Genus
Haliplidae:	Genus
Dytiscidae:	Genus
Noteridae:	Genus
Hydrophilidae:	Genus
Hydraenidae:	Genus
Psephenidae:	Species
Dryopidae:	Genus
Scirtidae:	Family
Elmidae:	Genus/Species
Limnichidae:	Genus
Heteroceridae:	Family
Ptilodactylidae:	Family
Chrysomelidae:	Family
Curculionidae:	Family
Lampyridae:	Family
Diptera	
Tipulidae:	Genus
Psychodidae:	Genus
Ptychopteridae:	Genus
Dixidae:	Genus
Chaoboridae:	Genus
Culicidae:	Genus
Thaumaleidae:	Genus
Simuliidae:	Genus
Certopogonidae:	Family/Genus/Species
Chironomidae	
Tanypodinae:	Genus/Species
Diamesinae:	Genus/Species
Prodiamesinae:	Genus/Species
Orthocladinae:	Genus/Species
Chironominae	
Chironomini:	Genus/Species
Pseudochironomini:	Genus/Species
Tanytarsini:	Genus/Species
Tabanidae:	Genus/Species
Athericidae:	Species
Stratiomyidae:	Genus
Empididae:	Family
Dolichopodidae:	Family
Syrphidae:	Family/Genus
Sciomyzidae:	Family/Genus
Ephydridae:	Family/Genus
Muscidae:	Species
Mollusca	
Gastropoda:	Family/Genus/Species
Pelecypoda:	Family/Genus/Species

Table V-1-2 Level of macroinvertebrate taxonomy attainable using keys (Asterisked references are used for final identifications)

Porifera: Pennak* (1978)/Species
Coelenterata: Pennak* (1978)/Species
Platyhelminthes: Pennak* (1978)/Species
Nematomorpha: Pennak* (1978)/Genus
Bryozoa: Pennak* (1978)/Species
Annelida
- Hirudinea: Klemm* (1982)/Species

Isopoda
- *Asellus*: Williams* (1972)/Species

Amphipoda
- Specific Keys: Pennak* (1978)/Species
- Gammaridae: Holsinger* (1972)/Species

Decapoda
- *Cambarus* and *Fallicambarus*: Jezerinac and Thoma* (1982)/ Species
- *Procambarus* and *Orconectes*: Jezerinac* (1978)/ Species

Ephemeroptera
- Generic Keys: Edmunds et al. (1976), Merritt and Cummins* (1984)/Genus
- *Baetis*: Morihara and McCafferty* (1979)/Species
- *Stenonema*: Bednarik and McCafferty* (1979)/Species
- *Attenella*: Allen and Edmunds* (1961)/Species
- *Dannella*: Allen and Edmunds* (1962)/Species
- *Drunella*: Allen and Edmunds* (1962)/Species
- *Ephemerella*: Allen and Edmunds* (1965)/Species
- *Eurylophella*: Allen and Edmunds* (1965)/Species
- *Serratella*: Allen and Edmunds* (1963)/Species
- *Ephemeroidea*: McCafferty* (1975)/Species
- Other Species Keys: Burks* (1953)/Species

Odonata
- Generic Keys: Merritt and Cummins* (1984)/Genus
- Zygoptera: Walker* (1953)/Species
- Anisoptera: Needham and Westfall* (1955), Walker (1958), Walker and Corbett (1975)/Species

Plecoptera
- Generic Keys: Stewart and Stark* (1988)/Genus
- Species Keys: Hitchcock* (1974)/Species
- *Agnetina*: Stark* (1986)/Species

Hemiptera Generic Keys: Hilsenhoff (1982), Merritt and Cummins* (1984)/Genus

Megaloptera
- Generic Keys: Merritt and Cummins* (1984)/Genus
- *Chauliodes*: Cuyler* (1958)/Species
- *Nigronia*: Neunzig* (1966)/Species

Neuroptera
- Generic Keys: Merritt and Cummins* (1984)/Genus

Trichoptera
- Generic keys: Wiggins* (1977)/Genus
- *Hydropsyche*: Schefter et al.* (1986)/Genus
  - Schuster and Etnier (1978)/Species
- *Rhyacophila*: Flint* (1962)/Species
- *Nectopsyche*: Haddock* (1977)/Species

Lepidoptera
- Generic Keys: Merritt and Cummins* (1984)/Genus

Coleoptera
- Generic Keys: Hilsenhoff (1982), Merritt and Cummins* (1984)/Genus
- Dryopoidea: Brown* (1972)/Species

Diptera
- Generic Keys: McAlpine et al.* (1981) (exc. Chironomidae)/Genus
- Simuliidae: Stone* (1964)/Species
- Chironomidae
  - Generic Keys: Wiederholm* (1983)/Genus
  - *Ablabesmyia*: Roback* (1985)/Species
  - *Clinotanypus*: Roback* (1976)/Species
  - *Coelotanypus*: Roback* (1974)/Species
  - *Labrundinia*: Roback* (1987)/Species
  - *Natarsia* and *Psectrotanypus*: Roback* (1978)/Species
  - *Nilotanypus*: Roback* (1986)/Species
  - *Tanypus*: Roback* (1977)/Species
  - *Pagastia*: Oliver and Roussel* (1982)/Species
  - *Monodiamesa*: Saether* (1973)/Species
  - *Brillia*: Oliver and Roussel* (1983)/Species
  - *Eukiefferiella* and *Tvetenia*: Bode* (1983)/Species group
  - *Nanocladius*: Saether* (1977)/Species
  - *Orthocladius* (*Orthocladius*): Soponis* (1977)/Species
  - *Axarus*: Roback* (1963)/Species
  - *Dicrotendipes*: Epler* (1987)/Species
  - *Endochironomus*, Tribelos, and Endotribelos: Grodhaus*(1987)/Species
  - *Paracladopelma* and *Saetheria*: Jackson* (1977)/Species
  - *Polypedium* (*Polypedilum*): Maschwitz* (1976)/Species
  - Other Species keys: Simpson and Bode* (1980)/Species
- Tabanidae: Pechuman et al.* (1983)/Species
- Athericidae: Webb (1977)*/Species
- Muscidae: Johannsen* (1935)/Species

Mollusca
- Gastropoda: Burch* (1982)/Species
- Pelecypoda: Burch* (1972)/Species

2) Macroinvertebrate Data Analysis

a) *Invertebrate Community Index*

The principle measure of overall macroinvertebrate community condition used by the Biological Field Evaluations Group is the Invertebrate Community Index (ICI), a measurement derived in-house from information collected over many years. The ICI is a modification of the Index of Biotic Integrity (IBI) for fish developed by Karr (1981). The ICI consists of ten structural community metrics, each with four scoring categories of 6, 4, 2, and 0 points (Table V-1-3). The point system evaluates a sample against a database of 247 relatively undisturbed reference sites throughout Ohio. Six points will be scored if a given metric has a value comparable to those of exceptional stream communities, 4 points for those metric values characteristic of more typical good communities, 2 points for metric values slightly deviating from the expected range of good values, and 0 points for metric values strongly deviating from the expected range of good values. The summation of the individual metric scores (determined by the relevant attributes of an invertebrate sample with some consideration given to stream drainage area) results in the ICI value. Metrics 1-9 are all generated from the artificial substrate sample data while Metric 10 is based solely on the qualitative sample data. More discussion of the derivation of the ICI including descriptions of each metric and the data plots and other information used to score each metric can be found in Ohio EPA (1987).

Table V-1-3. Invertebrate Community Index (ICI) Metrics and Scoring Criteria Based on Macroinvertebrate Community Data From 247 Reference Sites Throughout Ohio.

Metric	Scoring Criteria 0	2	4	6
1. Total Number of Taxa	Scoring of each metric varies with drainage area; see Ohio EPA (1987).			
2. Total Number of Mayfly Taxa				
3. Total Number of Caddisfly Taxa				
4. Total Number of Dipteran Taxa				
5. Percent Mayflies				
6. Percent Caddisflies				
7. Percent Tribe Tanytarsini Midges				
8. Percent Other Dipterans and Non-Insects				
9. Percent Tolerant Organisms				
10. Total Number of Qualitative Ephemroptera, Plecoptera, and Trichoptera (EPT) Taxa				

b) *Community Similarity Index*

A coefficient of similarity (c) between two stations can be calculated using Van Horn's (1950) equation modified from the general formula described by Gleason (1920):

$$c = \frac{2w}{a + b}$$

The variables in this expression can be based either on the number of taxa present or absent at each station or on actual numerical data collected at each site. If the presence/absence method is being used:

a = the number of taxa collected at one station,
b = the number of taxa collected at the other station, and
w = the number of taxa common to both stations.

When actual numerical data are being used, each taxon is assigned a prominence value calculated by multiplying the density of the taxon by the square root of its frequency of occurrence (Beals, 1961; Burlington, 1962). In this case:

a = the sum of the prominence values of all of the taxa at one station,
b = the sum of the prominence values of all of the taxa at the other station, and
w = the sum of the prominence values of all of the taxa of one station which it has in common with the other station. The lower of the two resulting values of w is used in the equation.

c) Rank Correlation Coefficient

A rank correlation coefficient between measured biological, chemical, or other physical data can be calculated using the formula defined by Spearman (1904):

$$r_s = 1 - \frac{6 \sum_{i=1}^{n} D_i^2}{n(n^2 - 1)}$$

where n = the number of paired observations ($x_i y_i$) and
D_i = the rank of x_i minus the rank of y_i.

d) Coefficient of Variation

In cases where replicate analyses are conducted (e.g., litigation purposes or NAWQMN stations), a coefficient of variation between replicates is determined following the procedures outlined by Li (1964) using the formula:

$$CV = \frac{s}{\bar{x}} \times 100$$

where s = the sample standard deviation and:
x = the sample mean.

Part D

Laboratory Methods and Data Analysis - Qualitative Sampling

Samples are entered and logged as outlined in Subsection 1, part c. Samples are examined using a dissecting microscope and a tabulated listing of the organisms identified is compiled. Dipterans of the family Chironomidae are prepared as outlined in Subsection 1, Part c. Taxonomic guides used for final identifications are the same as listed in Subsection 1, Part c. Assessment of the macroinvertebrate community condition is finalized using the preliminary assessment made in the field tempered with information on taxa richness and composition from the laboratory identified sample.

References

Allen, R.K. and G.F. Edmunds. 1961. A revision of the genus Ephemerella (Ephemeroptera: Ephemerellidae). III. The subgenus Attenuatella. J. Kansas Entomol. Soc. 34:161-173.

Allen, R.K. and G.F. Edmunds. 1962. A revision of the genus Ephemerella (Ephemeroptera: Ephemerellidae). IV. The subgenus Danella. J. Kansas Entomol. Soc. 35:333-338.

Allen, R.K. and G.F. Edmunds. 1962. A revision of the genus Ephemerella (Ephemeroptera: Ephemerellidae). V. The subgenus Drunella in North America. Misc. Pub. Entomol. Soc. Amer. 3:147-179

Allen, R.K. and G.F. Edmunds. 1965. A revision of the genus Ephemerella (Ephemeroptera: Ephemerellidae). VIII. The subgenus Ephemerella in North America. Misc. Pub. Entomol. Soc. Amer. 4:243-282.

Allen, R.K. and G.F. Edmunds. 1963. A revision of the genus Ephemerella (Ephemeroptera: Ephemerellidae). VII. The subgenus Eurylophella. Can. Entomol. 95:597-623.

Allen, R.K. and G.F. Edmunds. 1963. A revision of the genus Ephemerella (Ephemeroptera: Ephemerellidae). VI. The subgenus Serratella in North America. Ann. Entomol. Soc. Amer. 56:583-600.

Beals, E. 1961. Forest bird communities in the Apostle Islands of Wisconsin. The Wilson Bulletin 72(2):156.

Bednarik, A.F. and W.P. McCafferty. 1979. Biosystematic revision of the genus Stenonema (Ephemeroptera: Heptageniidae). Can. Bull. Fish. and Aquatic Sci. 201:1-73.

Bode, R.W. 1983. Larvae of North American Eukiefferiella and Tvetenia (Diptera: Chironomidae). N.Y. St. Mus. Bull. 452. 40p.

Brown, P. 1972. Aquatic dryopoid beetles (Coleoptera) of the United States. Water Pollution Control Research Series. Biota of Freshwater Ecosystems Identification Manual No. 6, USEPA.

Burch, J.B. 1972. Freshwater sphaeriacean clams (Mollusca: Pelecypoda) of North America. Water Pollution Control Research Series. Biota of Freshwater Ecosystems Identification Manual No. 3, USEPA.

Burch, J.B. 1982. Freshwater snails (Mollusca: Gastropoda) of North America. EPA-600/3-82-026, April 1982. U.S. EPA, Cincinnati, Ohio.

Burks, B.O. 1953. The mayflies or Ephemeroptera of Illinois. Bull. Ill. Nat. Hist. Survey 26(1).

Burlington, R.F. 1962. Quantitative biological assessment of pollution. J. Water Poll. Contr. Fed. 34:179-183. Cuyler, R.D. 1958. The larvae of Chauliodes Latreille (Megaloptera: Corydalidae) Ann. Entomol. Soc. Amer. 51:582-586.

Edmunds, G.F., S.L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. Univ. of Minnesota Press.

Epler, J.H. 1987. Revision of the Nearctic Dicrotendipes Kieffer, 1913 (Diptera: Chironomidae). Evol. Monogr. No. 9. 102 p. plus 37 plates.

Flint, O.S. 1962. Larvae of the caddisfly genus Rhyacophila in eastern North America (Trichoptera: Rhyacophilidae). Proc. U.S. Nat. Mus. 113:465-493.

Gleason, H.A. 1920. Some applications of the quadrat method. Torrey Bot. Club Bull. 47:21-33.

Grodhaus, G. 1987. Endochironmus Kieffer, Tribelos Townes, Synendotendipes, n. gen., and Endotribelos, n. gen.(Diptera: Chironomidae) of the Nearctic region. J. Kansas Ent. Soc, 60 (20): 167-247.

Haddock, J.D. 1977. The biosystematics of the caddisfly genus Nectopsyche in North America with emphasis on the aquatic stages. Amer. Midl. Nat. 98:382-421.

Hitchcock, S.W. 1974. Guide to the insects of Connecticut. Part VII. The Plecoptera or stoneflies of Connecticut. Bul. State Geol. Natur. Hist. Surv. Conn. 107:1-262.

Holsinger, J.R. 1972. The freshwater amphipod crustaceans (Gammaridae) of North America. Water Pollution Control Research Series. Biota of Freshwater Ecosystems Identification Manual No. 5, USEPA.

Jackson, G.A. 1977. Nearctic and Palearctic Paracladopelma Harnisch and Saetheria n. gen. (Diptera: Chironomidae). J. Fish. Res. Bd. Can. 34:1321-1359.

Jezerinac, R.F. and R.F. Thoma. 1984. The illustrated key to the Ohio Cambarus and Fallicambarus (Decapoda: Cambaridae) with comments and a new subspecies record. Ohio J. Sci. 84:120-125.

Jezerinac, R.F. 1978. Key to the first form male Procambarus and Orconectes (Decapoda: Cambaridae) of Ohio. Unpublished.

Johannsen, O.A. 1935. Aquatic Diptera. Part II. Orthorrhapha - Brachycera and Cyclorrhapha. Mem. Cornell Univ. Agric. Exp. Sta. 177:1-62.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6(6): 21-27

Klemm, D.J. 1982. Leeches (Annelida: Hirudinea) of North America. EPA-600/3-82-025, April 1982. U.S. EPA, Cincinnati, Ohio.

Li, J.C.R. 1964. Statistical inference, Vol. I. Edwards Brothers, Inc. Ann Arbor, Michigan. 658 p. Lloyd, M. and R.J. Ghelardi. 1964. A table for calculating the "equitability" component of species diversity. J. Anim. Ecol. 33:217-225.

Maschwitz, D.E. 1976. Revision of the Nearctic species of the subgenus Polypedilum (Chironomidae: Diptera). Doctoral Dissertation, University of Minnesota. 325 pp.

Mason, W.T. 1973. Introduction to the study of chironomid larvae. Nat. Environmental Res. Center, USEPA.

McAlpine, J.F., B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth and D.M. Wood (coordinators). 1981. Manual of Nearctic Diptera. Volume 1. Agr. Can. Monogr. No. 27. 674 pp.

McCaffety, W.P. 1975. The burrowing mayflies (Ephemeroptera: Ephemeroidea) of the United States. Trans. Amer. Entomol. Soc. 101:447-504.

Merritt, R.W. and K.W. Cummins (eds.). 1984. An introduction to the aquatic insects of North America (second edition). Kendall/Hunt Publishing Co., Dubuque. 722p.

Morihara, D.K. and W.P. McCafferty. 1979. The Baetis larvae of North America (Ephemeroptera: Baetidae). Trans. Amer. Entomol. Soc. 105:139-221.

Needham,J.G. and M.J. Westfall,Jr. 1955. A manual of the dragonflies of North America (Anisoptera) including the Greater Antilles and the provinces of the Mexican border. Univ. Calif. Press, Berkeley. 615 p.

Neunzig, H.H. 1966. Larvae of the genus Nigronia Banks (Neuroptera: Corydalidae). Proc. Entomol. Soc. Wash. 68:11-16.

Ohio EPA. 1987. Biological criteria for the protection of aquatic life: Vol. II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Monitoring and Assessment, Surface Water Monitoring Section. Columbus, Ohio. 119 p.

Oliver, D.R. and M.E. Roussel. 1982. The larvae of Pagastia Oliver (Diptera: Chironomidae) with descriptions of three Nearctic species. Can. Entomol. 114:849-854.

Oliver, D.R. and M.E. Roussel. 1983. Redescription of Brillia Kieffer (Diptera: Chironomidae) with descriptions of Nearctic species. Can. Entomol. 115:257-279.

Pechuman, L.L., D.W. Webb and H.J. Teskey. 1983. The Diptera, or true flies, of Illinois I. Tabanidae. Bull. Ill. Nat. Hist. Sur. 331:1-122.

Pennak, R.W. 1978. Freshwater invertebrates of the United States. The Ronald Press Co., New York.

Resh, V.H. 1976. The biology and immature stages of the caddisfly genus Ceraclea in eastern North America (Trichoptera: Leptoceridae). Ann. Entomol. Soc. Amer. 69:1039-1061. Roback, S.S. 1963. The genus Xenochironomus (Diptera: Tendipedidae) Kieffer, taxonomy and immature stages. Trans. Amer. Entomol. Soc. 88:235-245.

Roback, S.S. 1974. The immature stages of the genus Coelotanypus (Chironomidae: Tanypodinae: Coelotanypodini) in North America. Proc. Acad. Natur. Sci. Philadelphia. 126:9-19.

Roback, S.S. 1976. The immature chironomids of the eastern United States I. Introduction and Tanypodinae - Coelotanypodini. Proc. Acad. Natur. Sci. Philadelphia. 127:147-201.

Roback, S.S. 1977. The immature chironomids of the eastern United States II. Tanypodinae - Tanypodini. Proc. Acad. Natur. Sci. Philadelphia. 128:55-87.

Roback, S.S. 1978. The immature chironomids of the eastern United States III. Tanypodinae - Anatopyniini, Macropelopiini and Natarsiini. Proc. Acad. Natur. Sci. Philadelphia. 129:151-202.

Roback, S.S. 1985. The immature chironomids of the eastern United States VI. Penaneurini - Genus Ablabesmyia. Proc. Acad. Natur. Sci. Philadelphia. 137(2):153-212.

Roback, S.S. 1986. The immature chironomids of the eastern United States VIII. Pentaneurini- genus Nilotanypus, with the description of a new species from Kansas. Proc. Acad. Nat. Sci. Philadelphia. 138(2): 443-465.

Roback, S.S. 1987. The immature chironomids of the eastern United States IX. Pentaneurini - Genus Labrundinia, with the description of some Neotropical material. Proc. Acad. Nat. Sci. Philadelphia. 139: 159-209.

Ross, H. 1944. The caddisflies or Trichoptera of Illinois. Bull. Ill. Nat. Hist. Survey. 23(1).

Saether, O.A. 1973. Taxonomy and ecology of three new species of Monodiamesa Kieffer, with keys to Nearctic and Palaerctic species of the genus (Diptera: Chironomidae). J. Fish. Res. Bd. Can. 30:665-679.

Saether, O.A. 1977. Taxonomic studies on Chironomidae: Nanocladius, Pseudochironomus, and the Harnischia complex. Bull. Fish. Res. Bd. Can. 196:1-143.

Schefter, P.W., G.B. Wiggins, and J.D. Unzicker. 1986. A proposal for assignment of Ceratopsyche as a subgenus of Hydropsyche, with new synonyms and a new species (Trichoptera: Hydropsychidae). J.N. Am. Benthol. Soc. 5(1):67-84.

Schuster, G.A. and D.A. Etnier. 1978. A manual for the identification of the larvae of the caddisfly genera Hydropsyche Pictet and Symphitopsyche Ulmer in eastern and central North America (Trichoptera: Hydropsychidae). EPA-600/4-78-060, October 1978. USEPA, Cincinnati, Ohio.

Shannon, C.E. 1948. A mathematical theory of communication. Bell. Sys. Tech. J. 27:379-423.

Simpson, K.W. and R.W. Bode. 1980. Common larvae of Chironomidae (Diptera) from New York State streams and rivers. Bull. No. 439, New York State Education Dept., Albany. 105 p.

Simpson, K.W., R. W. Bode and P. Albu. 1983. Keys for the genus Cricotopus adapted from "Revision der Gattung Cricotopus van der Wulp und ihrer Verwandten (Diptera, Chironomidae)" by M. Hirvenoja. N.Y. St. Mus. Bull. 450, 133 pp.

Soponis, A.R. 1977. A revision of the Nearctic species of Orthocladius (Orthocladius) van der Wulp (Diptera: Chironomidae). Mem. Entomol. Soc. Can. No. 102:1-187.

Spearman, C. 1904. The proof and measurement of association between two things. Am. J. Psych. 15:72-101.

Stark, B.P. 1986. The Nearctic species of Agnetina (Plecoptera: Perlidae). Jour. Kansas Entomol. Soc. 59(3): 437-445.

Stewart, K.W. and B.P. Stark. 1988. Nymphs of North American stonefly genera (Plecoptera). Thomas Say Foundation Series 12: 1-436.

Stone, A. 1964. Guide to the insects of Connecticut. Part VI. The Diptera or true flies of Connecticut. Fasc. 9. Families Simuliidae and Thaumaleidae. Bull. Conn. State Geol. Nat. Hist. Surv. 97:1-123.

Van Horn, W.M. 1950. The biological indices of stream quality. Proc. 5th Ind. Waste Conf., Purdue Univ., Est. Ser. 72:215.

Walker, E.M. 1953. The Odonata of Canada and Alaska. Vol. 1: I. General. II. The Zygoptera - damselflies. Univ. Toronto Press, Toronto. 292 pp.

Walker, E.M. 1958. The Odonata of Canada and Alaska. Vol. 2. Univ. of Toronto.

Walker, E.M. and P.S. Corbett. 1975. The Odonata of Canada and Alaska. Vol. 3. Univer. of Toronto.

Webb, D.W. 1977. The Nearctic Athericidae (Insecta: Diptera). J. Kans. Entomol. Soc. 50:475-495.

Weber, C.I. (ed.). 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA-670/4-73-001, July 1973. USEPA, Cincinnati, Ohio.

Wiederholm, T. (ed.). 1983. Chironomidae of the Holarctic region. Keys and diagnoses. Vol. 1 Larvae. Ent. Scand. Suppl. No. 19, 457 pp.

Wiggins, G. B. 1977. Larvae of the North American caddisfly genera (Trichoptera). Univ. Toronto Press.

Williams, W.D. 1972. Freshwater isopods (Asellidae) of North America. Water Pollution Control Research Series. Biota of Freshwater Ecosystems Identification Manual No. 7, USEPA.

Subsection 4. Fish

Part A) Training
- 1) Sampling Methods
- 2) Species Identification

Part B) Field Methods
- 1) Sampling Site Selection
- 2) Fish Sampling Procedures
  - a) Introduction
  - b) Pulsed D.C. Electrofishing Methods and Equipment
  - c) Passive Gear Methods and Equipment
- 3) Field Counting and Weighing Procedures
  - a) Handling Live Specimens
  - b) Field Identification
  - c) Weighing
  - d) External Anomalies
- 4) Sampling Site Evaluation
  - a) Geographical Information
  - b) Habitat Characteristics: Qualitative Habitat Evaluation Index (QHEI)
  - c) Additional Information

Part C) Laboratory Methods
- 1) Handling Preserved Specimens
  - a) Preservation
  - b) Laboratory Identification and Verification
  - c) Disposition
- 2) Data Handling and Analysis
  - a) Data Sheets
  - b) Data Storage and Compilation
  - c) Analytical Methods

Part A) Training

1) *Sampling Methods*

All new full-time field personnel in the Fish Evaluation Group receive in-house training in the following procedures prior to the start of the field season. A senior staff member also accompanies the new field crew leader for at least the first two weeks of the field sampling season (and thereafter if necessary) instructing in all aspects of the field sampling. Individuals are then permitted to proceed on their own with periodic conferences with the Fish Evaluation Group supervisor to assure the sampling effort is being conducted in accordance with the procedures described herein.

New part-time summer field personnel receive copies of the fish section of the Quality Assurance Manual (Subsection 4) and are given pre-field season training on the procedures involved in the fish sampling program for a one week period prior to the field season.

2) Species Identification

All new field personnel, summer or full-time, are given a test consisting of a collection of different Ohio fish species to identify and count to determine their familiarity with Ohio fish taxonomy and their ability to accurately count large numbers of fish. Full-time field crew leaders perform or supervise *all* of the actual field identifications and counts with the summer personnel assisting.

Part B) Field Methods

1) *Sampling Site Selection*

The selection of fish sampling sites is based upon several factors including, but not limited to, the following:

1) location of point source dischargers;
2) stream use designation evaluation issues;

3) location of physical habitat features (e.g. dams, changes in geology, changes in stream order, presence of a stream confluence, etc.);
4) location of nonpoint sources of pollution; and,
5) variations in macrohabitat.
6) proximity to ecoregion boundaries.

Each study area has a set number of biological sampling sites allocated based on the number and complexity of the priority issues requiring field evaluation. Optimum placement of sampling sites is determined recognizing practical access and resource constraints. The principal objectives of each survey determine where sampling sites will be located. Generally, sites are located upstream from all pollution sources to determine the background condition for the study area. Should the upstream portion of the stream be impacted, an alternate site may be chosen on an adjacent stream with similar watershed characteristics. Reference sites within the same ecoregion may also be used in this role (these are listed in Ohio EPA 1987). The role of upstream sites is not necessarily to provide a biological performance level against which downstream sites are compared since the ecoregion biocriteria fill this niche for the respective aquatic life use designations. Upstream sites are, however, important in defining any site or watershed specific background conditions that might temporarily or permanently influence eventual aquatic life use attainment in the downstream reaches. Selection of sampling sites within a segment is accomplished by selecting the most *typical* habitat available in an effort to represent the current potential of that segment. An attempt should be made to sample typically similar macrohabitats at all sampling sites established within the study area.

To address point source discharge concerns, at least one site is situated upstream from the primary process wastewater outfall(s), one within the mixing zone, and sites located at intervals downstream from the mixing zone (i.e. dependent on stream size and mixing characteristics) to determine the near and far field impacts, the longitudinal extent and severity of any impact, and to determine if and where recovery occurs. Spacing of the downstream sampling sites is based on physical macrohabitat characteristics, access to the segment, other adjacent point and nonpoint sources, stream size, and other factors. An attempt is made to place sampling sites between point sources where sufficient distance between each exists. Sampling sites may also be situated in the mouths of major tributaries to determine any potential effects on the mainstem. Localized areas of macrohabitat modification such as instream impoundments or channelized sections alter macrohabitat available for fish and can affect community structure and function. Generally, these areas are not *typical* of the macrohabitat in a free-flowing river or stream. However, these areas are often times impacted by the principal sources targeted for evaluation in certain study areas (particularly in urban areas), therefore, sampling sites are located within these modified areas as needed. These areas should be sampled in order to understand the underlying influence that they exert on biological performance and eventual aquatic life use attainment.

2) Fish Sampling Procedures

a) Introduction

The principal method used by Ohio EPA to obtain fish relative abundance and distribution data is pulsed direct current electrofishing. As with any single method there exists inherent sampling selectivity and sampling bias. Pulsed D.C. electrofishing is, however, widely viewed as the single most effective method for sampling fish communities in lotic habitats. Twelve different fish sampling techniques have been assigned sampler type codes. Six codes are currently recognized as valid for generating fish relative abundance data for the purpose of calculating Index of Biotic Integrity (IBI) and Modified Index of Well-

Being (Iwb) scores from which aquatic life use attainment is partially judged (Table V-4-1). The remaining codes are assigned to seldom used or currently experimental methods. This system of letter codes superceded a system of numerical codes used prior to 1984. The use of any one of these sampling methods is dependent on the type of information required and the type of aquatic habitat being sampled. Since 1979 certain methods have been modified or abandoned (e.g. seining). The boat mounted and wading electrofishing methods are the most commonly used fish sampling techniques by Ohio EPA in lotic habitats. The boat electrofishing methods (sampler type A) are used to sample the largest streams and rivers (Table V-4-1). Wading methods (sampler types D, E, and F) are used in wadable streams. These are the most frequently used sampler types and are regarded as suitable for calculating IBI and modified Iwb scores (Ohio EPA 1987). Sampler type B (18' boat, circular electrode array) is used in the deeper rivers (e.g. Ohio River) and embayments (e.g. Lake Erie tributary river mouths). This is also considered to be an acceptable method. Sampler type C is used in free-flowing rivers to sample riffle habitats. This method is used only to supplement the boat methods and the data is not used to calculate the IBI or modified Iwb. Sampler types G and H are seining methods and are no longer in routine use. The fyke net and hoop net methods (types I and J) may be necessary in lentic, wetland, or large river habitats. The experimental gill net method (type K) may be necessary to sample for mid-channel and pelagic species. These *passive* methods (types I through K) are seldom used and only in special situations to supplement routine electrofishing sampling.

Fish sampling is preferably conducted between mid-June and early October, when stream and river flows are generally low, pollution stresses are potentially the greatest, and the fish community is most stable and sedentary. Sampling may be conducted outside of this time period, but the results may not be applicable for Ohio EPA biocriteria purposes. The use and applicability of this data will be evaluated on a case-by-case basis. Special studies are conducted by the Fish Evaluation Group on a periodic basis to determine the effectiveness of each sampling method, comparability of methods, necessary sampling frequency, evaluate new and emerging techniques, and to better understand gear selectivity and effectiveness.

Table V-4-1. Designation of sampler types and description of fish sampling methods used by Ohio EPA (revised June 1, 1984).

Sampling Method Description	Sampler Type	Relative Abundance Based On	Data Collected #	Data Collected Wt[a]
Boat-mounted electro-fishing - *straight electrode array*	A	Per 1.0 km	X	X
Boat-mounted electro-fishing - *circular electrode array*	B	Per 1.0 km	X	X
Boat longline - riffle method)[b]	C	Per 0.3 km	X	X
Sportyak-generator unit	D	Per 0.3 km	X	X
Longline generator unit	E	Per 0.3 km	X	X
Back-pack electro-fishing - battery unit	F	Per 0.3 km	X	X
Backpack electrofishing-seine combination[c]	G	Per 0.3 km	X	
Seines[d]	H	Per 0.3 km	X	
Fyke net[d]	I	Per 24 hours	X	X
Hoop net[d]	J	Per 24 hours	X	X
Gill net[d]	K	Per 24 hours	X	X
Boat-mounted electro-fishing - *straight electrode array* NIGHT	N	Per 1.0 km	X	X
Boat mounted electro-fishing - *circular electrode array* NIGHT	M	Per 1.0 km	X	X
Reserved	L-Z[e]			

[a]Weight data is taken if modified Iwb is needed.

[b]Experimental method in conjunction with sampler type A.

[c]Discontinued method .

[d]Method is not suitable for calculating IBI or modified Iwb scores.

[e]These codes are available for methods developed in the future.

b) Pulsed D.C. Electrofishing Methods and Equipment:

Selection of the Appropriate Sampler Type

Selection of the appropriate sampler type is dependent upon the type of data needed, the type of macrohabitat being sampled, and the size and *depth* of the water body being sampled. This is a critical part of the sampling process since data quality essentially determines data applicability for the purposes of evaluating attainment of aquatic life uses. Thus it is important that the appropriate sampler type be used.

Boat electrofishing methods (sampler type A) are used in moderate to large sized streams and rivers where the use of wading methods are both impractical and less efficient. These include streams and rivers that have pools deep enough to accommodate the 12', 14', or 16' boats and equipment. Sites sampled with the boat methods are referred to as *boat sites*. The usual drainage area range of boat sites is 150 to more than 6000 sq. mi. although the 12' boat method has been used for sites as small as 75 sq. mi. where pool depths exceed 1.5 - 2.0 m and greater. This situation is the most frequently encountered in the Western Allegheny Plateau ecoregion (southeastern Ohio). The 12' electrofishing boat is the smallest of the boat-mounted devices and is used in moderate sized streams that generally cannot be navigated by the larger boats, usually 150 - 400 sq. mi. drainage area. The 14' and 16' electrofishing boats are used in larger rivers where near continuous navigation is possible (usually greater than 400 - 500 sq. mi.). The 18' boat electrofishing method is designed for use in the largest and deepest rivers, impoundments, and embayments. This boat employs either a straight (sampler type A) or circular (sampler type B) electrode array. Night electrofishing may be appropriate for the largest rivers (e.g., Ohio River, impounded sections of the Muskingum R.) where the drainage area exceeds 6000 - 7000 sq. mi. Depending on the electrode array used this method is termed sampler type N (straight array) or sampler type M (circular array).

Wading methods are used in smaller, wadable streams that cannot accommodate the boat methods due to the physical limitations of the stream channel. These are referred to as *wading sites* and range from the smallest headwater areas (<20 sq. mi. drainage area) to sites of 400 - 500 sq. mi. The Sportyak-generator method (sampler type D) is used in streams that range in size from 5-20 m in width and 0.5 - 1.0m in depth (average). There is a great deal of overlap in terms of drainage area between the sites where either the wading or boat sampler types may be most appropriate. The key factors in making the choice between these two methods is pool width and depth *and* access for the sampling equipment. The longline-generator method (sampler type E) is used in areas where the pools are separated by shallow riffles which make the use of the Sportyak method impractical. Both methods will sample the same site with equal efficiency. The backpack electrofishing method (sampler type F) is used in very shallow, small headwaters streams where the longline method is not necessary to secure an adequate sample. Streams that are more than five times the width of the anode net ring and more than twice the depth of the same should not be sampled with the backpack method (sampler type F). The seining methods (sampler types G and H) were used in the past, but have been discontinued by Ohio EPA. These sampler types are retained only to accommodate data generated by non-Ohio EPA entities and to make possible the use of historical data. Results generated by these latter methods (sampler types G and H) may not be suitable for determining aquatic life use attainment using the IBI and modified Iwb.

Selection of any of the previously described methods is based on the best professional judgement of the field crew leader and information gathered in a pre-survey

reconnaissance of the stream. Reconnaissance should take place during low-flow conditions if at all possible. Drainage area, stream length, and stream order are good physical indicators which aid in the selection of the appropriate sampling gear. Information to be collected during the reconnaissance includes the general width and depth of the stream, presence of riffles, dams, log jams and other impediments to navigation, access sites, and location of pollution sources and tributaries. All of these factors are used in choosing the appropriate sampler type(s).

General Cautions Concerning Field Conditions

Electrofishing should be conducted *only* during "normal" water flow and clarity conditions. What constitutes "normal" can vary from stream to stream. Generally "normal" water conditions in Ohio occur during *below* annual average river discharge levels. Under these conditions the surface of the water generally will have a "placid" appearance. Abnormally turbid conditions are to be avoided as are elevated flow and current. All of these adversely affect sampling efficiency and may rule out data applicability for calculating the modified Iwb and IBI. Since the ability of the netter to see stunned fish is critical, sampling should take place only during periods of "normal" water clarity and flow. Most Ohio surface waters have some background turbidity due to planktonic algae and suspended sediment and very few, if any, are entirely clear. Rainfall and subsequent runoff can cause increased turbidity due to the increased presence of suspended sediment (clays and silt). In most areas this imparts a light to medium brown coloration in the water. Floating debris such as sticks and other trash are usually obvious on the surface. Visibility under such conditions is seldom more than a few inches. Such conditions should be avoided and sampling should be delayed until the water returns to its "normal" clarity. High flow should be avoided for the obvious safety reasons, but this also reduces sampling efficiency. The boat methods are particularly affected as it becomes more difficult for the driver to maneuver the boat into areas of cover and current heterogeneity. These cautions apply to all of the electrofishing methods.

Boat Electrofishing Methods and Equipment

The boat methods (sampler types A and B) include the use of 12', 14', 16', and 18' john boats rigged for electrofishing. Equipment type, electrode design, and sampling methods follow the rationale and procedures outlined in Gammon (1973, 1976) and Novotny and Priegel (1974). Figure V-4-1 provides a diagrammatic description of the boat apparatus. A Smith-Root Type VI-A[1] or 3.5 GPP electrofishing unit[2] is used in the 12', 14', 16' and 18' boats. The Type VI-A unit rectifies 60HZ 240VAC (which is supplied by a 3500 or 4500 watt gasoline powered alternator) to pulsed DC. The pulse configuration consists of a triangular wave that can be adjusted to 60 or 120 pulses/second. Six voltage settings from 166 to 996 VDC in 166 volt increments are available. The voltage setting used in a particular situation is determined on a trial and error basis by increasing the voltage setting until a pulse width of 4-5 milliseconds produces an amperage reading of 8 amperes. In Ohio waters during June through October, relative conductivity values normally range from 300-600 umhos/cm. This generally results in a voltage selection of 336, 504, or 672 VDC. Conductivity values below this range may require higher voltage settings, whereas higher conductivity values may require lower voltage settings. The Smith-Root Model 3.5 GPP gas powered alternator and pulsator also delivers pulsed DC current. The pulse configuration consists of a fast rise, slow decay pulse which can be interrupted into 30, 60 or 120 pulses/second. The voltage range is continuously variable between 0-1000 volts and is adjusted by a percent-of-range rheostat to maintain the output amperage between 4 and 11 amps.

---

[1] Use of product or company name does not signify endorsement.

[2] Smith-Root, Inc. 14014 N.E. Salmon Creek Ave., Vancouver, Washington 98665.

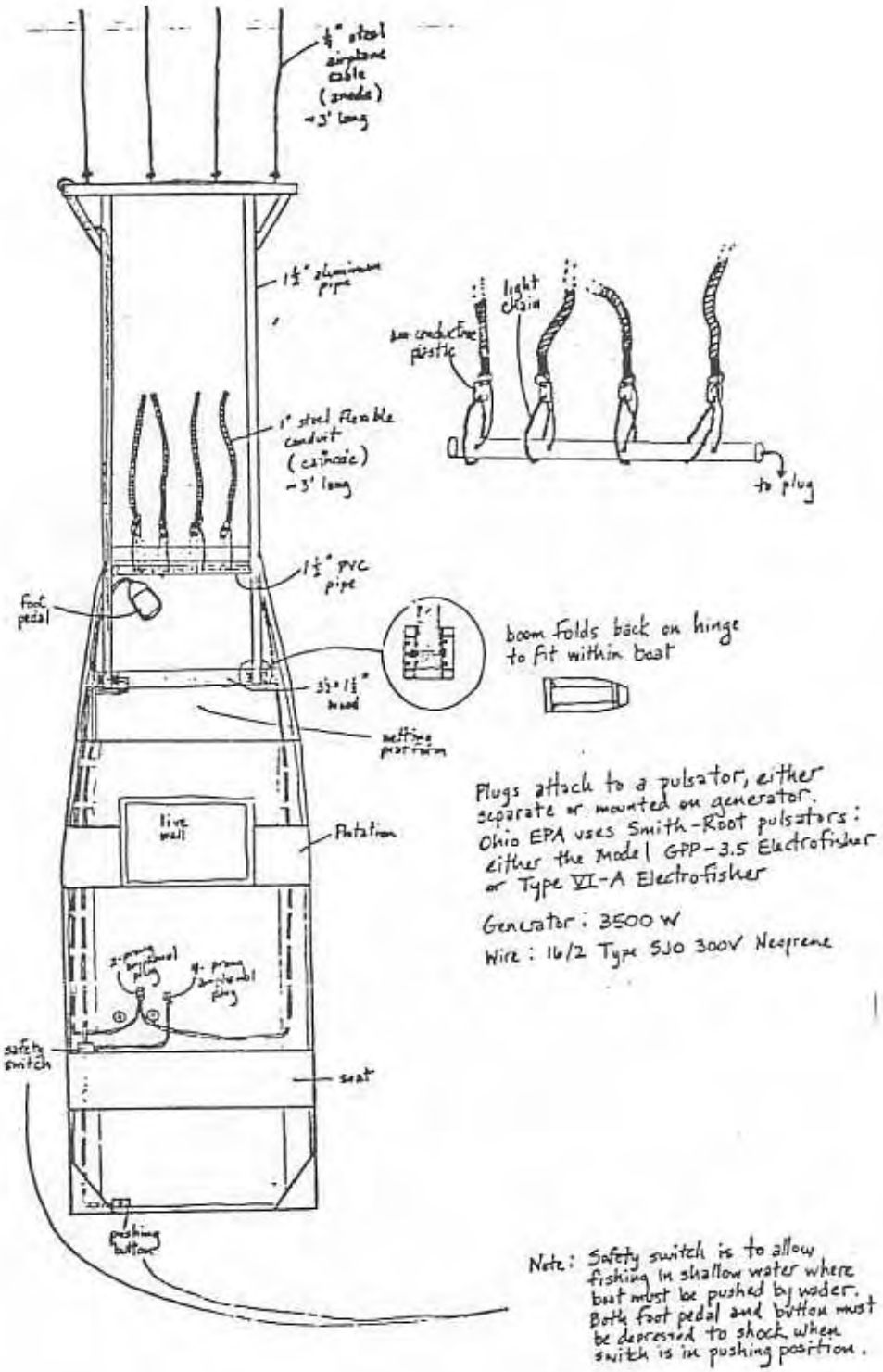

Figure V-4-1. Diagram of the boat electrofishing apparatus used by Ohio EPA to sample large river and stream fish communities.

The optimum range is selected on a trial and error basis by increasing the range until the indicator light flickers. Other comparable pulsed D.C. electrofishing units are acceptable for use as long as their performance is comparable to the aforementioned designs.

Pulsed DC current is transmitted through the water by an arrangement of anodes and cathodes suspended in the water from the boat. On the 12', 14' and 16' boats, four 32" long 1/4" diameter stainless steel aircraft cable anodes are hung from a retractable aluminum boom which extends in front of the boat. Boom length varies according to boat size and is approximately 3.05m on the 18' boat, 2.75m on the 16' boat, 2.15m on the 14' boat, and 2.0m on the 12' boat. Boom width varies from approximately 1.55 to 1.65m being wider on the larger boats. Four anodes are positioned on the front of the boom in a line perpendicular to the length of the boat. Four 64" lengths of 1" O.D. flexible galvanized steel conduit serve as cathodes, and are suspended directly from the bow in a line perpendicular to the length of the boat. The width of this array ranges from 0.75m on the 12' boat to 0.90m on the larger boats. Anodes and cathodes are replaced when damaged or worn. Safety equipment includes a positive pressure cut-off foot-pedal switch located on the bow deck and an emergency toggle cut-off switch adjacent to the stern seat. There is a magnetic-hydraulic circuit breaker on the Type VI-A electrofishing units.

For night electrofishing the equipment includes four 75 watt floodlamps attached to a guardrail which is mounted on the bow. These floodlamps are powered by 120 VAC produced by a separate gasoline powered generator.

A boat sampling crew consists of a *netter* and a *driver*. It is the netter's primary responsibility to capture all fish sighted; the driver's responsibility is to maneuver the boat as effectively as possible giving the netter the *best* opportunity to capture stunned fish (the driver may assist in netting stunned fish that appear at the rear or behind the boat). Both tasks are skill dependent with the boat maneuvering task requiring the most experience to gain adequate proficiency. Each sampling zone is fished in a downstream direction by slowly and steadily maneuvering the electrofishing boat as close to shore and submerged objects as possible by rowing or motoring. This may require *frequent* turning, backing, shifting (forward, reverse), changing speed, etc. in areas of moderate to extensive cover. The electrofishing boat is pushed on the transom by the driver when the water is too shallow to motor or row. A hand actuated positive pressure cut-off switch located on the inside of the transom is used during this procedure in addition to the bow foot-pedal switch. Both the netter and driver are clad in chest waders and rubber gloves. The netter also wears a jacket type personal flotation device. Safety equipment includes a positive pressure cut-off switch located on the bow deck and inside the transom.

Boat Sampling Site Selection

Sampling sites are selected along the shoreline with the most diverse macrohabitat features. This is generally along the gradual outside bends of the larger rivers but is not invariable. In free-flowing habitats part of each zone should include a run-type of habitat *if at all practical*. This of course is determined by the availability of such areas. Boat electrofishing zones generally measure 0.5 kilometers (km) in length, although shorter distances may be necessary in given instances. Distance is measured with a Topometric Products Limited (R) Hip Chain (preferred method) or a Ranging 620 optical rangefinder. Sampling sites are measured by securing the hip chain thread to a stationary object and then wading or motoring the length of the sampling zone. The length of the zone is then measured by the hip-chain counter. When using the optical rangefinder each zone is measured in increments approximating 50 m and accumulated to a distance of 0.5

km. This method is used only with boat methods where the use of the hip chain is impractical. Sampling site locations are verified on 7 1/2 minute USGS topographical maps. Hip chains and rangefinders are calibrated prior to being used in the field on a marked course and adjusted as necessary. The calibration results are recorded in a log book. Water depth in centimeters (cm) is determined to the nearest 10 cm at a minimum of ten locations in each zone with a marked dip net. The average depth is then recorded on the fish data sheet. The boundaries of each electrofishing zone are clearly marked on stationary objects (e.g. trees, bridge piers, etc.) with fluorescent orange paint. The starting point is marked with an arrow pointing in a downstream direction and the ending point is marked with a visible capital "E". This enables accurate relocation of the site on subsequent sampling dates. If the sampling zone is disjunct additional marks are necessary. If the zone stops and then resumes on the same bank then X marks where sampling stops and an arrow indicates where sampling resumes. If the zone switches banks then an arrow pointing skyward indicates the point to switch banks and an arrow pointing down on the opposite shore indicates where the zone resumes. The location of each sampling zone is indexed by river mile (using the river mile index contained in the Ohio EPA PEMSO RMI system) and marked on 7 1/2 minute USGS topographical maps for permanent reference.

Boat Electrofishing Techniques

Each boat sampling zone is electrofished two or three times during the sampling season starting (whenever possible) at the farthest upstream zone and sampling sequentially downstream until one pass is completed. The remaining one or two sequential passes occur later in the sampling season. Sampling passes should take place at least three to four weeks apart for a three pass effort. If only two passes are planned, five to six weeks should elapse between individual sampling passes. Individual sampling zones are electrofished from upstream to downstream by slowly and steadily maneuvering the electrofishing boat as close to the shore and submerged objects as possible. It is absolutely critical to sample *carefully*, particularly at difficult sites where there is extensive woody debris *or* moderately fast to swift current. Figure V-4-2 provides a diagrammatic portrayal of how two different boat electrofishing zones should be sampled. In zones with extensive woody debris and slow current it is necessary to maneuver the boat in and out of the "pockets" of habitat formed by the debris. If the water depth approaches 100-200 cm it is usually necessary to "wait" for the fish to appear. In moderately fast or swift current it is necessary to conduct fast turns and maneuvers in order to put the netter in a good position to capture stunned fish. The efficiency is enhanced if the electrofishing boat and electric field can be kept moving downstream at a pace just slightly greater than the current velocity. Fish are usually oriented into the current and must either swim into the approaching electrical field or turn sideways to escape downstream. This latter movement presents an increased voltage gradient making the fish more susceptible to the electric current. It is often necessary to pass over the fast water sections of these zones twice. Also, portions of zones with continuous fast current can be effectively sampled by "backing" the boat downstream and occasionally pausing to allow the netter to capture stunned fish. The driver may need to assist with netting when large numbers of fish are stunned. Attempting to electrofish such fast water areas in an upstream direction *only* will greatly diminish sampling efficiency.

Although sampling is done according to zone length, the amount of time spent electrofishing each zone is an equally important consideration. Time fished can legitimately vary depending on the current, number of fish being collected, and amount and type of cover within a zone. However, there is a general *minimum* amount of time that should be spent sampling each boat zone.

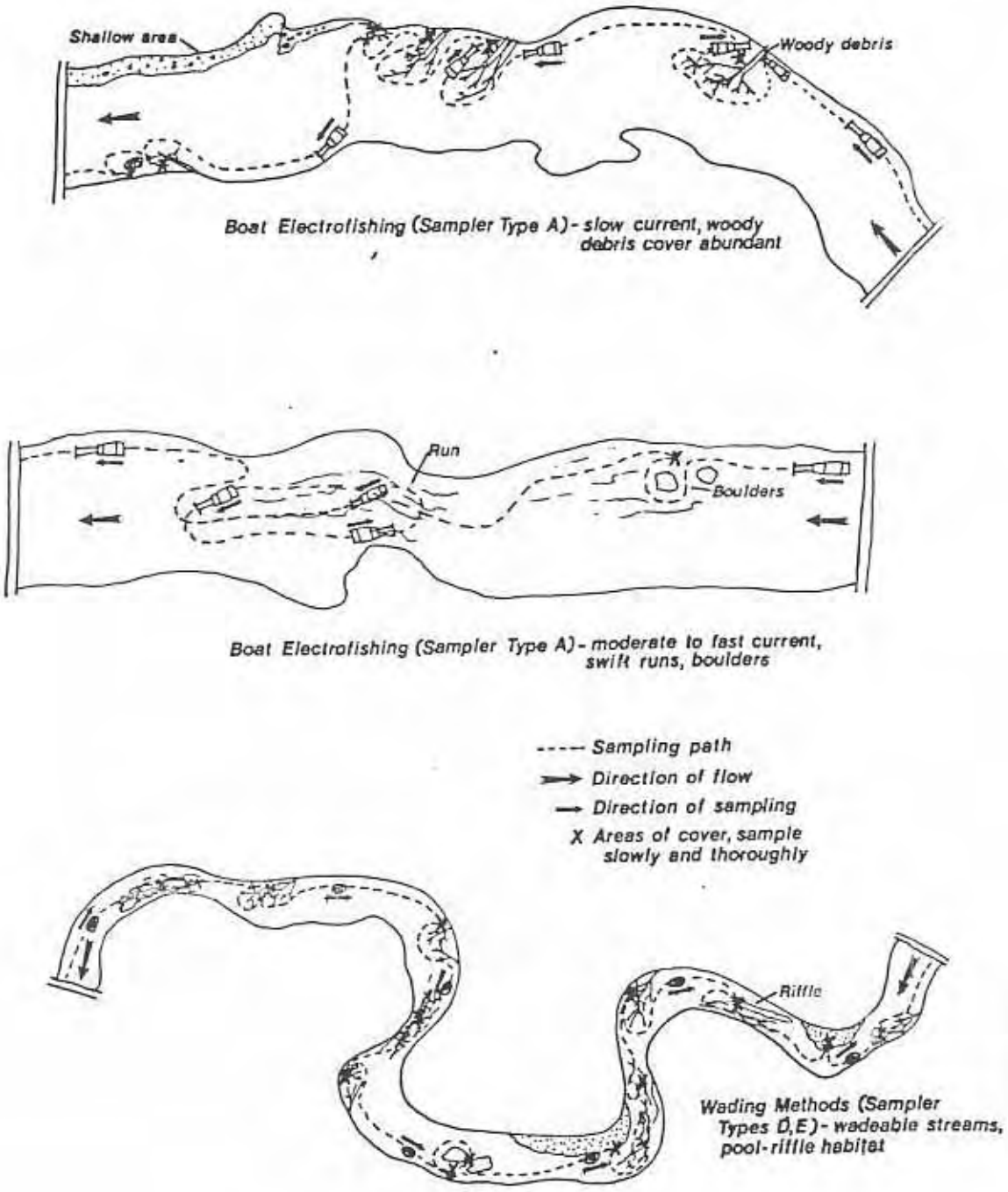

Figure V-4-2. Diagramatic portrayal of proper boat electrofishing technique at two different river sampling locations and wading methods technique in a typical pool-run-riffle stream habitat.

Based on an analysis of 1187 electrofishing samples where time fished was compared to various catch results (lwb, numbers, weight, species) that are sensitive to the relative level of effort expended. Inspection of the results show that *at least* 1300 to 1600 seconds should be spent sampling any 0.5 km boat electrofishing zone. This time will likely increase to more than 2000 seconds in slower flowing zones that have numerous downed trees, logs, and other submerged structure. Moderately fast to swift flowing zones may also take longer to sample since the boat must be maneuvered back upstream to cover such areas thoroughly.

Netters are required to wear a pair of polarized sunglasses to facilitate seeing stunned fish in the water during each electrofishing run. An exception to this is with night sampling where sunglasses are not worn. A boat net with an 2.5m long handle and 7.62mm Atlas mesh knotless netting is used to capture stunned fish as they are attracted to the anode array and/or stunned. An effort is made to capture every fish sighted by both the netter and driver.

Captured fish are immediately placed in an on-board livewell for later processing. Water is replaced regularly in warm weather to maintain adequate dissolved oxygen levels in the water and to minimize mortality.

A field crew consists of a minimum of three persons (whenever possible), a boat driver, a netter, and a support vehicle driver. Limited access to most rivers and streams requires the electrofishing boat to be launched at an upstream point with a two person crew. The third crew member is responsible for maintaining contact with the electrofishing boat and meeting the boat at points downstream. Smaller rivers that are not continuously navigable are sampled by locating put-in-and-take-out access points at each sampling location.

The distance of stream or river covered per day is dependent upon the number of sampling zones and ease of navigation. Generally, four to seven zones can be sampled in a 10 to 20 mile segment each day. Relative abundance data collected with this method is expressed as numbers/km and weight (kg)/1.0 km.

The 18' electrofishing boat can be used with either a standard straight electrode array (sampler type A) or with a circular electrode array (sampler type B). The circular array is outfitted according to the specifications listed in Novotny and Priegel (1974). Anode configuration is circular and can be altered by adding or removing electrodes or changing the surface area exposure of each electrode depending on the conductivity of the water. Anodes are added in very low conductivity water less than (100-150 umhos) or removed in extremely high conductivity water greater than (900 umhos). These sampling methods are being tested in rivers where average sampling zone depth is consistently deeper than 150-200 cm (e.g. Lake Erie river mouths, lower Muskingum River, Ohio River, etc.) and in lakes, reservoirs, and impoundments. In these larger and deeper water bodies sampling is also conducted at night. Otherwise, sampling is conducted essentially the same as the methods just described for smaller rivers and streams.

Wading Electrofishing Methods and Equipment and Sampling Techniques

The Sportyak-generator wading method (Sampler type D) is used to sample smaller, wadable streams where access by a 12' john boat is not possible. The longline-generator (sampler type E) method is used in streams that are too shallow to sample with the Sportyak-generator method. The backpack electrofishing method (sampler type F) may be used in lieu of the longline-generator method in *only* the smallest headwaters streams following the restrictions that were previously stated. The Sportyak-generator

method (Sampler type D) employs a light, plastic boat with the capacity to carry a small portable generator/pulsator, and livewell. The Ohio EPA presently uses a 2.1 m Sportyak to carry a model 1736 DCV T&J combination generator/pulsator pulsed DC electrofishing unit and a 30 gallon plastic holding tank. The T&J electrofishing unit has the capability to supply 125 or 250 volts pulsed DC at a maximum of 1750 watts. At sites which have pool width and depth characteristics that suggest the need for the 12' boat method, but which is not accessible may require the use of the more powerful Smith-Root 3.5 GPP unit rigged for use with the Sportyak. This arrangement provides the additional power needed to efficiently sample pools that are consistently more than 1m deep and wider than 30-40m. A 15.2cm wide by approximately 45.7cm long stainless steel strip attached from the bow of the Sportyak acts as a cathode. Spring cord attached directly to the T&J unit supplies pulsed direct current to the anode. The anode is the net ring attached to a 1.8m long tubular fiberglass net pole. A positive pressure switch mounted on the net pole must be depressed to complete the switch circuit and allow electrical current to the electrodes (see Figure V-4-3 for a diagrammatic description).

Procedures for sampling require a two or three person crew, all wearing chest waders and rubber gloves. The primary netter operates the anode net ring while one crew member guides the Sportyak and the third crew member assists in capturing fish. This method is also diagrammed in Figure V-4-2. All habitat types are thoroughly sampled in an *upstream* direction for a distance of 150-200 m. The primary netter works the net ring beneath undercut banks, in and around brush piles, log jams, large boulders and other submerged structure. An effective technique for capturing fish under such objects is to thrust the anode ring into and under the structure with the current on and then *quickly* withdraw the anode ring in one swift motion. This has the effect of drawing fish out from under such structure making their capture possible. Sampling effort is usually concentrated on one side of the stream and some switching from one stream bank to the other may be necessary to sample all habitat types. In riffle and run areas the primary netter *rakes* the anode ring from upstream to downstream,allowing it to drift with the current. At the same time the assist netter blocks off an area downstream of the anode ring. This minimizes escape and avoidance of the electrical field by riffle species. When the holding tank is full of fish or sampling is completed the fish are processed (see Fish Counting and Weighing Procedures).

Sampling procedures for the longline method (Sampler type E) are similar. The longline-generator method uses the same electrofishing unit as the Sportyak method. The longline consists of 100 meters of heavily insulated 4-insulator wire. The anode is the net ring (as in the Sportyak method). The cathode is a floating aluminum plate attached 3m behind the net pole. The backpack electrofishing units (Sampler type F) used are a design supplied by the Michigan Department of Natural Resources[3] that produces 100 or 200 VDC (pulsed) or a Coeffelt Model BP-2 electrofishing unit[4] that produces a similar output. Both units are powered by a 12 VDC power source (motorcycle battery). The net ring serves as the anode and is attached to the end of a 1.8m net pole. A positive pressure switch mounted on the net pole is used to turn the unit on and off and as a safety switch. The cathode configuration on the Michigan DNR unit consists of a piece of copper that approximates 1000 cm^2. A 2.4m long section of 3.8mm plastic jacketed stainless steel cable with a 0.3m section exposed at the tip serves as the cathode for the Coeffelt unit. Both are trailed behind the backpack unit which is worn by the primary netter. Batteries are recharged daily and one charge is usually adequate for sampling one location, or 2-3 hours, whichever occurs first.

---

[3]E. Schultz, P.O. Box 225, Grayling, Michigan 49738

[4] .Coeffelt Electronics Co. Inc., 2019 W. Union Ave., Englewood, Colo. 80110.

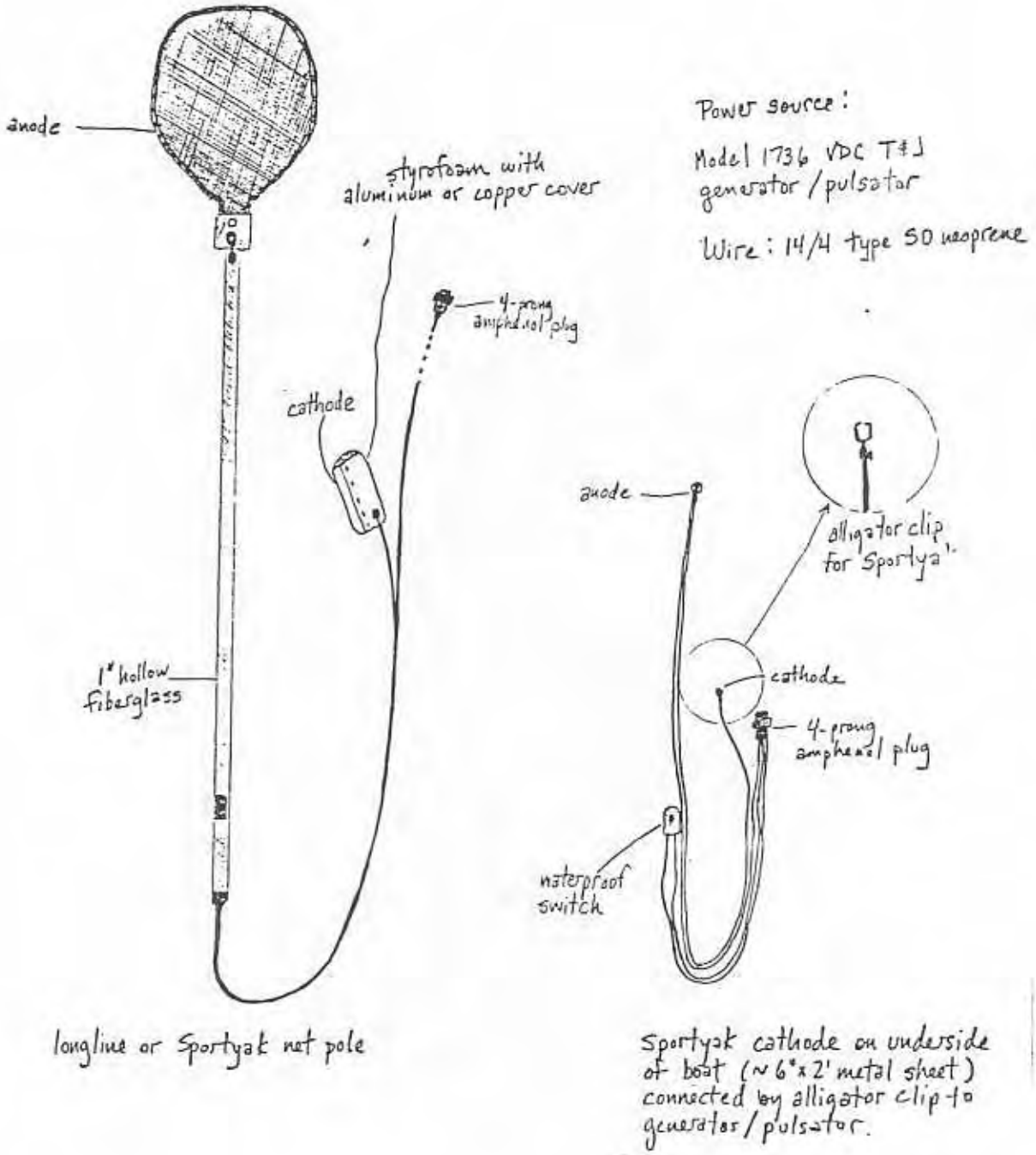

Figure V-4-3. Diagram of the net pole/electrode apparatus used with the Sportyak-generator and long-line electrofishing methods by Ohio EPA to stream fish communities.

Two or three individual sampling passes are preferred with the wading methods although one pass may be sufficient in small streams or certain non-complex situations. The number of passes affects how the catch data and biological indices are used to make environmental evaluations (Ohio EPA 1987). Relative abundance data is expressed in terms of numbers and weight (kg)/0.3km.

Seine Sampling Methods and Equipment and Sampling Techniques

The procedures and equipment used with the backpack electrofishing/seine methods (sampler type G) are generally the same as the backpack electrofishing method (sampler type F), except that seines are used in conjunction with the backpack electrofishing unit. This method was used to generate relative abundance data suitable for calculating the IBI in the years 1977-1981. The use of seines was discontinued in 1982 due to the relatively high degree of variability in the data caused by differing levels of skill between field crews. A detailed description of the methods can be found in earlier versions of this manual. While this method and seines alone may be used by non-Ohio EPA entities to generate fish relative abundance data it may not be acceptable to generate IBI or modified Iwb scores for aquatic life use attainment purposes. This will be evaluated on a case-by-case basis.

c) Passive Gear Methods and Equipment

Passive gear methods are those in which the sampling device is stationary and the capture of fish is dependent on their movements into the sampling device. These methods are not used on a routine basis by Ohio EPA and are considered experimental.

Four types of passive gear (fyke nets, trap nets, modified hoop nets, and gill nets) may be used to supplement boat electrofishing data in large rivers, estuaries, marshes, wetlands, lakes or impoundments. Fyke nets and trap nets are used in shallow water while modified hoop nets and gill nets are used in deep or open water.

Fyke nets (Sampler type I) are used in areas where a side channel can be completely blocked off by the two side leads which "funnel" fish into the net. Locations such as tributaries, marsh channels, or other channels off of the main channel are potential sampling sites. Fyke nets are set by anchoring the cod end just upstream of the channel confluence with the river, with the open end facing the main channel. The two side wings are angled toward the shoreline which blocks as much of the channel as possible. A center lead extends into the main channel helping to guide fish into the net. The Maine fyke net consists of a 4.5m body (11.4mm stretched mesh) supported by five square spring steel frames with three internal throats on the first three frames. Two 9m x 1.2 m wings and one 22.5m center lead are attached to the open end of the net. The cod end and all leads are anchored and floats attached to each anchor.

Trap nets (Sampler type J) are used to sample impoundments and wide river channels with slow velocity conditions. Trap nets are set in structurally complex areas where fish movement and density are anticipated to be highest in order to maximize net catches. One center lead is fastened to shore and the net is set perpendicular to the shore with the cod end anchored and marked with a float. Net dimensions are similar to those of the fyke net except a shorter 15m center lead is used. Modified hoop nets are used when sampling the deeper mid-channel areas. Modified hoop nets have been used to successfully capture fish moving upstream and downstream. By connecting two hoop nets together facing in opposite directions and placing them parallel to the flow, it is possible to discern fish movement in both the upstream and downstream directions. Modified hoop nets are set in

mid-channel parallel to the flow and anchored and marked with floats at both ends.

Gill nets (Sampler type K) are set in open water areas to sample fishes in large rivers, lakes, and impoundments where portions of the fish community are not accessible to shoreline electrofishing. Gill nets can be set at the surface, mid-depth, or on the bottom, depending on the objectives of the sampling and intended target species within the fish community. Gill nets are anchored in open water areas and marked with floats on both ends. Monofilament experimental gill nets are 37.5 m long with 7.5 m panels of 15.2mm, 22.9mm, 25.4mm, 40.6mm, and 50.8mm bar mesh.

All passive gear is checked and emptied 12 to 24 hours after setting. Standard procedures are used to process fish captured by passive gear. Data collected by passive gear can used to determine relative abundance which are expressed as numbers/24 hours and weight (kg)/24 hours. These results *have not* been used by Ohio EPA to calculate IBI and modified Iwb scores for aquatic life use attainment purposes.

3) Field Counting and Weighing Procedures

a) Handling Live Specimens

All sampling methods require placing captured fish in a livewell for processing when sampling each site is complete or when the livewell is full. Water in the livewell is changed as needed to minimize mortality of the captured fish. Fish are released immediately after they are identified *to species*, examined for external anomalies, and, if necessary, weighed. Efforts are made to minimize handling and holding times.

b) Field Identification

The majority of captured fish are identified to species in the field; however, *any* uncertainty about the field identification of individual fish *requires* their preservation for later laboratory identification (see **Part C**). Fish are preserved for future identification in borax buffered 10% formalin and labeled by date, river or stream, and river mile. Identification is required to the *species* level at a minimum and may be necessary to the sub-specific level in certain instances (*e.g.* banded killifish).

The collection techniques used may not be consistently effective for fish less than 15-20 mm in length, thus inclusion in the catch is not recommended. Also, Angermier and Karr (1986) and Angermier and Schlosser (1988) recommend that fish of this size (young-of-the-year) not be included in IBI calculations as they may unduly bias its function as a long-term aquatic ecosystem health measure. Ohio EPA supports this recommendation.

c) Weighing Procedures

For samples of species which are comprised entirely of one size class (*e.g.* adults, juveniles, young-of-the-year), two methods may be used. For larger species (*e.g.* carp, redhorse, most sunfish), where the adult fish are of a similar size, the catch may be weighed as separate individuals *or* in aggregate as a species. All results are recorded on the fish data sheet (Figure V-4-4). For catches with more than 15 individuals per species a *subsample* of 15 fish is weighed as individuals or in aggregate. If there is a *noticeable* variation in sizes between individual fish of a species individual weights should be taken using the subsampling technique if necessary. With smaller species (*e.g.* most minnows and darters) mass weighing in aggregate is recommended. If more than 50 individuals of a species comprise the catch a subsample of at least 50 fish is weighed and the remainder are counted. If extremely high numbers of a particular species are collected and the fish are of a relatively uniform size, the number of individuals may be determined by mass weighing all fish collected and extrapolating the numbers from a counted

Figure V-4-4. Ohio EPA fish field data sheet.

Fish Data Sheet

Field Crew: (Collector) (Recorder) ____________ Time of Day: ______ Page ___ of ___

River/Stream: ____________ Location: ____________

Date: ________

River Code: ________ Sampler Type: ____ Time Fished: ' __ " ___ Total Seconds ______

RM: ________ Depth: ________ Observed Flow: ________

Distance: ________ Data Source: _____ Number of Species: ______

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; M-multiple DELT anomalies; N-blind; P-parasites; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other/ [H-Heavy; L-Light are combined with anomalies A, B, and C]

SPECIES	# WEIGHED	TOTAL COUNTED	WEIGHT (GRAMS)	ANOMALIES

OhioEPA

EPA 4508

Mass Weighing Convention: Total Weight (g) — 536 (12) — Number Weighed

and weighed *subsample*.

Samples that are comprised of two distinct size classes of fish (*e.g.* adults and juveniles) of a species are processed as two, separate size groups. Adults and juveniles are recorded separately on the fish data sheet by adding an "A" to the species code for adults and a "B" for juveniles. For example, if both adult and juvenile white suckers occur in the same sample the adult numbers and weights are recorded as family-species code 40-016A with juvenile numbers and weights recorded as 40-016B. Although each is listed separately on the fish data sheet they are treated as a subsample of the same species in any subsequent data analyses. The FINS (Fish Information System) programs are designed to calculate relative numbers and weight data based on the input of the weighted subsample data.

Individual fish weighing less than 1000 grams (g) are weighed to the nearest 1g on a Homs 1000 spring dial scale (1000g capacity x 2g intervals). Fish weighing more than 1000g are weighed to the nearest 25g on a Universal Accu-weigh spring dial scale M1250 (with air dash pot; 12000 g capacity in 50 g increments). All scales are checked once each week with National Bureau of Standards Class F check weights (up to 2000g in 1g increments) and adjusted as necessary.

d) External Anomalies

All fish that are weighed whether done individually, in aggregate, or subsampled (only the fish that are actually weighed) are examined for the presence of gross external anomalies and their occurrence is recorded on the fish data sheet (Figure V-4-4) and subsequently entered into FINS. In order to standardize the procedure for counting and identifying anomalies the following criteria should be followed.

All fish that are *weighed* are examined for gross external anomalies. These are anomalies that are visible to the naked eye when the fish are captured, identified, sorted, weighed and counted. Table V-4-2 lists the types of anomalies which are recorded on the fish data sheet and subsequently entered into FINS. Exact counts of anomalies present (i.e. the number of tumors, lesions, etc. per fish) are not made; however, light and heavy infestations are noted for certain types of anomalies (Table V-4-2). An external anomaly is defined as the presence of externally visible skin or subcutaneous disorders, and is expressed as percent (weighted) of affected fish among all fish *weighed*. This is computed for each type of anomaly for each species in each sample. It is computed as a weighted number (i.e. based on percent incidence among weighed fish times the total number of that fish species in the sample). Then the total percent anomalies for a specific type of anomaly or group of anomalies can be calculated for one or more sites.

The following is a review of some anomalies commonly encountered in freshwater fishes. These characteristics should be used in determining the types of external anomalies present and in coding the fish data sheet (Fig. V-4-4).

1) *Deformities* - These can affect the head, spinal vertebrae, fins, stomach shape, and have a variety of causes including toxic chemicals, viruses, bacteria (e.g. *Mycobacterium* sp.), infections, and protozoan parasites (e.g. *Myxosoma cerebalis*; Post 1983). Fish with extruded eyes (see Popeye disease) or obvious injuries should not be included.

2) *Eroded fins* - These are the result of a chronic disease principally caused by flexibacteria invading the fins causing a necrosis of the tissue (Post 1983). Necrosis of the fins may also be caused by gryodactylids, a small trematode

parasite. When necrosis occurs in the tissue at the base of the caudal fin it is referred to as peduncle disease. Erosions also occur on the preopercle and operculum and these *should be* included. In Ohio streams and rivers this anomaly is generally absent in least impacted fish communities, but can have a high incidence in polluted areas. It occurs most frequently in areas with multiple stresses, particularly low or marginal D.O. or high temperatures in combination with chronic toxicity (Pippy and Hare 1969; Sniezko 1962).

Table V-4-2. Codes utilized to record external anomalies on fish.

Anomaly Code	Description
D	Deformities of the head, skeleton, fins, and other body parts.
E	Eroded fins.
L	Lesions, ulcers.
T	Tumors.
M	Multiple DELT anomalies (e.g. lesions and tumors, etc.) on the same individual fish.
AL	Anchor worm - Light infestation: fish with five or fewer attached worms and/or previous attachment sites.
AH	Anchor worm - Heavy infestation: fish with six or more attached worms and/or previous attachment sites.
BL	Black Spot - Light infestation: spots do not cover most of the body with the average distance between spots greater than the diameter of the eye.
BH	Black Spot - Heavy infestation: spots cover most of the body and fins with the average distance between spots less than or equal to the diameter of the eye.
CL	Leeches - Light infestation: fish with five or fewer attached leeches and/or previous attachment sites.
CH	Leeches - Heavy infestation: fish with six or more attached leeches and/or previous attachment sites.
F	Fungus.
I	Ich.
N	Blind - one or both eyes; includes missing and grown over eyes (does not include eyes missing due to popeye disease).
S	Emaciated (poor condition, thin, lacking form).
P	External parasites (other than those already specified).
Y	Popeye disease.
W	Swirled scales.
Z	Other, not included above.

3) *Lesions and Ulcers* - These appear as open sores or exposed tissue and can be caused by viral (*e.g. Lymphocystis* sp.) and bacterial (*e.g. Flexibacter columnaris, Aeromonas* spp., *Vibrio* sp.) infections. Prominent bloody areas on fish should also be included. Small, characteristic sores left by anchor worms and leeches should not be included unless they are enlarged by this infection. Obvious injuries, however, should not be included unless they too, are likewise infected. As with eroded fins, lesions often times appear in areas impacted by multiple stresses, particularly marginal D.O. in combination with sublethal levels of toxics.

4) *Tumors* - These result from the loss of carefully regulated cellular proliferative growth in tissue and are generally referred to as neoplasia (Post 1983). In wild fish populations tumors can be the result of exposure to toxic chemicals. Baumann *et al.* (1987) identified polynuclear aromatic hydrocarbons (PAHs) as the cause of hepatic tumors in brown bullheads in the Black River (Ohio). Viral infections (e.g. Lymphocystis) can also cause tumors. Parasites (e.g. *Glugea anomala* and *Ceratomyxa shasta*; Post 1983) may cause tumor like masses, but these *should not* be considered as tumors. Parasite masses can be squeezed and broken between the thumb and forefinger whereas true tumors are firm and not easily broken (P. Baumann, pers. comm.).

5) *Anchor worm (Lernaea cyprinacea)* - This is a common parasitic copepod and can be identified by the presence of an adult female which appears as a slender, worm-like body with the head attached (buried) in the flesh of the fish. A small, characteristic sore is left after the anchor worm detaches. Attachment sites are included in the determination of light and heavy infestations. If the former attachment site becomes infected and enlarged as the result of an infection it should be recorded as a lesion.

6) *Black spot* - This disease is common on fish in Ohio streams and is caused by the larval stage of a trematode parasite (e.g. *Uvulifer ambloplitis* and *Crassiphiala bulboglossa*). They are easily identified as small black cysts (approximately the size of a pin head) on the skin and fins. Black spot has been reported as being most prevalent on fish inhabiting relatively shallow stream and lake habitats which have an abundance of aquatic vegetation with snails and fish eating birds, two of its intermediate animal hosts. It may also increase in frequency in mildly polluted streams or where fish are crowded due to intermittent pooling.

7) *Leeches* - These are parasites belong to the family Piscicolidae and are usually greenish brown in color and 5-25 mm long (Allison *et al.* 1977). Leeches can be identified by the presence of two suckers (one on each end) and the ability to contract or elongate their body. They may occur almost anywhere on the external surface of fish, but are most frequently seen on the anterioventral surface of bullheads (*Ictalurus* sp.). Field investigators should become familiar with the small sores or scars left by leeches as these are included in the determination of light and heavy infestations. If these sores become enlarged and infected they are also regarded as lesions. Leeches are seldom harmful to fish unless the infestation is very heavy.

8) *Fungus* - This is a growth that can appear on a fish's body as a white cottony growth and is most frequently caused by *Saprolegnia parasitica*. This fungus usually attacks an injured or open area of the fish and can eventually cause further disease or death.

9) *Ich or Icthyophthirus multifilis* - This is a protozoan that manifests itself on a fish's skin and fins as a white spotting. This disease rarely occurs in wild fish populations.

10) *Popeye* - This disease is generally identified by bulging eyes and can be caused by gas accumulation in areas where the water is gas supersaturated. It occurs most frequently in Ohio as the result of fluid accumulation from viral infection, nematodes (*Philometra* sp.), or certain trematode larvae (Rogers and Plumb 1977).

Information on external anomalies is recorded because many are either caused or exacerbated by environmental factors and often times indicate the presence of multiple, sublethal stresses. Komanda (1980) found that morphological abnormalities are uncommon in unimpacted, natural fish populations. The effects of temperature, salinity, dissolved oxygen, diet, chemicals, organic wastes, etc., especially during the ontogeny and larval stages of fishes can be the cause of many types of anomalies (Berra and Au, 1981). The presence of anomalies on fish may act as an index of pollution stress. A high frequency of DELT anomalies (deformities, eroded fins, lesions, and tumors) is a good indication of a stress caused by sublethal stresses, intermittent stresses, and chemically contaminated substrates. The percent DELT anomalies is a metric of the IBI (Ohio EPA 1987). Field investigators are urged to refer to texts on fish health for further information and pictures of specific anomalies. If necessary, affected fish should be preserved for laboratory examination.

4) Fish Sampling Site Habitat Evaluation:
Qualitative Habitat Evaluation Index (QHEI)

A general evaluation of macrohabitat is made by the *fish field crew leader* while sampling each location using the Ohio EPA Site Description Sheet - Fish (Figure V-4-5). This form is used to tabulate data and information for calculating the **Qualitative Habitat Evaluation Index (QHEI)**. The following guidance should be used when completing the site evaluation form.

Figure V-4-5. Front side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record information for the calculation of the Qualitative Habitat Evaluation Index (QHEI).

Ohio EPA Site Description Sheet - Fish **QHEI SCORE:** ☐

Stream_____ RM_____ Date_____ River Code_____

Location_____ Crew:_____

1] SUBSTRATE (Check *ONLY* Two Substrate *TYPE BOXES; Check all types present*); ***SUBSTRATE SCORE:*** ☐

TYPE	POOL	RIFFLE		POOL	RIFFLE
☐☐-BLDER /SLABS[10]	___	___	☐☐-GRAVEL [7]	___	___
☐☐-BOULDER [9]	___	___	☐☐-SAND [6]	___	___
☐☐-COBBLE [8]	___	___	☐☐-BEDROCK[5]	___	___
☐☐-HARDPAN [4]	___	___	☐☐-DETRITUS[3]	___	___
☐☐-MUCK [2]	___	___	☐☐-ARTIFIC.[0]	___	___

TOTAL NUMBER OF SUBSTRATE TYPES: ☐> 4 [2] ☐— <= 4 [0] ☐-COAL FINES [-2]

NOTE: (Ignore sludge that originates from point-sources; score is based on natural substrates)

SUBSTRATE QUALITY

Substrate Origin (Check all)
☐-LIMESTONE [1] ☐-RIP/RAP [0] ☐-HARDPAN [0] ☐-TILLS [1] ☐-SANDSTONE [0] ☐-SHALE [-1]

Silt Cover (Check One)
☐-SILT HEAVY [-2] ☐-SILT MODERATE [-1] ☐ - SILT NORMAL [0] ☐ - SILT FREE [1]

Extent Of Embeddness (Check One)
☐—EXTENSIVE [-2] ☐—MODERATE[-1] ☐—LOW[0] ☐—NONE[1]

COMMENTS_____

COVER SCORE: ☐

2] INSTREAM COVER

TYPE (Check *All* That Apply)
☐-UNDERCUT BANKS [1] ☐-DEEP POOLS [2] ☐-OXBOWS [1]
☐-OVERHANGING VEGETATION [1] ☐-ROOTWADS [1] ☐-AQUATIC MACROPHYTES [1]
☐-SHALLOWS (IN SLOW WATER) [1] ☐-BOULDERS [1] ☐-LOGS OR WOODY DEBRIS [1]

AMOUNT(Check *ONLY* One or check 2 and *AVERAGE*)
☐ - EXTENSIVE > 75% [11]
☐ - MODERATE 25-75% [7]
☐ - SPARSE 5-25% [3]
☐ - NEARLY ABSENT < 5%[1]

COMMENTS:_____

CHANNEL: ☐

3] CHANNEL MORPHOLOGY: (Check *ONLY* One PER Category OR check 2 and *AVERAGE*)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐ - HIGH [4]	☐ - EXCELLENT [7]	☐ - NONE [6]	☐ - HIGH [3]	☐ - SNAGGING	☐ - IMPOUND.
☐ - MODERATE [3]	☐ - GOOD [5]	☐ - RECOVERED [4]	☐ - MODERATE [2]	☐ - RELOCATION	☐ - ISLANDS
☐ - LOW [2]	☐ - FAIR [3]	☐ - RECOVERING [3]	☐ - LOW [1]	☐ - CANOPY REMOVAL	☐ - LEVEED
☐ - NONE [1]	☐ - POOR [1]	☐ - RECENT OR NO RECOVERY [1]		☐ - DREDGING	☐ - BANK SHAPING
				☐ - ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS:_____

RIPARIAN: ☐

4] RIPARIAN ZONE AND BANK EROSION - (check ONE box per bank or check 2 and AVERAGE per bank)

"River Right Looking Downstream"

RIPARIAN WIDTH L R (Per Bank)	EROSION/RUNOFF - FLOOD PLAIN QUALITY L R (Most Predominant Per Bank)	L R (Per Bank)	BANK EROSION
☐☐-WIDE>50m [4]	☐☐-FOREST, SWAMP [3]	☐☐-URBAN OR INDUSTRIAL[0]	☐ ☐-NONE OR LITTLE [3]
☐☐-MODERATE 10-50 [3]	☐☐-OPEN PASTURE/ ROWCROP[0]	☐☐-SHRUB OR OLD FIELD[2]	☐ ☐-MODERATE [2]
☐☐-NARROW 5-10m [2]	☐☐- RESID.,PARK,NEW FIELD [1]	☐☐-CONSERV. TILLAGE [1]	☐ ☐-HEAVY OR SEVERE[1]
☐☐-VERY NARROW 1-5m [1]	☐☐-FENCED PASTURE [1]	☐☐-MINING/CONSTRUCTION [0]	
☐☐-NONE[0]			

COMMENTS:_____

POOL: ☐

POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1)	MORPHOLOGY (Check 1)	POOL/RUN/RIFFLE CURRENT VELOCITY (Check *All* That Apply)	
☐- >1m [6]			
☐- 0.7-1m [4]	☐-POOL WIDTH > RIFFLE WIDTH [2]	☐-TORRENTIAL[-1]	☐-EDDIES[1]
☐- 0.4-0.7m [2]	☐-POOL WIDTH = RIFFLE WIDTH [1]	☐-FAST[1]	☐-INTERSTITIAL[-1]
☐- < 0.4m [1]	☐-POOL WIDTH < RIFFLE W. [0]	☐-MODERATE [1]	☐-INTERMITTENT[-2]
☐—<0.2m [Pool = 0]		☐-SLOW [1]	

☐-NO POOL[0]

COMMENTS:_____

RIFFLE: ☐

RIFFLE/RUN DEPTH	RIFFLE/RUN SUBSTRATE	RIFFLE/RUN EMBEDDEDNESS	
☐ - GENERALLY >10 cm,MAX>50 [4]	☐-STABLE (e.g.,Cobble, Boulder) [2]	☐-EXTENSIVE [-1]	☐-MODERATE[0]
☐ - GENERALLY >10 cm,MAX<50 [3]	☐-MOD. STABLE (e.g.,Pea Gravel) [1]	☐-LOW. [1]	☐-NONE[2]
☐ - GENERALLY 5-10 cm [1]	☐-UNSTABLE (Gravel,Sand) [0]		
☐ - GENERALLY < 5 cm [Riffle = 0]			

☐-NO RIFFLE[0]

COMMENTS_____

GRADIENT: ☐

6] Gradient (feet/mile): _____ %POOL:_____ %RIFFLE:_____ %RUN:_____

EPA 4520

Geographical Information

1) *Stream, River Mile (RM), Date* – The official stream name may be found in the Gazetteer of Ohio Streams (Ohio DNR, 1960) or on USGS 7.5 minute topographic maps. If the stream is unnamed, a name and stream code is assigned by the *Surface Water Section Database Coordinator*. Usually the name of a nearby landmark is used for the stream name. A basin-river code is also assigned from the FINS river code system. The River Mile (RM) designations used are found on 7.5 minute topo maps stored at the Ohio EPA, Office of Planning, 1800 WaterMark Drive (PEMSO RMI maps), one of five Ohio EPA District offices (maps for that district), and Ohio EPA, Division of Water Quality Monitoring Assessment laboratory at 1030 King Avenue.

2) Specific Location

A brief description of the sampling location should include proximity to a local landmark such as a bridge, road, discharge outfall, railroad crossing, park, tributary, dam, etc.

3) Field Sampling Crew

The field crew involved with the sampling is noted on the sheet with the person who filled out the sheet listed first. QHEI information is to be completed by the crew leader *only*.

*4) Habitat Characteristics: **QHEI** Metrics*

The **Qualitative Habitat Evaluation Index (QHEI)** is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic *macrohabitat* characteristics that are important to fish communities. A detailed analysis of the development and use of the QHEI is available in Rankin (1989). The **QHEI** is composed of six principal metrics each of which are described below. The maximum possible **QHEI** site score is 100. Each of the metrics are scored individually and then summed to provide the total **QHEI** site score. This is completed at least once for each sampling site during each year of sampling. An exception to this convention would be when substantial changes to the macrohabitat have occurred between sampling passes.Standardized definitions for pool, run, and riffle habitats, for which a variety of existing definitions and perceptions exist, are essential for accurately using the **QHEI**. For consistency the following definitions are taken from Platts *et al.* (1983). It is recommended that this reference also be consulted prior to scoring individual sites.

Riffle and Run Habitats:

Riffle - areas of the stream with fast current velocity and shallow depth; the water surface is visibly broken.

Run - areas of the stream that have a rapid, non-turbulent flow; runs are deeper than riffles with a faster current velocity than pools and are generally located downstream from riffles where the stream narrows; the stream bed is often flat beneath a run and the water surface is not visibly broken.

Pool and Glide Habitats:

Pool[5] - an area of the stream with slow current velocity and a depth greater than riffle and run areas; the stream bed is often concave and stream width frequently is the greatest; the water surface slope is nearly zero.

Glide - this is an area common to most modified stream channels that do not have distinguishable pool, run, and riffle habitats; the current and flow is similar to that of a canal; the water surface gradient is nearly zero.

The following is a description of each of the six **QHEI**

[5] If a pool or glide has a maximum depth of less than 20 cm, it is deemed to have lost its functionality and the metric is scored a 0.

metrics and the individual metric components. Guidelines on how to score each is presented. Generally, metrics are scored by checking boxes. In certain cases the biologist completing the **QHEI** sheet may interpret a habitat characteristic as being intermediate between the possible choices; in cases where this is allowed (denoted by the term **"Double-Checking"**) two boxes may be checked and their scores averaged.

Metric 1: Substrate

This metric includes two components, *substrate type* and *substrate quality*.

Substrate type

Check the two most common substrate types in the stream reach. If one substrate type predominates (greater than approximately 75-80% of the bottom area *OR* what is clearly the most *functionally* predominant substrate) then this substrate type should be checked twice. **DO NOT CHECK MORE THAN TWO BOXES**. *Note the category for artificial substrates.* Spaces are provided to note the presence (by check marks, or estimates of % if time allows) of *all* substrate types present in pools and riffles that each comprise at least 5% of the site (*i.e.*, they occur in sufficient quantity to support species that may commonly be associated with the habitat type). This section must be filled out completely to permit future analyses of this metric. If there are more than four substrate types in the zone that are present in greater than approximately 5% of the sampling area check the appropriate box.

Substrate quality

Substrate *origin* refers to the "parent" material that the stream substrate is derived from. Check **ONE** box under the substrate origin column *unless* the parent material is from multiple sources (*e.g.*, limestone and tills). **Embeddedness** is the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine materials (sand and silt). Substrates should be considered embedded if >50% of surface of the substrates are embedded in fine material. Embedded substrates cannot be easily dislodged. This also includes substrates that are concreted or "armour-plated". Naturally sandy streams are not considered embedded; however, a sand predominated stream that is the result of anthropogenic activities that have buried the natural coarse substrates is considered embedded. Boxes are checked for *extensiveness* (area of sampling zone) of the embedded substrates as follows: **Extensive** — > 75% of site area, **Moderate** — 50-75%, **Sparse** — 25-50%, **Low** — < 25%.

Silt Cover is the extent that substrates are covered by a silt layer (*i.e.*, more than 1 inch thickness). **Silt Heavy** means that nearly all of the stream bottom is layered with a deep covering of silt. **Moderate** includes extensive coverings of silts, but with some areas of cleaner substrate (*e.g.*, riffles). **Normal** silt cover includes areas where silt is deposited in small amounts along the stream margin *or* is present as a "dusting" that appears to have little functional significance. If substrates are exceptionally clean the **Silt Free** box should be checked.

Substrate types are defined as:

a) *Bedrock* - solid rock forming a continuous surface.
b) *Boulder* - rounded stones over 256 mm in diameter(10 in.) or large "slabs" more than 256 mm in length (*Boulder slabs*).
c) *Cobble* - stones from 64-256 mm (2 1/2 - 10in.) in diameter.
d) *Gravel* - mixture of rounded course material from 2-64 mm (1/12 - 2 1/2 in.) in diameter.
e) *Sand* - materials 0.06 - 2.0 mm in diameter, gritty texture when rubbed between fingers.

f) *Silt* - 0.004 - 0.06 mm in diameter, generally this is fine material which feels "greasy" when rubbed between fingers.

g) *Hardpan* - particles less than 0.004 mm in diameter, usually clay, which forms a dense, gummy surface that is difficult to penetrate.

h) *Marl* - calcium carbonate; usually greyish-white; often contains fragments of mollusc shells.

i) *Detritus* - dead, unconsolidated organic material covering the bottom which could include sticks, wood and other partially or undecayed coarse plant material.

j) *Muck* - black, fine, flocculent, completely decomposed organic matter (*does not include* sewage sludge).

k) *Artificial* - substrates such as rock baskets, gabions, bricks, trash, concrete etc., placed in the stream for reasons *OTHER* than habitat mitigation

Sludge is defined as a thick layer of organic matter, that is decidedly of human or animal origin. **NOTE: SLUDGE THAT ORIGINATES FROM POINT SOURCES IS NOT INCLUDED; THE SUBSTRATE SCORE IS BASED ON THE UNDERLYING MATERIAL.**

Substrate Metric Score:

Although the theoretical maximum metric score is > 20 the maximum score allowed for the **QHEI** is limited to **20 points**.

Metric 2: Instream Cover

This metric consists of *instream cover type* and *instream cover amount*. All of the cover types that are present in greater than approximately 5% of the sampling area (i.e., they occur in sufficient quantity to support species that may commonly be associated with the habitat type) should be checked. Cover should not be counted when it is in areas of the stream with insufficient depth (usually < 20 cm) to make it useful. For example a logjam in 5 cm of water contributes very little if any cover, and at low flow may be dry. Other cover types with limited utility in shallow water include *undercut banks* and *overhanging vegetation*, *boulders*, and *rootwads*. Under *amount*, one or two boxes may be checked. *Extensive* cover is that which is present throughout the sampling area, generally greater than about 75% of the stream reach. Cover is *moderate* when it occurs over 25-75% of the sampling area. Cover is *sparse* when it is present in less than 25% of the stream margins (sparse cover usually exists in one or more isolated patches). Cover is *nearly absent* when no large patch of any type of cover exists anywhere in the sampling area. This situation is usually found in recently channelized streams or other highly modified reaches (*e.g.* ship channels). If cover is thought to be intermediate in amount between two categories, *check two boxes and* ***average*** *their scores*. Cover types include: 1) undercut banks, 2) overhanging vegetation, 3) shallows (in slow water), 4) logs or woody debris, 5) deep pools (> 70 cm), 6) oxbows, 7) boulders, 8) aquatic macrophytes, and 9) rootwads (tree roots that extend into stream). Do not check undercut banks AND rootwads unless undercut banks exist *along with* rootwads as a major component.

Cover Metric Score:

Although the theoretical maximum score is > 20 the maximum score assigned for the QHEI for the instream cover metric is limited to **20 points**

Metric 3: Channel Morphology

This metric emphasizes the quality of the stream channel that relates to the creation and stability of macrohabitat. It includes channel sinuosity (*i.e.* the

degree to which the stream meanders), channel development, channelization, and channel stability. One box under each should be checked unless conditions are considered to be intermediate between two categories; in these cases *check two boxes and average their scores.*

a) *Sinuosity* - **No** sinuosity is a straight channel. **Low** sinuosity is a channel with only 1 or 2 poorly defined outside bends in a sampling reach, or perhaps slight meandering within modified banks. **Moderate** sinuosity is more than 2 outside bends, with at least one bend well defined. **High** sinuosity is more than 2 or 3 well defined outside bends with deep areas outside and shallow areas inside. Sinuosity may be more conceptually described by the ratio of the stream distance between two points on the channel of a stream and the straight-line distance between these same two points, taken from a topographic map. Check *only* one box.

b) *Development* - This refers to the development of riffle/pool complexes. **Poor** means *riffles* are absent, or if present, shallow with sand and fine gravel substrates; *pools*, if present are shallow. Glide habitats, if predominant, receive a **Poor** rating. **Fair** means riffles are poorly developed or absent; however, pools are more developed with greater variation in depth. **Good** means better defined riffles present with larger substrates (gravel, rubble or boulder); pools have variation in depth and there is a distinct transition between pools and riffles. **Excellent** means development is similar to the Good category except the following characteristics must be present: pools must have a maximum depth of >1m and deep riffles and runs (>0.5m) must also be present. In streams sampled with wading methods, a sequence of riffles, runs, and pools must occur more than once in a sampling zone. Check *one* box.

c) *Channelization* - This refers to anthropogenic channel modifications. **Recovered** refers to streams that have been channelized in the past, but which have recovered most of their natural channel characteristics. **Recovering** refers to channelized streams which are still in the process of regaining their former, natural characteristics; however, these habitats are still degraded. This category also applies to those streams, especially in the Huron/Erie Lake Plain ecoregion (NW Ohio), that were channelized long ago and have a riparian border of mature trees, but still have **Poor** channel characteristics. **Recent** or **No Recovery** refers to streams that were recently channelized or those that show no significant recovery of habitats (*e.g.* drainage ditches, grass lined or rock rip-rap banks, etc.). The specific type of habitat modification is checked in the last two columns but not scored.

d) *Stability* - This refers to channel stability. Artificially stable (concrete) stream channels receive a **High** score. Even though they are generally a negative influence on fish the negative effects are related to features other than their stability. Channels with **Low** stability are usually characterized by fine substrates in riffles that often change location, have unstable and severely eroding banks, and a high bedload that slowly creeps downstream. Channels with **Moderate** stability are those that appear to maintain stable riffle/pool and channel characteristics, but which exhibit some symptoms of instability, *e.g.* high bedload, eroding or false banks, or show the effects of wide fluctuations in water level. Channels with **High** stability have stable banks and substrates, and little or no erosion and bedload.

e) *Modifications/Other* - Check the appropriate box if

impounded, islands present, or leveed (these are not included in the QHEI scoring) as well as the appropriate source of habitat modifications.

The maximum QHEI metric score for Channel Morphology is **20 points**.

Metric 4: Riparian Zone and Bank Erosion

This metric emphasizes the quality of the riparian buffer zone and quality of the floodplain vegetation. This includes riparian zone width, floodplain quality, and extent of bank erosion. Each of the three components require scoring the left *and* right banks (looking downstream). The *average* of the left and right banks is taken to derive the component value. One box per bank should be checked unless conditions are considered to be intermediate between two categories; in these cases *check two boxes and* ***average*** *their scores.*

a) *Width of the Floodplain* - This is the width of the riparian (stream side) vegetation. Width estimates are only done for forest, shrub, swamp, and old field vegetation. Old field refers to the a fairly mature successional field that has stable, woody plant growth; this generally does not include weedy urban or industrial lots that often still have high runoff potential. Two boxes, one each for the left and right bank (looking downstream), should be checked and then averaged.

b) *Floodplain Quality* - The two most predominant floodplain quality types should be checked, one each for the left and right banks (includes urban, residential, etc.), and then averaged. By floodplain we mean the areas *immediately outside* of the riparian zone *or greater than 100 feet from the stream*, whichever is wider on each side of the stream. These are areas adjacent to the stream that can have direct runoff and erosional effects during normal wet weather. We do not limit it to the riparian zone and it is much less encompassing than the stream basin.

c) *Bank Erosion* - The following Streambank Soil Alteration Ratings from Platts *et al.* (1983) should be used; check one box for each side of the stream and average the scores. False banks are used in the sense of Platts *et al.* (1983) to mean banks that are no longer adjacent to the normal flow of the channel but have been moved back into the floodplain most commonly as a result of livestock trampling.

1) **None** - streambanks are stable and not being altered by water flows or animals (e.g. livestock) - Score **3**.
2) **Little** - streambanks are stable, but are being lightly altered along the transect line; less than 25% of the streambank is receiving any kind of stress, and if stress is being received it is very light; less than 25% of the streambank is false, broken down or eroding - Score **3**.
3) **Moderate** - streambanks are receiving moderate alteration along the transect line; at least 50 percent of the streambank is in a natural stable condition; less than 50% of the streambank is false, broken down or eroding; false banks are rated as altered - Score **2**.
4) **Heavy** - streambanks have received major alterations along the transect line; less than 50% of the streambank is in a stable condition; over 50% of the streambank is false, broken down, or eroding - Score **1**.
5) **Severe** - streambanks along the transect line are severely altered; less than 25% of the streambank is in a stable condition; over 75% of the streambank is false, broken down, or eroding - Score **1**.

The maximum score for Riparian Zone and Erosion metric is **10 points**.

Metric 5: Pool/Glide and Riffle-Run Quality

This metric emphasizes the quality of the pool, glide and/or riffle-run habitats. This includes pool depth, overall diversity of current velocities (in pools *and* riffles), pool morphology, riffle-run depth, riffle-run substrate, and riffle-run substrate quality.

A) **Pool/Glide Quality**

1) *Maximum depth of pool or glide*; check one box only (Score **0** to **6**). Pools or glides with maximum depths of *less than* 20 cm are considered to have lost their function and the *total metric* is scored a **0**. No other characteristics need be scored in this case.

2) *Current Types* - check each current type that is present in the stream (including riffles and runs; score - **2** to **4**), definitions are:

Torrential - extremely turbulent and fast flow with large standing waves; water surface is very broken with no definable, connected surface; usually limited to gorges and dam spillway tailwaters.

Fast - mostly non-turbulent flow with small standing waves in riffle-run areas; water surface may be partially broken, but there is a visibly connected surface.

Moderate - non-turbulent flow that is detectable and visible (i.e. floating objects are readily transported downstream); water surface is visibly connected.

Slow - water flow is perceptible, but very sluggish.

Eddies - small areas of circular current motion usually formed in pools immediately downstream from riffle-run areas.

Interstitial - water flow that is perceptible only in the interstitial spaces between substrate particles in riffle-run areas.

Intermittent - no flow is evident anywhere leaving standing pools that are separated by dry areas.

4) *Morphology* - Check *Wide* if pools are wider than riffles, *Equal* if pools and riffles are the same width, and *Narrow* if the riffles are wider than the pools (Score **0** to **2**). If the morphology varies throughout the site *average* the types. If the entire stream area (including areas outside of the sampling zone) is pool or riffle, then check riffle = pool.

Although the theoretical maximum score is > 12 the maximum score assigned for the QHEI for the Pool Quality metric is limited to **12 points.**

B) **Riffle-Run Quality**

(score **0** for this metric if no riffles are present)

1) *Riffle/Run Depth* - select one box that most closely describes the depth characteristics of the riffle (Score **0 to 4**). If the riffle is generally less than 5 cm in depth riffles are considered to have loss their function and the entire riffle metric is scored a **0**.

2) *Riffle/Run Substrate Stability*—select one box from each that best describes the substrate type and stability of the riffle habitats (Score **0** to **2**).

3) *Riffle/Run Embeddedness*—**Embeddedness** is the degree that cobble, gravel, and boulder substrates are surrounded or covered by fine material (sand, silt). We consider substrates embedded if >50% of surface of the substrates are embedded in fine material—these substrates cannot be easily dislodged. This also includes substrates that are concreted. Boxes are checked for *extensiveness* (riffle area of sampling

zone) with embedded substrates: **Extensive** — > 75% of stream area, **Moderate** — 50-75%, **Sparse** — 25-50%, **Low** — < 25%.

The maximum score assigned for the QHEI for the Riffle/Run Quality metric is **8 points**.

Metric 6: Map Gradient

Local or map gradient is calculated from USGS 7.5 minute topographic maps by measuring the elevation drop through the sampling area.This is done by measuring the stream length between the first contour line upstream and the first contour line downstream of the sampling site and dividing the distance by the contour interval. If the contour lines are closely "packed" a minimum distance of at least one mile should be used. Some judgement may need to be exercised in certain anomalous areas (*e.g.* in the vicinity of waterfalls, impounded areas, etc.) and this can be compared to an in-field, visual estimate which is recorded on the back of the habitat sheet.

Scoring for ranges of stream gradient takes into account the varying influence of gradient with stream size, preferably measured as drainage area in square miles or stream width. Gradient classifications (Table V-4-3) were modified from Trautman (p 139, 1981) and scores were assigned, by stream size category, after examining scatterplots of IBI vs natural log of gradient in feet/mile. Scores are listed in Table V-4-3

The maximum QHEI metric score for Gradient is **10 points**.

*Computing the Total **QHEI** Score:*

To compute the total **QHEI** score, add the components of each metric to obtain the metric scores and then sum the metric scores to obtain the total **QHEI** score. The **QHEI** metric scores cannot exceed the Metric Maximum Score indicated below.

QHEI SCORING (Maximum = 100)

QHEI Metric	Metric Component	Component Scoring Range	Metric Max. Score
1) Substrate	a) Type	0 to 21	20
	b) Quality	-5 to 3	
2) Instream Cover	a) Type	0 to 10	20
	b) Amount	1 to 11	
3) Channel Morphology	a) Sinuosity	1 to 4	20
	b) Development	1 to 7	
	c) Channelization	1 to 6	
	d) Stability	1 to 3	
4) Riparian Zone	a) Width	0 to 4	10
	b) Quality	0 to 3	
	c) Bank Erosion	1 to 3	
5a) Pool Quality	a) Max. Depth	0 to 6	12
	b) Current	-2 to 4	
	c) Morphology	0 to 2	
5b) Riffle Quality	a) Depth	0 to 4	8
	b) Substr Stab.	0 to 2	
	c) Substr Embd.	-1 to 2	
6)Gradient		2 to 15	10
TOTAL	Maximum Score		100

Additional Information

Additional information is recorded on the reverse side of the Site Description Sheet (Fig. V-4-6) and is described as follows:

1) *Additional Comments/Pollution Impacts* - Different types of pollution sources (*e.g.* wastewater treatment plant, feedlot, industrial discharge, nonpoint source

Table V-4-3. Classification of stream gradients for Ohio, corrected for stream size. Modified from Trautman (p 139, 1981). Scores were derived from plots of IBI versus the natural log of gradient for each stream size category.

Average Stream Width (m)	Drainage Area (sq mi)	Gradient (ft/mile) Very Low	Low	Low-Moderate	Moderate	Moderate High	High	Very High[1]
0.3-4.7	0-9.2	0-1.0 2	1.1-5.0 4	5.1-10.0 6	10.1-15.0 8	15.1-20 10	20.1-30 10	30.1-40 8
4.8-9.2	9.2-41.6	0-1.0 2	1.1-3.0 4	3.1-6.0 6	6.1-12.0 10	12.1-18.0 10	18.0-30 8	30.1-40 6
9.2-13.8	41.6-103.7	0-1.0 2	1.1-.2.5 4	2.6-5.0 6	5.1-7.5 8	7.6-12.0 10	12.1-20 8	20.1-30 6
13.9-30.6	103.7-622.9	0-1.0 4	1.1-2.0 6	2.1-4.0 8	4.1-6.0 10	6.1-10.0 10	10.1-15 8	15.1-25 6
>30.6	>622.9	-	0-0.5 6	0.6-1.0 8	1.1-2.5 10	2.6-4.0 10	4.1-9.0 10	>9.0 8

[1] Any site with a gradient > than the upper bound of the "very high" gradient classification is assigned a score of 4.

Figure V-4-6. Reverse side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record additional information about the sampling site and adjacent area.

Is Reach Representative of Stream? (Y/N)_____ If Not: _____

Additional Comments/Pollution Impacts: _____

	GEAR	DISTANC	WATER CLARITY	WATER STAGE
FIRST PASS				
SECOND PASS				
THIRD PASS				

SUBJECTIVE RATING (1-10)

AESTHETIC RATING (1-10)

CANOPY (%OPEN) _____ GRADIENT: Ó-LOW Ó-MODERATE Ó-HIGH PHOTOS: _____

STREAM MEASUREMENTS: AVERAGE WIDTH:_____ AVERAGE DEPTH:_____ MAX. DEPTH _____

LENGTH	WIDTH	DEPTHS ⊳										POOL;GLD;RIF;RUN

CROSS-SECTIONS OF STREAM

DRAWING OF STREAM

inputs) are noted with their proximity (in 0.1 mile increments) to the sampling site; any evidence of litter either instream or on the stream bank is also noted.

2) *Sampling Gear/Distance Sampled* - The type of fish sampling gear used during each pass is specified (See Table V-4-1) and any variation in sampling procedures is noted (*e.g.*, sampler type A specifies sampling along one shoreline of 0.5 km, but due to local restrictions, sampling may be performed on both shorelines to accumulate 0.5 km); the total sampling distance in kilometers for each sampling site for each pass is recorded.

3) *Water Clarity* - The following descriptions can be used as a guide:

a) Clear - bottom is clearly visible (if shallow enough) and the water contains no apparent color or staining.

b) Stained - usually a brownish (or other) color to the water; the bottom may be visible in shallow areas.

c) Turbid - bottom seldom visible at more than a few inches; caused by suspended sediment particles.

The apparent source of stained (*e.g.* tannic acid, leaf decay, etc.) and turbid (*e.g.* runoff [clay/silt], algae/diatoms, sewage, etc.) may be specified under additional comments.

4) *Water Stage* - This is the general water level of the stream during each pass; suggested descriptors are: a) flood, b) high, c) elevated, d) normal, e) low, and f) interstitial. (Note: sampling should not be conducted during flood or high flows).

5) *Canopy* - This is the percentage of the sampling site that is *not* covered or shaded by woody bank vegetation. In wide streams and rivers this determination should be made along both sides of the river or stream (*i.e.*, the percent of the sampling path that is open).

6) *Gradient* - Check the box that best describes the gradient at the site. This will be used to check the accuracy of gradients taken from topographic maps.

7) *Field Crew* - The names of all individuals involved with the sampling/site description at each site are included.

8) *Photographs* - The number of each photograph taken is recorded; the subject of the photograph is briefly described.

9) *Stream Measurements (optional)* - When measuring the individual sampling sites, length, width, and average and maximum depth information should be recorded; each measurement should be recorded as either a riffle, run, or pool or glide by placing an X in the correct box to the right of where measurements are recorded (Figure V-4-6); see the introduction for definitions of riffles, runs, etc.

The number of width measurements is left to the discretion of the field crew leader. Short riffles may require only one or two width measurements while long pools will probably require more depending on the degree of variation that exists in the stream's width. Depth measurements should be made in association with individual width measurements. Depths should be taken at the stream margins and various points across the stream. Up to nine depth measurements may be taken depending on the variability in the stream bottom. Maximum depth is the deepest spot in the stream section sampled. One purpose of this information is to calculate pool volume.

10) *Stream Diagram - Cross-sections:* Two or three cross-sections of the stream are drawn to provide information on features of the stream bank, stream bottom, stream channel, and floodplain. A series of well defined stream channels (downstream view) are shown in Figure V-4-7. Definitions of these terms follow Platts *et al.* (1983):

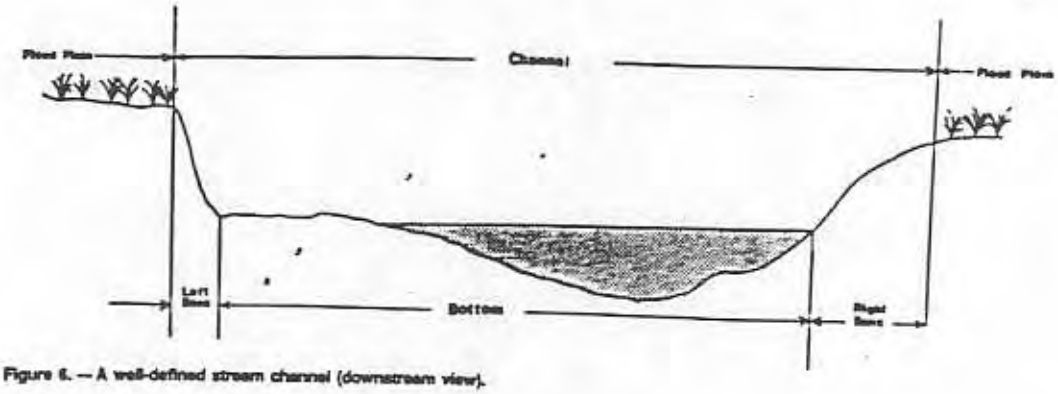

Figure 6. — A well-defined stream channel (downstream view).

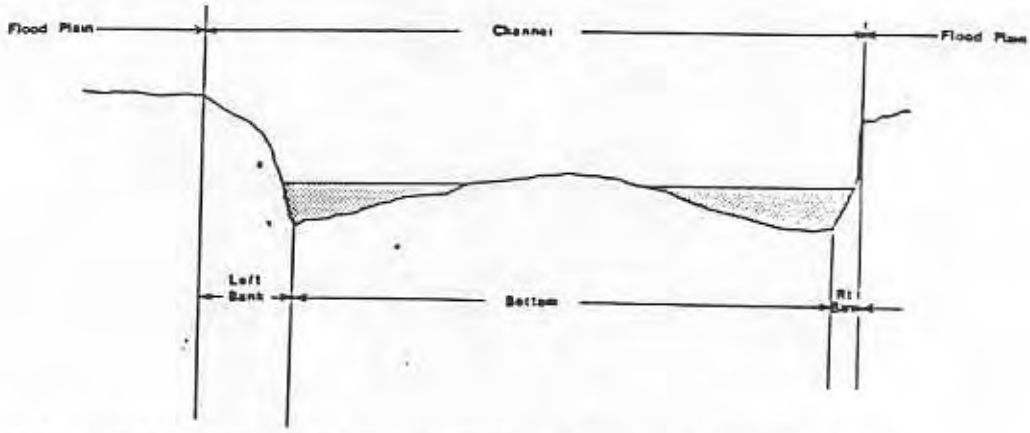

Figure 7. — A well-defined stream channel with concentrated low flows and exposed bottom (downstream view).

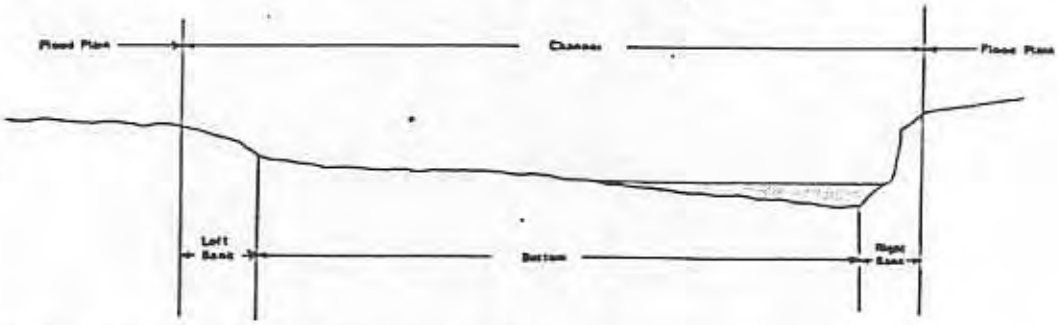

Figure 8. — Stream channel cross channel section on a bend in a stream.

Figure V-4-7. Three variations of a well defined stream channel (downstream view) (from Platts et al. 1983; Figs. 6-8).

Channel - The cross-section containing the stream that is distinct from the surrounding area due to breaks in the general slope of the land, lack of terrestrial vegetation, and changes in the composition of the substrate materials. The channel is made up of streambanks and stream bottoms.

Banks - The portion of the channel cross-section that tends to restrict lateral movement of water. The banks often have a slope steeper than 45° and exhibit a distinct break in slope from the stream bottom.Also, an obvious change in substrate materials is a reliable delineation of the bank.

Stream bottom - The portion of the channel cross-section not classified as bank. The bottom is usually composed of stream sediments or water transported debris and may be covered by rooted or clinging aquatic vegetation. In some geologic formations, the stream bottom may consist of bedrock rather than sediments.

Flood plain - The area adjacent to the channel that is seasonally submerged under water. Usually the flood plain is a low area covered by various types of riparian vegetation.

Stream Map

The entire sampling zone is sketched in the area provided. Important physical features are noted on the map with standard symbols used where possible. The sampling path taken is described along with any other pertinent information

Part C): Laboratory Methods

1) Handling Preserved Materials

a) Preservation Techniques - Fish that are preserved for subsequent identification or for vouchers are immersed in a fixative solution as soon as possible after capture. This helps retain chromatophore patterns which aid in identification. The recommended fixative is a solution of one part commercially prepared formalin and nine parts water with one teaspoon of borax added per 1/2 gallon of fixative. The borax acts as a buffer which neutralizes the acidic effect of the formalin, retarding shrinkage, preventing the hardening of soft body parts, and preventing decalcification of the tissues (Lagler *et al.* 1962). Temperatures greater than 80°F (26.7°C) necessitate a stronger solution of one part formalin to seven or eight parts water. Large fish or containers with closely packed fish also require stronger concentrations of formalin. Strong solutions of formalin can cause gaping or distortion of the mouth and gills, thus care should be taken to obtain correct concentrations when making up the solutions. Specimens more than a few inches long should be slit along the right side of the abdomen prior to preservation; fish heavier than 1 - 2 pounds should also be injected in the muscles on each side of the backbone. Fish normally remain in the formalin solution for at least 2-3 weeks to fix the tissues. Fish are then rinsed in clean water to wash off any excess formalin. The fish are allowed to drain for one-half hour. The fish are then placed in a 35% alcohol wash for 2-3 weeks, switched to a 50% alcohol wash for 2-3 weeks, and placed in a 70% aqueous solution of ethyl alcohol for permanent storage.

Preserving containers are labelled as soon as the fish are collected detailing essential aspects of the sample as completely as possible. Minimum information to be recorded is the stream or river name, location, date, river mile, and principal collector. This information may be written on the initial preserving container with a waterproof marker. If paper is used for making labels it should be 100% rag (which is waterproof) and labeled with India ink or a soft lead pencil.

b) Laboratory Identification and Verification - As discussed previously, fish are field identified by the field crew leader and *when the identification is certain*. However, if there is

any uncertainty the fish are preserved and brought back to the laboratory for verification. In the Ohio EPA laboratory, keys available in Becker (1983), Clay (1975), Pflieger (1975), Scott and Crossman (1973), and Trautman (1957, 1981) are used to identify the preserved fish. Scientific nomenclature follows the recommendations of the American Fisheries Society (Robins *et al.* 1980).

Identifications are verified in-house by at least two trained, full-time Ohio EPA staff. Once taxonomic verification is made, the information is transferred to the fish data sheet for the respective location and either entered into or corrected in FINS. If there remains any question as to the identity of a specimen, it is taken to the Ohio State Museum of Zoology (OSUMZ) for identification by the Curator of Fishes.

c) Disposition -.Ohio EPA maintains an up-to-date reference collection of Ohio and midwestern U.S. region fishes at the Ohio EPA Fish Laboratory. New species or unique specimens are added to the collection as they are encountered. Duplicate specimens are deposited in the OSUMZ where they are permanently catalogued.

2) Data Handling and Analysis

a) Data sheets - Fish data sheets (see example, Figure V-4-4) are completed in the following manner:

1) *Field Crew* - **Sampler** is the individual who actually nets the fish; **Recorder** is the individual who records the data; and **Driver** is the individual who either drives the field vehicle or assists with netting.

2) *Time* - military time sampling started and completed.

3) *River/Stream* - major river or stream being sampled.

4) *Location* - location described as adjacent to, upstream or downstream from a notable landmark.

5)*Date* - month/date/year.

6) *River Code* - assigned number found in FINS RIVLST printout, originally derived from Ohio Gazetteer of Streams (**NOTE:** *contact Central Office Data Coordinator for unnamed or unlisted stream codes*).

7) *River Mile* - river mile (from the *middle* of the electrofishing zone) to the nearest 0.1 mile determined by inspection of PEMSO river mile index maps.

8) *Distance* - electrofishing distance in kilometers to the nearest 0.01 km.

9) *Sampler Type* - sampler type letter code should be noted here (letter codes can be found in Table V-4-1).

10) *Depth* - average depth for the sampling zone to the nearest 10 cm, determined by measuring at 10 random locations with marked depth poles.

11) *Data Source* - two digit code designating the group responsible for data collection, *i.e.* Central Office, Southwest District Office, etc. (**NOTE:** *contact Central Office for Data Source codes*).

12) *Time Fished* - actual time devoted to sampling fish *in seconds.*

13) *Number of Species* - number of species of fish captured during each sampling (hybrids and exotics are *not* included and should be indicated separately).

14) *Species Codes* - each species and any hybrids are recorded by a family-species code following the system presented in Table V-4-5 (located at the end of **Subsection 4**). External anomalies if any, are recorded, for each species according to guidance stated previously.

Additional information that can be entered into FINS includes purpose of the data, latitude and longitude, site drainage area (sq. mi.), local gradient, sample designation, flow, temperature (^{o}C), and dissolved oxygen (mg/l) (Figure V-4-7).

b) Data Storage and Compilation

All completed fish data sheets are logged by the field crew leaders to prevent loss and assure that all sites are sampled according to the plan of study. The data sheets are filed

according to survey, river mile, and date, in that order, at the Ohio EPA Fish Laboratory. The Fish Evaluation Group Leader then logs the data sheets onto master tracking sheets kept at the Ohio EPA Fish Laboratory. Data is then entered into the Fish Information System (FINS) which was developed by Ohio EPA for the purpose of storing and analyzing fish relative abundance data. Data are entered in the format presented in Figure V-4-7. Each data entry is then logged by basin-river code, date of entry, river mile, and date of sampling by the Surface Water Section Data Coordinator. Both the fish data sheet and log book are then initialed by the data entry operator. The data sheets are then assembled in a notebook along with site description sheets, maps of the sampling sites and the preliminary study plans. This is then filed for future reference at the Ohio EPA Fish Laboratory. Any subsequent changes that are made to the fish data sheets are initialed and dated. After all data for a survey have been entered into FINS the entered data are proofread by the field crew leader for accuracy. All corrections or updates are then entered into FINS. Occasionally data from a sampling run may be considered invalid for calculating IBI and modified Iwb scores (*e.g.* due to elevated water levels during sampling, etc.). Although these data are entered into FINS they are designated as invalid samples for calculating community evaluation indices.

c) Analytical Methods

Relative abundance data are analyzed for both community (all species included) and population (single species) parameters. FINS is designed to perform a wide array of analyses. Presently, summarized data from FINS is downloaded to a Sperry PC/IT microcomputer for further detailed analyses. Relative abundance is expressed in terms of numbers/unit distance (or time for passive gear) and weight (kg)/unit distance (or time for passive gear). Community analyses include the number of species per sample, cumulative species per sampling location, Shannon indices (H) based on numbers and weight, the modified Index of Well-Being (Iwb), and the Index of Biotic Integrity modified for application to Ohio waters and Ohio EPA sampling methods. The specific details of how these indices and evaluations are derived is described in the "Users Manual for Biological Field Evaluation of Ohio Surface Waters" (Ohio EPA 1987).

Table V-4-4. Family-species codes used by Ohio EPA fish field crews to code fish data sheets and for data entry into the Fish Information System (FINS).

FISH INFORMATION SYSTEM (FINS) FAMILY CODES

Family	Code
Petromyzondidae	01
Polyodontidae	04
Acipenseridae	08
Lepisosteidae	10
Amiidae	15
Hiodontidae	18
Clupeidae	20
Salmonidae	25
Osmeridae	30
Umbridae	34
Esocidae	37
Catostomidae	40
Cyprinidae	43
Ictaluridae	47
Anguillidae	50
Cyprinodontidae	54
Poeciliidae	57
Gadidae	60
Percopsidae	63
Aphredoderidae	68
Atherinidae	70
Percichthyidae	74
Centrarchidae	77
Percidae	80
Sciaenidae	85
Cottidae	90
Gasterosteidae	95

Figure V-4-8. Data entry format used to enter raw fish relative abundance into the Fish Information System (FINS). The example below is data collected on September 9, 1984 in the Scioto R. at river mile 125.6. Species 43-001 includes 34 individuals from which a subsample of 15 were individually weighed. Species 43-043 includes 356 individuals of which a subsample of 54 individuals were collectively or "mass" weighed. Anomalies were recorded from the weighed subsample only.

DATE	09/09/84	DEPTH (CM)	120	PURPOSE	01	INVALID SAMPLE	N
RIV CODE	02-001	DATA SOURCE	01	LATITUDE	39 54 03	DESIGNATION	01
RIV MILE	125.6	STREAM ORDER	6	LONGITUDE	83 00 01	FLOW CFS	345
DISTANCE	0.5	TIME (SEC)	1587	DRAIN. AREA	4500	TEMPERATURE	26.8
SAMPLER TYPE	A	OBSERVED FLOW	C	GRADIENT	4.5	DISS. OXYGEN	5.8

NUMBER OF SPECIES 12

ANOMALIES (Y or N?) Y

FAMILY-SPECIES CODE 43-001-C

NUMBER WEIGHED 15 TOTAL COUNT 34

WEIGHT (GRAMS)					ANOMALIES					
2350	4550	3450	2000	1225	A	L	P			
985	634	5800	1250	1300	2	4	1			
2300	3400	230	3250	5700						

FAMILY-SPECIES CODE 43-043-C

NUMBER WEIGHED 54 TOTAL COUNT 356

WEIGHT (GRAMS)	ANOMALIES					
2345	BL	E				
	12	3				

(additional weight and anomalies spaces would follow for the remaining 10 species)

Table V-4-5. Family-species codes used by Ohio EPA fish field crews to code fish data sheets and for data entry into the Fish Information System (FINS). Designation of Ohio fish species for the purposes of the Index of Biotic Integrity, the Modified Index of Well-Being (Iwb), and the Fish Information System (FINS). Explanation of column headings appears at the end of the table.

FINS Code	Species	Spc Grp	Feed Guild	TOL	IBI Grp	Riv Size	Brd Gld	Hab Pref	Family
01001	Silver lamprey	0	P	-	-	L	N	B	Petromyzontidae
01002	Northern brook lamprey	0	F	R	-	-	N	P	Petromyzontidae
01003	Ohio lamprey	0	P	S	-	-	N	B	Petromyzontidae
01004	Mountain brook lamprey	0	F	S	-	-	N	P	Petromyzontidae
01005	Sea lamprey	0	P	-	E	-	N	B	Petromyzontidae
01006	Least brook lamprey	0	F	-	-	H	N	P	Petromyzontidae
01007	American brook lamprey	0	F	R	-	H	N	P	Petromyzontidae
04001	Paddlefish	0	F	S	-	L	S	B	Polyodontidae
08001	Lake sturgeon	0	V	-	-	L	S	B	Acipenseridae
08002	Shovelnose sturgeon	0	I	-	-	L	S	P	Acipenseridae
10001	Alligator gar	L	P	-	-	L	M	P	Lepisosteidae
10002	Shortnose gar	L	P	-	-	L	M	P	Lepisosteidae
10003	Spotted gar	L	P	-	-	L	M	P	Lepisosteidae
10004	Longnose gar	L	P	-	-	L	M	P	Lepisosteidae
15001	Bowfin	O	P	-	-	-	C	P	Amiidae
18001	Goldeye	W	I	R	-	L	M	B	Hiodontidae
18002	Mooneye	W	I	R	-	L	M	B	Hiodontidae
20001	Skipjack herring	W	P	-	-	L	M	B	Clupeidae
20002	Alewife	O	-	-	E	-	M	P	Clupeidae
20003	Gizzard shad	GS	O	-	-	-	M	P	Clupeidae
20004	Threadfin shad	GS	O	-	-	L	M	P	Clupeidae
25001	Brown trout	SA	-	-	E	-	N	B	Salmonidae
25002	Rainbow trout	SA	-	-	E	-	N	B	Salmonidae
25003	Brook trout	SA	-	-	-	-	N	B	Salmonidae
25004	Lake trout	SA	P	-	F	-	N	P	Salmonidae
25005	Coho salmon	SA	-	-	E	-	N	P	Salmonidae
25006	Chinook salmon	SA	-	-	E	-	N	P	Salmonidae
25007	Cisco or Lake Herring	WF	-	-	-	-	M	P	Salmonidae
25008	Lake whitefish	WF	V	-	-	-	M	P	Salmonidae
30001	Rainbow smelt	0	-	-	-	-	M	P	Osmeridae
34001	Central mudminnow	T	I	T	-	-	C	P	Umbridae
37001	Grass pickerel	P	P	P	-	-	M	P	Esocidae
37002	Chain pickerel	P	P	-	F	-	M	P	Esocidae
37003	Northern pike	P	P	-	F	-	M	P	Esocidae
37004	Muskellunge	P	P	-	F	-	M	P	Esocidae
37005	N. Pike x Muskellunge	P	P	-	E	-	-	-	Esocidae
37006	Grass P. x Chain	P.	P	P -	F	-	-	-	Esocidae
40001	Blue sucker	R	I	R	R	L	S	R	Catostomidae
40002	Bigmouth buffalo	C	I	-	C	L	M	P	Catostomidae
40003	Black buffalo	C	I	-	C	L	M	P	Catostomidae
40004	Smallmouth buffalo	C	I	-	C	L	M	P	Catostomidae
40005	Quillback	C	O	-	C	-	M	P	Catostomidae
40006	River carpsucker	C	O	-	C	L	M	P	Catostomidae

Table V-4-5. Continued

FINS Code	Species	Spc Grp	Feed Guild	TOL	IBI Grp	Riv Size	Brd Gld	Hab Pref	Family
40007	Highfin carpsucker	C	O	-	C	L	M	P	Catostomidae
40008	Silver redhorse	R	I	M	R	-	S	P	Catostomidae
40009	Black redhorse	R	I	I	R	-	S	P	Catostomidae
40010	Golden redhorse	R	I	M	R	-	S	P	Catostomidae
40011	Shorthead redhorse	R	I	M	R	-	S	P	Catostomidae
40012	Greater redhorse	R	I	R	R	-	S	P	Catostomidae
40013	River redhorse	R	I	I	R	-	S	P	Catostomidae
40014	Harelip sucker	R	-	S	R	-	S	P	Catostomidae
40015	Northern hog sucker	R	I	M	R	-	S	R	Catostomidae
40016	White sucker	R	O	T	W	-	S	B	Catostomidae
40017	Longnose sucker	R	I	-	R	-	S	P	Catostomidae
40018	Spotted sucker	R	I	-	R	-	S	P	Catostomidae
40019	Lake chubsucker	R	I	-	R	-	M	P	Catostomidae
40020	Creek chubsucker	R	I	-	R	P	M	P	Catostomidae
43001	Common carp	G	O	T	G	-	M	P	Cyprinidae
43002	Goldfish	G	O	T	G	-	M	P	Cyprinidae
43003	Golden shiner	N	I	T	N	-	M	P	Cyprinidae
43004	Hornyhead chub	M	I	I	N	-	N	B	Cyprinidae
43005	River chub	M	I	I	N	-	N	B	Cyprinidae
43006	Silver chub	M	I	-	N	L	M	P	Cyprinidae
43007	Bigeye chub	M	I	I	N	-	S	R	Cyprinidae
43008	Streamline chub	M	I	R	N	L	S	R	Cyprinidae
43009	Gravel chub	M	I	M	N	L	S	R	Cyprinidae
43010	Speckled chub	M	I	S	N	L	M	R	Cyprinidae
43011	Blacknose dace	M	G	T	N	H	S	R	Cyprinidae
43012	Longnose dace	M	I	R	N	-	S	R	Cyprinidae
43013	Creek chub	M	G	T	N	P	N	B	Cyprinidae
43014	Tonguetied minnow	M	I	S	N	-	N	P	Cyprinidae
43015	Suckermouth minnow	M	I	-	N	-	S	R	Cyprinidae
43016	Southern redbelly dace	M	H	-	N	H	S	B	Cyprinidae
43017	Redside dace	M	I	I	N	H	S	P	Cyprinidae
43018	Rosyside dace	M	I	S	N	H	S	P	Cyprinidae
43019	Pugnose minnow	N	I	R	N	-	M	P	Cyprinidae
43020	Emerald shiner	N	I	-	N	-	S	P	Cyprinidae
43021	Silver shiner	N	I	I	N	-	S	P	Cyprinidae
43022	Rosyface shiner	N	I	I	N	-	S	R	Cyprinidae
43023	Redfin shiner	N	I	-	N	-	N	P	Cyprinidae
43024	Rosefin shiner	N	I	M	N	-	S	P	Cyprinidae
43025	Striped shiner	N	I	-	N	-	S	B	Cyprinidae
43026	Common shiner	N	I	-	N	-	S	P	Cyprinidae
43027	River shiner	N	I	-	N	L	S	P	Cyprinidae
43028	Spottail shiner	N	I	P	N	L	M	P	Cyprinidae
43029	Blackchin shiner	N	I	S	N	-	M	P	Cyprinidae
43030	Bigeye shiner	N	I	R	N	-	S	B	Cyprinidae
43031	Steelcolor shiner	N	I	P	N	-	M	P	Cyprinidae
43032	Spotfin shiner	N	I	-	N	-	M	B	Cyprinidae

Table V-4-5. Continued

FINS Code	Species	Spc Grp	Feed Guild	TOL	IBI Grp	Riv Size	Brd Gld	Hab Pref	Family
43033	Bigmouth shiner	N	I	-	N	-	M	B	Cyprinidae
43034	Sand shiner	N	I	M	N	-	M	B	Cyprinidae
43035	Mimic shiner	N	I	I	N	-	M	B	Cyprinidae
43036	Ghost shiner	N	I	-	N	L	M	P	Cyprinidae
43037	Blacknose shiner	N	I	R	N	-	M	P	Cyprinidae
43038	Pugnose shiner	N	I	S	N	-	M	P	Cyprinidae
43039	Silverjaw minnow	M	I	-	N	P	M	B	Cyprinidae
43040	Mississippi silvery minnow	M	H	-	N	-	M	P	Cyprinidae
43041	Bullhead minnow	N	O	-	N	-	C	P	Cyprinidae
43042	Fathead minnow	M	O	T	N	P	C	B	Cyprinidae
43043	Bluntnose minnow	M	O	T	N	P	C	B	Cyprinidae
43044	Central stoneroller	M	H	-	N	-	N	B	Cyprinidae
43045	Common carp x Goldfish	G	O	T	G	-	-	-	Cyprinidae
43046	Popeye shiner	N	I	S	N	-	S	P	Cyprinidae
43047	Grass carp	G	-	-	E	-	M	B	Cyprinidae
43048	Red shiner	N	I	-	E	-	N	P	Cyprinidae
43049	Common x Rosyface Shiner	N	I	-	-	-	-	-	Cyprinidae
43057	Striped shiner/Stoneroller	M	-	-	-	-	-	-	Cyprinidae
43058	Common shiner/Stoneroller	M	-	-	-	-	-	-	Cyprinidae
43059	Striped shiner/Horny chub	M	I	-	-	-	-	-	Cyprinidae
43999	Hybrid Minnow	M	-	-	-	-	-	-	Cyprinidae
47001	Blue catfish	F	C	-	F	L	C	P	Ictaluridae
47002	Channel catfish	F	-	-	F	-	C	P	Ictaluridae
47003	White catfish	F	I	-	E	-	C	P	Ictaluridae
47004	Yellow bullhead	F	I	T	-	-	C	P	Ictaluridae
47005	Brown bullhead	F	I	T	-	-	C	P	Ictaluridae
47006	Black bullhead	F	I	P	-	-	C	P	Ictaluridae
47007	Flathead catfish	F	P	-	F	L	C	B	Ictaluridae
47008	Stonecat	O	I	I	-	-	C	R	Ictaluridae
47009	Mountain madtom	O	I	R	-	-	C	R	Ictaluridae
47010	Northern madtom	O	I	R	-	-	C	R	Ictaluridae
47011	Scioto madtom	O	I	S	-	-	C	R	Ictaluridae
47012	Brindled madtom	O	I	I	-	-	C	B	Ictaluridae
47013	Tadpole madtom	O	I	-	-	-	C	B	Ictaluridae
50001	American eel	O	C	-	-	-	M	P	Anguillidae
54000	Western Banded killifish	T	I	S	-	-	M	P	Cyprinodontidae
54001	Eastern Banded killifish	T	I	T	E	-	M	P	Cyprinodontidae
54002	Blackstripe topminnow	T	I	-	-	-	M	P	Cyprinodontidae
57001	Mosquitofish	O	I	-	E	-	N	P	Poeciliidae
60001	Burbot	O	-	-	-	-	S	B	Gadidae
63001	Trout-perch	O	I	-	-	-	M	P	Percopsidae
68001	Pirate perch	O	I	-	-	-	M	P	Aphredoderidae
70001	Brook silverside	O	I	M	-	-	M	P	Atherinidae
74001	White bass	W	P	-	F	L	M	P	Percichthyidae
74002	Striped bass	W	P	-	E	-	M	P	Percichthyidae
74003	White perch	W	-	-	E	-	M	P	Percichthyidae

Table V-4-5. Continued

FINS Code	Species	Spc Grp	Feed Guild	TOL	IBI Grp	Riv Size	Brd Gld	Hab Pref	Family
74004	White bass x White perch	W	-	-	-	-	-	-	Percichthyidae
74005	Striped bass x White bass	W	-	-	E	-	-	-	Percichthyidae
77001	White crappie	B	-	-	S	-	C	P	Centrarchidae
77002	Black crappie	B	-	-	S	-	C	P	Centrarchidae
77003	Rock bass	B	C	-	S	-	C	P	Centrarchidae
77004	Smallmouth bass	B	C	M	F	-	C	P	Centrarchidae
77005	Spotted bass	B	C	-	F	-	C	P	Centrarchidae
77006	Largemouth bass	B	C	-	F	-	C	P	Centrarchidae
77007	Warmouth	S	C	-	S	-	C	P	Centrarchidae
77008	Green sunfish	S	I	T	S	P	C	P	Centrarchidae
77009	Bluegill	S	I	P	S	-	C	P	Centrarchidae
77010	Orangespotted sunfish	S	I	-	S	-	C	P	Centrarchidae
77011	Longear sunfish	S	I	M	S	-	C	P	Centrarchidae
77012	Redear sunfish	S	I	-	E	-	C	P	Centrarchidae
77013	Pumpkinseed	S	I	P	S	-	C	P	Centrarchidae
77014	Bluegill x Pumpkinseed	S	-	-	-	-	-	-	Centrarchidae
77015	Green x Bluegill	S	-	-	-	-	-	-	Centrarchidae
77016	Green x Pumpkinseed	S	-	-	-	-	-	-	Centrarchidae
77017	Longear x Bluegill	S	-	-	-	-	-	-	Centrarchidae
77018	Bluegill x Orangespotted	S	-	-	-	-	-	-	Centrarchidae
77019	Green x Orangespotted	S	-	-	-	-	-	-	Centrarchidae
77020	Pumpkinseed x Longear	S	-	-	-	-	-	-	Centrarchidae
77021	Green x Longear	S	-	-	-	-	-	-	Centrarchidae
77022	O'spotted x Pumpkinseed	S	-	-	-	-	-	-	Centrarchidae
77023	Longear x Orangespotted	S	-	-	-	-	-	-	Centrarchidae
77024	Green x Warmouth	S	-	-	-	-	-	-	Centrarchidae
77025	Warmouth x Pumpkinseed	S	-	-	-	-	-	-	Centrarchidae
77998	Green Sunfish Hybrid	S	-	-	-	-	-	-	Centrarchidae
77999	Hybrid Sunfish	S	-	-	-	-	-	-	Centrarchidae
80001	Sauger	V	P	-	F	L	S	P	Percidae
80002	Walleye	V	P	-	F	-	S	P	Percidae
80003	Yellow perch	V	-	-	-	-	M	P	Percidae
80004	Dusky darter	D	I	M	D	-	S	B	Percidae
80005	Blackside darter	D	I	-	D	-	S	B	Percidae
80006	Longhead darter	D	I	S	D	-	S	R	Percidae
80007	Slenderhead darter	D	I	R	D	L	S	R	Percidae
80008	River darter	D	I	-	D	L	S	R	Percidae
80009	Channel darter	D	I	S	D	-	S	P	Percidae
80010	Gilt darter	D	I	S	D	-	S	B	Percidae
80011	Logperch	D	I	M	D	-	S	B	Percidae
80012	Crystal darter	D	I	S	D	-	S	R	Percidae
80013	Eastern sand darter	D	I	R	D	-	S	R	Percidae
80014	Johnny darter	D	I	-	D	P	C	B	Percidae
80015	Greenside darter	D	I	M	D	-	S	R	Percidae
80016	Banded darter	D	I	I	D	-	S	R	Percidae
80017	Variegate darter	D	I	I	D	-	S	R	Percidae

Table V-4-5. Continued

FINS Code	Species	Spc Grp	Feed Guild	TOL	IBI Grp	Riv Size	Brd Gld	Hab Pref	Family
80018	Spotted darter	D	I	R	D	-	S	R	Percidae
80019	Bluebreast darter	D	I	R	D	-	S	R	Percidae
80020	Tippecanoe darter	D	I	R	D	-	S	R	Percidae
80021	Iowa darter	D	I	-	D	-	M	P	Percidae
80022	Rainbow darter	D	I	M	D	-	S	R	Percidae
80023	Orangethroat darter	D	I	-	D	P	S	B	Percidae
80024	Fantail darter	D	I	-	D	H	C	R	Percidae
80025	Least darter	D	I	-	D	-	N	B	Percidae
80026	Sauger x Walleye	V	P	-	E	-	-	-	Percidae
85001	Freshwater drum	F	-	P	-	L	M	P	Sciaenidae
90001	Spoonhead sculpin	SC	-	-	-	-	C	P	Cottidae
90002	Mottled sculpin	SC	I	-	-	H	C	R	Cottidae
90003	Slimy sculpin	SC	-	-	-	-	-	-	Cottidae
90004	Deepwater sculpin	SC	-	-	-	-	-	-	Cottidae
95001	Brookstickleback	O	I	-	-	H	C	P	Gasterosteidae

Table V-4-5, Continued

SPCLST - Legend for Species Designations

The following letter symbol designations are used to classify Ohio fish species according to their taxonomic, functional, structural, pollution tolerance, and ecological characteristics. These designations provide the basis for the Fish Information System (FINS) to calculate metrics for the Index of Biotic Integrity (FINIBI) and the Modified Index of Well-Being (FINLS2) as well as other uses.

SPC GRP (Species Group)[a]
- O - Other
- L - Gars
- W - Large River Species
- GS - Gizzard Shad
- SA - Salmonid
- WF - Whitefish
- T - Tolerant
- P - Pickerels
- R - Round-bodied Suckers
- C - Deep-bodied Suckers
- G - Carp/Goldfish
- N - Shiners
- M - Minnows
- F - Catfish, Drum
- B - Blackbass, Crappie
- S - Sunfish
- V - Non-darter Percidae
- D - Darters
- SC - Sculpins

FEED GUILD (Feeding Guild)[b]
- P - Piscivore
- F - Filter Feeder
- V - Invertivore
- I - Specialist Insectivore
- O - Omnivore
- G - Generalist
- H - Herbivore
- C - Carnivore

IBI GRP (IBI Group)[b]
- E - Exotic (non-native)
- F - Sport Species
- R - Round-bodied Sucker
- C - Deep-bodied Sucker
- W - White sucker
- G - Carp/Goldfish
- N - Other Cyprinidae
- S - Sunfish (less Blackbasses)
- D - Darters

TOL (Pollution Tolerance)
- R - Rare Intolerant
- S - Special Intolerant
- I - Common Intolerant
- M - Moderately Intolerant
- T - Highly Tolerant
- P - Moderately Tolerant

RIV SIZ (River Size)
- L - Large River Species
- H - Headwaters Species
- P - Pioneering Species

BRD GLD (Breeding Guild)[c]
- N - Complex, no parental care
- C - Complex with parental care
- M - simple, miscellaneous
- S - simple lithophils

HAB PRF (Habitat Pref.)[c]
- P - prefers pools
- R - preferes riffles
- B - prefers both

---

[a]these designations are not for use in any FINS analytical programs.

[b]designations are patterned after Karr et al. (1986).

[c]designations are patterned after Berkman and Rabeni (1987).

References for Table V-4-5.

Berkman, H.E. and C.F. Rabeni. 1987. Effect of siltation on stream fish communities. Env. Biol. Fishes. 18(4): 285-294.

Karr, J.R., K.D. Fausch, P.L. Angermier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Ill. Nat. Hist. Surv. Spec. Publ. 5. 28 pp.

Subsection 4: References

Allison, L.N., J.G. Hnath and W.G. Yoder. 1977. Manual of common diseases, parasites, and anomalies of Michigan fishes. Michigan Dept. Nat. Res., Lansing. Fish Mgmt. Rept. No. 8, 132 pp.

Angermier, P.L. and J.R. Karr. 1986 Applying an index of biotic integrity based on stream-fish communities: considerations in sampling and interpretation. N. Am. J. Fish. Mgmt. 6: 418-429.

Angermier, P.L. and I.J. Schlosser. 1988. Assessing biotic integrity in the fish community of a small Illinois stream. N. Am. J. Fish. Mgmt. 7:331-338.

Baumann, P.C., W.D. Smith and W.K. Parland. 1987. Tumor frequencies and contaminant concentrations in brown bullhead from an industrialized river and a recreational lake. Trans. Am. Fish. Soc. 116(1): 79-86.

Becker, G.C. 1983. Fishes of Wisconsin. Univ. Wisconsin Press. 1052 pp.

Berkman, H.E. and C.F. Rabeni. 1987. Effect of siltation on stream fish communities. Env. Biol. Fishes. 18(4): 285-294.

Berra, T.M. and R. Au. 1981. Incidences of teratological fishes from Cedar Fork Creek, Ohio. Ohio J. Sci. 81(5): 225.

Clay, W.M. 1975. The fishes of Kentucky. Kentucky Dept. Fish Wildl. Res., Frankfort. 416 pp.

Esch, G.W. and T.C. Hazen. 1980. Stress and body condition in a population of largemouth bass: implications for red-sore disease. Trans. Am. Fish. Soc. 109: 532-536.

Gammon, J.R. 1973. The effect of thermal inputs on the populations of fish and macroinvertebrates in the Wabash River. Purdue Univ. Water Resources Res. Cen. Tech. Rep. 32. 106 pp.

Gammon, J.R. 1976. The fish populations of the middle 340 km of the Wabash River. Purdue Univ. Water Resources Res. Cen. Tech. Rep. 86. 73 pp.

Karr, J.R., K.D. Fausch, P.L. Angermier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Ill. Nat. Hist. Surv. Spec. Publ. 5. 28 pp.

Komanda, N. 1980. Incidence of gross malformations and vertebral anomalies of natural and hatchery Plecoglossus altivelis. Copeia 1980: 29-35.

Lagler, K.F., J.E. Bardach, and R.R. Miller. 1962. Ichthyology. John Wiley & Sons, Inc. 545 pp.

Novotny D.W. and G.R. Priegel. 1974. Electrofishing boats, improved designs, and operational guidelines to increase the effectiveness of boom shockers. Wisc. DNR Tech. Bull. No. 73, Madison WI. 48 pp.

Ohio Department of Natural Resources. 1960. Gazetteer of Ohio streams. Ohio DNR, Div. of Water, Columbus, Ohio. Ohio Water Plan Inventory Rept. No. 12. 179 pp.

Ohio Environmental Protection Agency. 1987. Users manual for biological field assessment of Ohio rivers and streams. Div. of Water Quality Monitoring & Assessment, Columbus.

Pflieger, W.L. 1975. The fishes of Missouri. Missouri Dept. of Conservation. 343 pp.

Pippy, J.H. and G.M. Hare. 1969. Relationship of river pollution to bacterial infection in salmon and suckers. Trans. Am. Fish. Soc. 1969(4): 685-690