Manual of Fisheries Survey Methods II: with periodic updates

Chapter 25A: GLEAS Procedure #51 Survey Protocols for Wadable Rivers

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TOC

NEXT PAGE

PREVIOUS PAGE

CITATION

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Chapter 25A: GLEAS Procedure #51 Survey Protocols for Wadable Rivers

Michigan Department of Environmental Quality
Surface Water Quality Division

[Editor's note: Chapter 25 presents methods developed by the Surface Water Quality Division for surveying and evaluating fish, invertebrates, and habitat in wadable streams and rivers. The methods are included in Manual of Fisheries Survey Methods II because they can be useful to Fisheries Division personnel as well. The first section, Chapter 25A, presents qualitative biological and habitat survey protocols. The second section, Chapter 25B, presents methods for scoring and interpreting the resulting metrics.

Chapter 25A consists of a document, revised in January 1997, prepared by Michigan Department of Environmental Quality, Surface Water Quality Division, Great Lakes and Environmental Assessment Section. It has been included here with permission, and has been modified only as needed for formatting. Contents of this report are subject to modification by the authors, and a time lag may occur before such revisions appear in the Manual of Fisheries Survey Methods.]

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

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GLEAS PROCEDURE #51

QUALITATIVE BIOLOGICAL AND HABITAT SURVEY PROTOCOLS FOR WADABLE STREAMS AND RIVERS

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Michigan Department of Environmental Quality
Surface Water Quality Division
Great Lakes and Environmental Assessment Section

Approved Date

TABLE OF CONTENTS

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

QUALITATIVE BIOLOGICAL AND HABITAT SURVEY PROTOCOLS

I. INTRODUCTION

The development of these Biological and Habitat Survey protocols was a result of the increasing demand for a more vigorous and standardized evaluation of nonpoint source impacts. The nature and diversity of the causes of nonpoint pollution created a need for greater refinement and sophistication of the Surface Water Quality Division standard biological survey procedures in order to assess the degree and causes of these biological impacts. The origins of nonpoint effects often extend throughout an entire watershed basin. Such basin wide effects prevent the traditional upstream/downstream comparisons from providing a true picture of the extent of stream impairment. Methods, therefore, need to be more sensitive and reproducible to consistently detect the changes in the biotic communities caused by possible widespread nonpoint source effects and yet still be applicable to the many differing aquatic systems found throughout Michigan. The application of these biological survey protocols will provide a more accurate and precise database on biological conditions and trends statewide.

The biosurvey protocols consist of three parts including evaluation of the macroinvertebrate community, the fish community, and the habitat quality. Any one or combination of the three categories can be evaluated. The biological integrity of a stream is based on the results of the fish and macroinvertebrate communities.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

These protocols only address qualitative methods for wadable streams. Methods for non-wadable streams and other waterbodies will be developed at a later date. In addition, certain studies may require quantitative, or other alternate methods. The biosurvey protocols presented here do not preclude the use of alternate methods, however, the use of alternate methods will be the exception.

The analysis of the fish, macroinvertebrate, and habitat quality is made according to a set of selected measurements or "metrics". These metrics have been selected from those used by EPA for the Rapid Biological Assessment Protocols, Ohio's Environmental Protection Agency's protocols, the State of Illinois' biological procedures, and those procedures developed specifically for Michigan and tested by MDEQ staff. The metrics represent a wide array of criteria for the majority of biological or habitat conditions known to occur in response to various stream quality conditions. The accuracy of the protocols, however, depends on the selection and evaluation of excellent sites. These excellent sites are selected from streams within each of Michigan's Ecoregions recognized as excellent in quality by biologists. These sites then become the level against which all other field measured stream biological and physical parameters are compared. Each Ecoregion will have several excellent sites, according to stream width. The glacial history of Michigan created five distinct Ecoregions, separable by soil types, topography, and stratigraphy (Omernik, 1987). The Ecoregion approach provides a logical framework to use with these biological monitoring protocols when excellent sites are described within each Ecoregion.

Each survey station is described with up to three numbers, one each for the macroinvertebrate community, the fish community, and the habitat. An excellent quality stream for the Ecoregion would have most metrics performing like an excellent site. Poor quality streams would have most metrics performs substantially different than excellent sites. The use of these metrics creates a uniform and systematic evaluation for each station with the result expressed as a single numerical score. This makes the results easily interpretable, since they are expressed relative to the excellent sites.

These protocols can become the yardstick used to measure the effectiveness of Best Management Practices in controlling basin wide nonpoint source effects, to predict potential intra-basin or regional trends early, and to determine the degree of use attainability of individual waterbodies. The advantages of this approach include greater consistency and accuracy, together with a better overall measurement of total biological integrity and habitat conditions.

II. PRINCIPLES OF FISH, MACROINVERTEBRATE AND HABITAT SURVEYS

Better stream quality is normally indicated by greater warmwater fish and benthic macro-invertebrate diversity and abundance, as well as a more even distribution of individuals among taxa at one station compared with another. Conversely, poorer stream quality is indicated by a lower diversity and abundance at one station when compared to another. Changes in stream quality over time may be recognized at a given station by repeated sampling and comparison of fish and macroinvertebrate data.

Fish and macroinvertebrate community composition generally reflect conditions present for an extended period of time prior to sampling. However, temporary events, such as decreases in dissolved oxygen concentrations or the presence of toxicants, may cause losses of sensitive species within the biological community either by emigration or death. Similarly, an abundance of tolerant organisms may indicate persistent degraded stream quality. Changes in fish or macro-invertebrate community structure will also occur if trophic changes occur due to pollution or perturbation. The emphasis on data interpretation is therefore directed toward evaluating the fish or macroinvertebrate community, which is obtained from these procedures by combining a variety of different community evaluation tools or 'metrics'. These metrics measure a wide spectrum of community attributes and are used in combination to determine biosurvey categories.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

The metrics for coldwater fish have been removed from this version of the procedure. The present data set for coldwater wadable streams in Michigan was not conducive to metric development at this time. Instead, the coldwater fish community is evaluated for the presence of at least 50 fish, anomalies, and percentage of salmonids relative to the total number collected.

The habitat evaluation is also important in determining the nature and degree of abiotic constraints on the biological potential. This evaluation is accomplished through characterizing the stream based on selected physical measurements and descriptive watershed features. The habitat metrics measure a wide range of physical characteristics, which are important to the optimum development and stability of biological communities, and are used to develop habitat survey categories.

III. GENERAL SAMPLING CONSIDERATIONS

1. Sampling should occur between June 1 and September 30 during periods of stable discharge, at times of low or moderate flow. This will help ensure consistency between sampling studies by reducing variability due to flow fluctuations within years or between years.

2. For basin investigations or long-term studies, stations should be sampled during the same time frame to minimize seasonal variability in fish and macroinvertebrate distribution or abundance.

3. Maximum impact of a municipal or industrial discharge usually occurs during summer low stream flow and maximum temperature conditions. Dilution is minimal for pollutants during low flow conditions, while elevated stream temperatures and productivity will produce maximum fluctuations in diurnal oxygen concentrations. High temperatures also increase fish and macroinvertebrate metabolic rates which may amplify toxics effects.

4. Consideration must be given to the sampling sequence. For most sites, the sampling sequence should first be fish, then macroinvertebrates, with habitat evaluation last. This is to insure the least disruption of the communities to be sampled.

5. Record all data on the Stream Survey Cards shown in Appendix J, including a sketch of the station location to assist future sampling. The following channel modifications should be noted by checking the appropriate box(es) on the survey card:

   none - natural stream channel, no evidence of modifications.
   dredged - stream channel has been excavated (widened, deepened, straightened), evidence of dredge spoils along stream banks.
   canopy removal - woody riparian vegetation has been removed from one or both banks either by physical removal or with the use of defoliant sprays.
   snagging - removal of logs, deadfalls, and other large woody debris from the stream channel.
   impounded - station is located either directly upstream of an impoundment or directly downstream of a dam.
   relocated - stream channel has been completely rerouted from the original channel usually to follow a roadway, railway, or has been redirected for industrial purposes (e.g. mill race) or has been rerouted to another watershed.
   bank stabilization - this includes engineered cattle access points or the stream bank has been armored with rip-rap, sheet piling, revetments, etc.
   habitat improvement - identified by the presence of artificial banks (lunker structures), wing deflectors, half-logs, rock dams, etc.

   The presence of attached algae, aquatic macrophytes, or bacterial slimes should also be noted. Although the determination of nuisance conditions will be left to the biologist's professional judgment, the following examples are provided as guidance for identifying nuisance conditions:

   1. Cladophora spp. and/or Rhizoclonium spp. greater than ten inches long and covering greater than 25% of a riffle.
   2. Rooted macrophytes present at densities which would impair the designated uses of the waterbody.
   3. The presence of bacterial slimes.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

IV. SITE SELECTION

Site selection in general will be made to meet the objectives of the biological survey. In addition to the objectives of the biological survey, sites must be carefully selected to ensure that all habitats of the waterbody are represented.

Locally modified sites, such as small impoundments and bridge areas, should be avoided, unless data are needed to assess their effects. When the sampling station is located at a road crossing, sampling should occur upstream to avoid direct influence of the roadway. Sampling near the mouths of tributaries entering large waterbodies should also be avoided, if possible, since these areas will have habitat more typical of the larger waterbody (Karr et al., 1986).

V. QUALITATIVE FISH SAMPLING PROCEDURES AND DATA ANALYSIS TECHNIQUES

Fish Sampling is optional for this procedure. Special consideration should be given to the need for sampling fish in coldwater streams, since there is a limited set of metrics (number collected, anomalies, % coldwater fish) that are available to evaluate the results with.

A. Fish Sampling Procedures

1. The stream shocking unit is the preferred fish sampling device, except where physically impractical. Backpack shocking units may be used when sampling smaller streams or headwaters. All safety procedures must be observed when using these units (see GLEAS procedure No. 48).
2. Fish shocking must always be done in an upstream direction.
3. The sampling effort expended should be sufficient to ensure that all fish species present are sampled in proportion to their occurrence in the stream reach chosen. As a goal, at least 100 individual fish should be examined from each station. This will generally require approximately 30 minutes of electrofishing per station, encompassing 100-300 feet with sufficient sampling to include all significant available habitat. In small streams (10 feet wide), the length of the sampling station should be approximately 100 feet. In moderate size streams (30 feet wide), the length should be approximately 300 feet. In larger streams and rivers, the length of the sampling station should be about 5-10 channel widths. If necessary, increase the length of the selected sampling area. If the number of fish collected is no greater than 100 individuals after 45 minutes, discontinue further sampling and calculate metrics based on reduced sample size.
4. All collected fish should be placed immediately in water filled tubs. Care should be taken to keep fish alive by replenishing the holding tub water and processing the fish as quickly as possible. Tubs may be placed in the stream shocking unit or along the stream banks. A live box may also be placed directly in the stream to hold collected fish. Portable battery operated aerators may also be used.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

B. Data to be Recorded

When sampling has been completed at each station, the following information should be recorded:

1. The location of the sampling stations should be specifically indicated on the station card so that future studies can be repeated at the same station. The station reaches should be identified on a detailed map of the study area together with any necessary comments or descriptions on the field card.
2. Record the names and number of each species collected with a length greater than 1 inch and determine the total number of fish collected. If unsure of correct field

identification, return representatives to the lab for later identification. Regional keys have been chosen for their ease of use and elimination of extraneous taxa. Hubbs and Lagler (1964) should be used as the primary key when identifying all gamefish. For nongame fish, Smith (1988) may be used but verification of identification should be through the use of Hubbs and Lagler (1964). Additional information on Petromyzonidae (lampreys) can be found in Vladykov and Kott (1980).

3. The following externally observable anomalies should be noted as total number of individuals afflicted: bent spine (scoliosis), open lesions, severely eroded fins, fungus patches, growths on skin or fins, tumors, and poor physical condition indicated by severe emaciation, excessive mucus coating, and hemorrhaging. This measurement is meant to apply only to <u>extreme</u> or <u>obvious</u> conditions. Common external parasites, such as copepods (anchorworms), and common visible internal parasites, such as black spot and yellow grub should <u>not</u> be considered anomalies unless extreme or very severe infestations are present. All determinations of anomalies should be compared to those illustrated and presented in Allison et al. (1977).

4. Record the amount of time spent electrofishing at each station including the number of passes through the sampling station and the number of shocking probes used. Also record average stream width (wetted stream channel width at time of sampling) and distance of reach electrofished. Catch per unit effort (CPE) will be calculated as the total number of fish collected divided by the number of minutes spent shocking at each station (catch per minute), and as the number of fish per stream area (catch per square meter).

5. Record the length of all fish listed in Appendix G to inch group or to size range. These data may be used for additional biomass or productivity estimates.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

C. Data Analysis Techniques

Following sample analyses, a Fish Score will be calculated for each warmwater station based on the sum of each of the ten metrics listed below. Each metric score for an individual station is contrasted to the ecoregional excellent sites. A biosurvey category describing the degree of similarity to the excellent sites will be given each station based on the total metric point score calculated. These contrasts and categories are described in separate reports (available upon request).

There are some overriding considerations in this interpretation. When fewer than 50 fish are collected, or when the percent of fish with anomalies exceeds 2%, the site will not be scored following the metrics, but will be considered to be "Poor" (below acceptable quality).

In addition, for coldwater designated streams, the requirement is to have significant populations of salmonids. Therefore, for coldwater designated streams, if the percentage of salmonids relative to total number collected exceeds 1%, the stream will be considered to meet its coldwater designation and overall quality will be judged by the macroinvertebrate metrics.

<u>Metric Description</u>

Metric 1. <u>Total Number of Fish Species</u>. This is total number of fish species collected at each sampling station. For a given watershed size and type of stream (warmwater), total number of fish species decreases with environmental

degradation. This metric is scored by comparison to excellent sites of similar size.

Metric 2. Number of Darter Species. This is the number of species in the genera Ammocrypta, Etheostoma, and Percina (Percidae: Etheostomatinae), and the number of species of Sculpins (Cottidae) and of Madtoms (genus Noturus). These species are sensitive to habitat degradation due to the unique habitats they require for reproduction. Such habitats are degraded by siltation, dredging, or reductions in oxygen content. The presence of one or two taxa may indicate good water quality so care should be taken during sampling to collect all small fish.

Metric 3. Number of Sunfish Species. This is the total number of species in the family Centrarchidae exclusive of largemouth and smallmouth basses (Micropterus sp.). They are particularly responsive to declines in pool habitats and habitat structure such as instream cover (Gammon et al., 1981; Angermeier, 1983).

Metric 4. Number of Sucker Species. This is the total number of species in the family Catostomidae. Many species are not tolerant of habitat and chemical degradation, due to habitat specificity and dominance of benthic insects in their diet. In addition, large size and long lives provide a multiyear integrative perspective.

Metric 5. Number of Intolerant Species. This is the total number of species classified as intolerant (Appendix A). Intolerant fish are those that are sensitive to many types of environmental degradation and tend to be absent from degraded surface waterbodies.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Metric 6. Percentage of Total Sample as Omnivores. This is the ratio of the number of omnivores to the total number of fish collected. Omnivorous fishes are those species that routinely take significant quantities of both plant and animal material (often including detritus) and have the ability, usually indicated by the presence of a long gut and dark peritoneum, to utilize both. Appendix B contains a list of omnivorous fishes commonly found in Michigan. The common omnivores of small midwestern streams are Pimephales notatus and P. promelas, while Cyprinus carpio and Dorosoma cepedianum, also omnivores, are found over a wider range of stream sizes. Omnivores can become dominant in degraded conditions, apparently as a result of irregular supply of both plants and invertebrate foods. Irregularity in plant or invertebrate availability results in declining abundances for fish that specialize on one food type or the other.

Metric 7. Percentage of Total Sample as Insectivorous Fish. This metric measures the ratio of the number of insectivorous fish to the total number of fish collected and tends to vary inversely with Metric 6. Most cyprinids are insectivores (Carlander 1969, 1977); besides the omnivores mentioned above (Pimephales), some other minnow species are strict herbivores and a few are piscivores. Although a dominant trophic group in Midwestern streams, relative abundance of insectivorous fish decreases with degradation, perhaps in response to variability in supply or production of insects, which in turn may decline in response to alteration of water quality, energy sources, or instream habitat. Appendix C contains a list of insectivorous fish commonly found in Michigan.

Metric 8. Percentage of Total Sample as Piscivores. This metric is a ratio of the number of all species that are predominantly piscivores as adults to the total number of fish collected. Some opportunistic fish species may feed on invertebrates as well as fish, including both fry and juveniles. Do not include species, such as creek chub, that may opportunistically include some fish in their diet only when very large (Fraser and Sise, 1980). Viable and healthy populations of top carnivore species such as smallmouth bass, walleye, northern pike, grass pickerel, and others indicate a healthy, trophically diverse community. Appendix D contains a list of piscivorous fishes commonly found in Michigan.

Metric 9. Percentage of Total Sample as Tolerant Species. This metric is a ratio of the number of tolerant fish to the total number of fish collected. Tolerant fish are those species able to adapt to a wide range of environmental conditions and are often common in highly degraded surface waterbodies. Appendix E provides a list of tolerant species.

Metric 10. Percentage of Total Sample as Simple Lithophilic Spawners. This metric is a ratio of the number of simple lithophilic spawners to the total number of fish collected. Simple lithophilic spawners require clean gravel or cobble for spawning and do not construct nests or provide parental care. They are especially sensitive to sedimentation and siltation of these substrates. Appendix F provides a list of simple lithophilic spawners.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

VI. QUALITATIVE BENTHIC MACROINVERTEBRATE SAMPLING PROCEDURES AND DATA ANALYSIS TECHNIQUES

A. Benthic Macroinvertebrate Sampling Procedures

1. The sampling effort or time expended at each station should be sufficient to assure that taxa present are sampled in proportion to their occurrence in the stream reach chosen. This will generally be about 30 minutes of total sampling time per survey station.

2. Macroinvertebrate samples should be taken from all available habitats within the sample reach using a triangular dip net with a 1 mm mesh or by hand picking. Samples should be taken from both high velocity and low velocity areas within the selected sampling station. It is generally accepted that the optimum habitat for macroinvertebrates includes gravel, cobble, and boulder substrates necessary to support the periphyton-based benthic community. Efforts should be directed toward preferentially sampling these habitats. However, additional organisms may be hand picked or netted from other habitats such as fixed submerged boulders, vegetation, logs, pilings, or other structures. Substrates such as sand and silt should be sampled if present.

3. All organisms collected should first be placed in a bucket to form a single composite sample. The composite sample should be thoroughly rinsed in the sampling net or by using a 1 mm screen. Large organic or inorganic debris fragments should be removed. The remaining sample contents should be distributed into an enamel or plastic counting pan with a lightly colored bottom.

4. The organisms may be anesthetized, if necessary, with soda water to eliminate invertebrate movement. Add just enough water to aid in the even distribution of organisms within the pan. Discard remaining leaf fragments, twigs, and other material.

5. Subsampling of the macroinvertebrate sample can be achieved by using a small fish or minnow net or other device to remove approximately 100 organisms. To lessen sampling bias, the biologist should pick smaller, more cryptic organisms as well as larger more obvious ones not obtained from the subsample. This can be accomplished with forceps or a small bulb pipette and ensures that all taxa representing the sampling station are present in the 100 organism subsample. A subsample of about 100 organisms is designed to assure greater reproducibility and accuracy and to lessen variability due to station habitat variability and sampling effort or method variability. This subsample will provide a consistent size to allow simple or sophisticated statistical data analyses. The invertebrate biological surveys can subsequently be contrasted by ecoregion, watershed, or stream site.

B. Data to be Recorded

1. Organisms should be identified to the taxonomic level indicated in Appendix H. Appendix H also contains a list of the primary keys to be used to identify the macroinvertebrates. Alternate keys may be used, but verification of identification should be through those keys listed in Appendix H. The collected organisms in the subsample should be returned to the laboratory for identification where field identification is not feasible.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

2. When sampling has been completed at each station, the following information should be recorded on the stream survey data sheet:

   a. The sampling area should be identified on a detailed map together with necessary comments on the field card.

   b. The total number of organisms collected.

   c. The numbers of each taxa collected and identified.

   d. Sampling time in minutes (total time for all samplers).

C. Data Analysis Techniques

Following sample analyses, a macroinvertebrate score will be calculated for each station based on the sum of the nine metrics listed below. Each metric score for an individual station is contrasted to the ecoregional excellent sites. A final biosurvey category describing the degree of similarity to the excellent sites will be given each station based on the total metric point score calculated. These contrasts and categories are described in a separate report (available upon request).

<u>Metric Description</u>

Metric 1. <u>Total Number of Taxa</u>. This is the total number of taxa identified, as specified in Appendix H in the macroinvertebrate subsample. Taxa richness has historically been a key component in most all evaluations of macroinvertebrate community integrity. The underlying reason is the basic ecological principle that healthy, stable biological communities have high

species diversity. Increases in number of taxa are well documented to correspond with increasing water quality and habitat suitability. Small, pristine headwater streams may, however, be exceptions and show low taxa richness.

Metric 2. Total Number of Mayfly Taxa. This is the number of taxa in the order Ephemeroptera. Mayflies are an important component of a high quality stream biota. As a group, they are decidedly pollution sensitive and are often the first group to disappear with the onset of perturbation. Thus, the number of taxa present is a good indicator of environmental conditions.

Metric 3. Total Number of Caddisfly Taxa. This is the number of taxa in the order Trichoptera. Caddisflies are often a predominant component of the macroinvertebrate fauna in larger, relatively unimpacted streams and rivers but are also important in small headwater streams. Though tending to be slightly more pollution tolerant as a group than mayflies, caddisflies display a wide range of tolerance and habitat selection among species. However, few species are extremely pollution tolerant and, as such, the number of taxa present can be a good indicator of environmental conditions.

Metric 4. Total Number of Stonefly Taxa. This is the number of taxa in the order Plecoptera. Stoneflies are one of the most sensitive groups of aquatic insects. The presence of one or more taxa is often used to indicate very good environmental quality. Small increases or small declines in overall numbers of different stonefly taxa is thus very critical for correct evaluation of stream quality.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Metric 5. Percent Mayfly Composition. This is the ratio of the number of individuals in the order Ephemeroptera to the total number of organisms collected. As with the number of mayfly taxa, the percent abundance of mayflies in the total invertebrate sample can change dramatically and rapidly to minor environmental disturbances or fluctuations.

Metric 6. Percent Caddisfly Composition. This is the ratio of the number of individuals in the order Trichoptera to the total number of organisms collected. As with the number of caddisfly taxa, percent abundance of caddisflies is strongly related to stream size with greater proportions found in larger order streams. Optimal habitat and availability of appropriate food type seem to be the main constraints for large populations of caddisflies.

Metric 7. Percent Contribution of the Dominant Taxon. This is the ratio of the number of individuals in the most abundant taxon to the total number of organisms collected. The abundance of the numerically dominant taxon is an indication of community balance. A community dominated by relatively few taxa for example, would indicate environmental stress, as would a community composed of several taxa but numerically dominated by only one or two taxa.

Metric 8. Percent Isopods, Snails, and Leeches. This is the ratio of the sum of the number of individuals in the order Isopoda, class Gastropoda, and class Hirudinea to the total number of organisms collected. These three taxa, when compared as a combined percentage of the invertebrate community, can give an indication of the severity of environmental perturbation present. These organisms show a high tolerance to a variety of physical and chemical parameters. High percentages of these organisms at a sample site are very good evidence for stream degradation.

Metric 9. Percent Surface Dependent. This metric is the ratio of the number of macroinvertebrates which obtain oxygen via a generally direct atmospheric exchange, usually at the air/water interface, to the total number of organisms collected. High numbers or percentages of surface breathers may indicate large diurnal dissolved oxygen shifts or other biological or chemical oxygen demanding constraints. Areas subject to elevated temperatures, low or erratic flows may also show disproportionately high percentages of surface dependent macroinvertebrates. Appendix I contains a list of surface dependent aquatic macroinvertebrates.

VII. HABITAT SURVEY PROCEDURE AND DATA ANALYSIS TECHNIQUES

A. Habitat Evaluation

Each station will be scored for the nine metrics described below. A final habitat survey category describing the overall quality of the fish and macroinvertebrate habitat will be given each station based on the total metric point score calculated.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Habitat quality parameters are separated into three principal categories: 1. Substrate and Instream Cover; 2. Channel Morphology; and 3. Riparian and Bank Structure. These categories, and different scoring levels, are based on levels of importance in influencing biological community composition. The most important biological habitat parameters are those characterizing bottom substrate and instream cover, estimation of embeddedness, and estimation of water velocity. These three parameters have a direct influence on biological composition and abundance. These metrics have a greater score (20) than other parameters (Table 1) because of their greater importance in affecting biological composition. Parameters associated with channel morphology and structure have a slightly smaller score of 15. Riparian and bank parameters, which may directly affect species composition the least, have the lowest score of 10.

Habitat evaluations are first made on instream habitat, followed by channel morphology, and finally on structural features of the bank and riparian vegetation. Bottom substrate and available cover, embeddedness, and velocity are evaluated in the immediate sampling area, usually the first riffle/pool or run/bend sequence. Channel morphology, riparian and bank structure are evaluated over a larger stream area (primarily upstream where conditions have greater impact on the study site). The actual habitat survey process involves rating the nine metrics as excellent, good, fair, or poor and determining the point scores for each based on the criteria included on the Habitat Survey Data Sheet (Table 1).

The station habitat score is obtained by adding together the individual scores for the nine habitat parameters. The station is then classified as excellent, good, fair, or poor based on its potential to support biological communities using the following rating table.

METRIC	HABITAT SCORING CRITERIA			
	Excellent	**Good**	**Fair**	**Poor**
Substrate and Instream Cover				
1. Bottom Substrate and Available Cover	16-20	11-15	6-10	0-5
2. Embeddedness/Siltation	16-20	11-15	6-10	0-5
3. Water Velocity	16-20	11-15	6-10	0-5
Channel Morphology				
4. Flow Stability	12-15	8-11	4-7	0-3
5. Deposition/Sedimentation	12-15	8-11	4-7	0-3
6. Pools-Riffle-Runs-Bends	12-15	8-11	4-7	0-3
Riparian and Bank Structure				
7. Bank Stability	9-10	6-8	3-5	0-2
8. Bank Vegetation	9-10	6-8	3-5	0-2
9. Streamside Cover	9-10	6-8	3-5	0-2

Habitat Survey Category	**Total Point Score (metrics 1-9)**
Excellent	≥ 107
Good	≥ 71
Fair	≥ 35
Poor	< 35

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

<u>Metric Description</u>

Substrate and Instream Cover

The instream habitat directly pertinent to the support of aquatic communities consists of substrate type and stability, availability of refugia, and migration or passage potential. These parameters are weighted the highest to reflect their degree of importance to biological communities. Examples of the survey categories: Excellent, Good, Fair and Poor are presented in Table 1 together with their respective point scores.

Metric 1. <u>Bottom Substrate</u>. This refers to the availability of suitable, diverse habitat for the support of aquatic organisms. An excellent assessment would indicate the presence of a variety of substrate material and habitat types capable of supporting a large variety of fish and macroinvertebrates. The presence of rock and gravel is generally considered to provide the most desirable cover habitat. However, other forms of habitat may also provide the niches required for community support. Logs and tree roots, for example, along with undercut banks or emergent vegetation provide excellent cover habitat for a variety of organisms, particularly fish. Consider the variety of substrate as well as the amounts of suitable substrates.

Metric 2. <u>Embeddedness/Siltation</u>. This parameter evaluates the degree to which boulders, rubble, logs, or gravel in run or riffle areas are surrounded or covered by fine sediments (sand, clay, or silt). This metric indicates the suitability of the stream substrate in offering clean, unsilted habitat (excellent assessment, Table 1) for benthic macroinvertebrates, such as grazers or filter feeders, as well as offering abundant, suitable sites for fish spawning and egg incubation. Examples of degrees of embeddedness/siltation are depicted in Figure 1. The percent of individual substrate surfaces surrounded or covered by silt should only be examined in relatively fast flowing stream reaches, i.e. run or riffle zones. Disturbing suspended in-stream substrates, like logs or branches and observing downstream silt clouds would indicate high siltation. This metric should be expressed as the degree to which the total overall substrate area in a run/riffle is surrounded or covered with fine sediments or silt.

Metric 3. Stream Velocity. This metric evaluates different velocity/depth combinations. Velocity, in conjunction with depth, has direct influence on the structure of fish and benthic macroinvertebrate communities. The quality of the aquatic habitat can be evaluated in terms of a velocity and depth relationship and categorized according to the relative amounts of each type. As patterned after Oswood and Barber (1982), four general categories of velocity and depth are optimal for fish and benthic macroinvertebrate communities:

a.	Shallow Pool	<1 fps	<1.5 feet deep
b.	Pool	<1 fps	>1.5 feet deep
c.	Run	>1 fps	>1.5 feet deep
d.	Riffle	>1 fps	<1.5 feet deep

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Habitat quality is reduced in the absence of one or more of these velocity/depth combinations, particularly the riffle zone or category d. For example, an optimal site would include all 4 habitats, with no one habitat type present in amounts greater than 50 percent.

Channel Morphology

Channel morphology is determined by the flow regime of the stream, local geology, land surface form, soil, and human activities (Platts et al., 1983). The sediment movement along the channel is influenced by the flowing water forces and the sinuosity of the channel. Both affect the habitat conditions of the indigenous biological communities. A constant supply of water and varied but predictable flows are key ingredients for maintaining biological diversity and stability in running waters.

Metric 4. Flow Stability. The maintenance of adequate water flow is a prime requisite for most organisms typically found in streams. The stability of the flow in a particular stream from season to season is often reflected by the diversity of the biota found there. Stream biota subject to erratic flows with large mid-summer variations beyond the expected spring and fall floods, or subject to periodic occasions of no flow or low flow, will reflect a depauperate biota typical of these adverse flow conditions. The flow contribution to these streams by natural discharges, such as springs or seeps or groundwater recharge, should be contrasted to the extent of flow contributed by point or non-point discharges. The extreme case (poor assessment, Table 1) would be an ephemeral stream, kept flowing in mid-summer only because of the large contributions made by an upstream discharge source. Examination of surroundings for past high water marks or recent flood deposits can help assess the degree of discharge stability.

Metric 5. Deposition/Sedimentation. This metric measures the ratio of stream bottom affected by deposition of larger particles of sediments, clays, or loose sand to the total area of stream bottom in the study station. A stream where extreme sediment, clay, or sand deposition occurs degrades habitat (poor assessment, Table 1), resulting in unsuitable substrates for most aquatic macroinvertebrates, as well as preventing future macroinvertebrate colonization. Deposition of sediment, sand or clay in pools or over run areas is evaluated as percentage of stream bottom area covered with sediment (i.e. a 50 foot covered section in a 100 foot sample station equals 50 percent).

Metric 6. Pools-Riffles-Runs-Bends. This metric evaluates the variety of habitats contained with the study station. A stream with riffles or bends contains better habitat (excellent assessment) for community development than a straight or uniform depth stream (poor assessment). Bends are included because some low gradient streams may not have riffle areas, but excellent habitat can be provided by the cutting action of water at bends (undercut banks). If a stream contains both riffles and bends, the most dominant feature which provides the best habitat should be evaluated.

Riparian and Bank Structure

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Well-vegetated banks are usually stable regardless of bank undercutting; undercutting actually provides excellent cover for fish (Platts et al., 1983). The ability of vegetation and other materials on the streambanks to resist erosion from flowing water is important in determining the stability of the stream channel, and maintaining good instream habitats. However, these parameters, by virtue of the fact that they act indirectly and are outside the immediate instream habitat features, are weighted as slightly less important than the other categories.

Habitat parameters evaluated include observations of both upper and lower bank characteristics. The upper bank is the land area from the break in the general slope of the surrounding land to the normal high water line. It is normally vegetated and is covered by water only in extreme high water periods. Land forms vary from wide, flat floodplains to narrow, steep slopes. The lower bank is the intermittently submerged portion of the stream cross section from the normal high water line to the lower water line.

Metric 7. Bank Stability. This metric is evaluated by observing existing or potential detachment of soil from the upper and lower stream bank and its potential movement into the stream. Steeper banks are generally more subject to erosion and failure, and may not support stable vegetation. Streams with poor banks will often have poor instream habitat. Adjustments should be made in areas with clay banks where steep, raw areas may not be as susceptible to erosion as other soil types.

Metric 8. Bank Vegetative Stability. This metric evaluates the density of bank vegetation (or amount of boulder, cobble, or gravel material) covering the bank and provides an indication of bank stability and potential for instream sedimentation. Bank soil is held in place by well established plant root systems. Over 80% of the streambank covered by vegetation or otherwise stabilized would result in an excellent assessment (Table 1). Erosional protection may also be provided by boulder, cobble, or gravel material.

Metric 9. Streamside Cover. This metric evaluates the quality of streamside material in terms of potential as habitat, providing food sources, stream-shading ability and escape cover or refuge for fish. A rating is obtained by visually determining the dominant vegetation type covering the exposed stream bank. Large numbers of dense shrubs would result in an excellent assessment (Table 1).

VIII. OVERALL APPLICATION AND INTEGRATION

A. Relationship of Habitat Quality and Biological Condition

The optimum biological community stability and biological diversity of a site for both fish and macroinvertebrates may be determined by the quality of the habitat at that site. Excellent habitat will allow for high quality biological communities. Community responses to minor alteration in habitat are often subtle and may result in insignificant changes. As habitat quality continues to decline, however, recognizable and measurable biological changes (impairments) occur. These changes, in the absence of confounding water quality effects, are generally in direct proportion to the degree of habitat change. Once habitat becomes severely degraded, measurable changes in the biological communities become harder to recognize and measure. The biological communities existing under these habitat degraded conditions are represented by opportunistic species, which are more tolerant of such habitat perturbations and often insensitive to further habitat degradation. This may result in a poor habitat characterization corresponding to either a moderately or severely impacted biological community depending on the specific site and situation.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

In areas of good or excellent habitat, biological communities will reflect degraded conditions when adverse water quality effects exist. As habitat degrades further in the continued presence of water quality problems, such as chemical toxicants or nutrient enrichment, the biological communities may show less dramatic changes as each community becomes dominated by tolerant and opportunistic species.

B. Application

Each site should be carefully evaluated using the habitat and the biological protocols. The lowest biological category assigned to either fish or macroinvertebrate will be used to categorize the overall station's biological condition. If, for example, an excellent fish community survey together with an excellent macroinvertebrate community is matched with poor habitat survey, then the site would be categorized as excellent. When the fish community is scored 'excellent', the habitat scored 'excellent', and the macroinvertebrate community scored 'poor', then the site would be categorized as poor.

IX. QUALITY ASSURANCE/QUALITY CONTROL

As with any scientific study, quality must be assured and tested before the results can be accepted. Quality assurance is accomplished through use of professional and trained biologists, establishment of thorough field training, defined collection guidelines, and comprehensive field documentation and data analysis.

A. Training

All personnel conducting surveys are trained in a consistent manner (preferably by the same person) to ensure that the surveys are conducted properly and in a standardized fashion. At least one investigator for each site will be a professional biologist trained and skilled in field aquatic sampling methods and organism identification.

B. Standard Procedures

The standard procedures described in this document are followed in the surveys. Field experience and taxonomic expertise requirements must be met by staff involved in surveys. Any deviations from the procedures should be documented as to the reason for deviation.

Field crew personnel will be alternated to maintain objectivity in the surveys.

C. Documentation

The field data sheets (stream survey cards, Appendix J) are filled out as completely and as accurately as possible to provide a record in support of the survey and analysis conclusions.

Field and laboratory data sheets and final reports are filed in the GLEAS raw data files and report files, respectively.

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

D. Habitat Assessment

All personnel are appropriately trained in the evaluation technique and periodic cross-checks are conducted among personnel to promote consistency.

E. Benthic Collections

The data developed during the benthic collection efforts is directly comparable to data developed at other sites because: (1) all habitats are sampled at each site, and (2) a uniform method (consistent unit of effort, 100-organism count) is used for benthic data acquisition. To ensure reproducible data, well characterized sites are periodically resampled by a variety of investigators.

F. Fish Collections

Data comparability is maintained by using similar collection methods and sampling effort in waterbodies of similar size. Also, where possible, major habitats (riffle, run, pool) are sampled at each site, and the proportion of each habitat type sampled, should be comparable.

Data reproducibility is ensured by having a variety of investigators periodically resample well characterized sites.

TOC

NEXT PAGE

PREVIOUS PAGE

CITATION

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TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Table 1. Habitat Assessment Field Data Sheet

Habitat Parameter	Excellent	Good	Fair	Poor
Bottom Substrate / Available Cover	Greater than 50% rubble, gravel, submerged logs, undercut banks, or other stable habitat. 16-20	30-50% rubble, gravel or other stable habitat. Adequate habitat. 11-15	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 6-10	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 0-5
Embeddedness / Siltation	Gravel, logs, cobble, and boulder particles have between 0 and 25% of their surface covered by fine sediment / silt. 16-20	Gravel, logs, cobble, and boulder particles have between 25 and 50% of their surface covered by fine sediment / silt. 11-15	Gravel, logs, cobble and boulder particles have between 50 and 70% of their surface covered by fine sediment / silt. 6-10	Gravel, logs, cobble, and boulder particles have over 75% of their surface covered by fine sediment / silt. 0-5
Velocity: Depth: pool - <1ft/s >1.5ft shallow pool - <1ft/s <1.5ft run - >1ft/s >1.5ft riffle - >1ft/s <1.5ft	All habitats well represented. None greater than 50% of total area. 16-20	Only 3 of the 4 habitat categories present. Or if all 4 are present, one greater than 50% total area. 11-15	Only 2 of the 4 habitat categories present. 6-10	Dominated by one velocity/ depth category (usually pool). 0-5
Flow stability	Continual flow all year. Natural water supply substantial. 12-15	Seasonal high flows. Low flow constant or nearly so. Some point discharge contributes to flow. 8-11	Periodic high and low flows. Irregular flow pattern. Discharges contribute substantially to low flow. 4-7	Ephemeral stream. Usually no mid-summer flow. If it flows year-round, discharges form major contribution to low flow. 0-3
Bottom Deposition / Sedimentation	Less than 5% of the bottom affected by deposition. Hard bottom substrate. 12-15	5-30% affected. Some deposition in pools. Soft bottom mainly in pools. 8-11	30-50% affected. Deposits, obstructions, constrictions and bends. Some filling of pools with sediments/sand. Soft bottom more common. 4-7	More than 50% of the bottom affected. Pools almost absent due to deposition. Only large rocks in riffle exposed. Soft bottom, loose deposits very common, often deep. 0-3
Pools-Riffles-Runs-Bends	Variety of habitats. Deep riffles and pools. 12-15	Adequate depth in pools and riffles. Bends provide habitat. 8-11	Occasional riffle or bend. Bottom contours provide some habitat. 4-7	Straight stream. Generally all flat water or shallow riffle. 0-3
Bank Stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%, little potential for future problem. 9-10	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40%. Slight erosion potential in extreme floods. 6-8	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential in extreme floods. 3-5	Unstable. Many eroded areas. Side slopes >60% common. “Raw” areas frequent along straight sections and bends. 0-2
Bank Vegetative Stability	Over 80% of the stream bank surfaces covered by vegetation or boulders and cobble. 9-10	50-79% of the stream bank surfaces covered by vegetation, gravel or larger material. 6-8	25-49% of the stream bank surfaces covered by vegetation, gravel or larger material. 3-5	Less than 25% of the stream bank surfaces covered by vegetation, gravel or larger material. 0-2
Streamside Cover	Dominant vegetation is shrub. 9-10	Dominant vegetation is of tree form. 6-8	Dominant vegetation is grass or forbes. 3-5	Over 50% of the stream bank has no vegetation. Dominant material is soil, rock, bridge materials, or mine tailings. 0-2

Appendix A

Michigan Fishes Classified as Intolerant

Common Name	**Scientific Name**
Petromyzontidae (lampreys)	
Sea lamprey (ammocete)	Petromyzon marinus
Silver lamprey (ammocete)	Ichthyomyzon unicuspis
Silver lamprey (adult)	Ichthyomyzon unicuspis
Northern brook (ammocete)	Ichthyomyzon fossor
Northern brook (adult)	Ichthyomyzon fossor
Chestnut lamprey (ammocete)	Ichthyomyzon castaneus
Chestnut lamprey (adult)	Ichthyomyzon castaneus
American brook (ammocete)	Lampetra appendix
American brook (adult)	Lampetra appendix
Acipenseridae (sturgeons)	
Lake sturgeon	Acipenser fulvescens
Polydontidae (paddlefish)	
Paddlefish	Polydon spatula
Hiodontidae (Mooneyes)	
Mooneye	Hiodon tergisus
Salmonidae (trouts)	
Rainbow trout	Oncorhynchus mykiss
Brown trout	Salmo trutta
Brook trout	Salvelinus fontinalis
Coho salmon	Oncorhynchus kisutch
Chinook salmon	Oncorhynchus tshawytscha
Pink salmon	Oncorhynchus gorbuscha
Lake herring	Coregonus artedi
Lake whitefish	Coregonus cupeaformis
Bloater	Coregonus hoyi
Deepwater cisco	Coregonus johannae
Kiyi	Coregonus kiyi
Blackfin cisco	Coregonus nigripinnis
Shortnose cisco	Coregonus reighardi
Shortjaw cisco	Coregonus zenithicus
Pygmy whitefish	Prosopium coulte
Round whitefish	Prosopium cylindraceum
Atlantic salmon	Salmo salar
Lake trout	Salvelinus namaycush
Arctic grayling	Thymallus arcticus
Esocidae (pikes)	
Muskellunge	Esox masquinongy

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix A (continued)

Common Name	Scientific Name
Cyprinidae (minnows and carps)	
Bigeye chub	Notropis amblops
River chub	Nocomis micropogon
Pugnose shiner	Notropis anogenus
Bigeye shiner	Notropis boops
Ironcolor shiner	Notropis chalybaeus
Weed shiner	Notropis texanus
Blackchin shiner	Notropis heterodon
Blacknose shiner	Notropis heterolepis
Spottail shiner	Notropis hudsonius
Silver shiner	Notropis photogenis
Rosyface shiner	Notropis rubellus
Southern redbelly dace	Phoxinus erthrogaster
Longnose dace	Rhinichthys cataractae
Redside dace	Clinostomus elongatus
Pearl dace	Margariscus margarita
Silver chub	Macrhybopsis storeriana
Pugnose minnow	Opsopoedus emiliae
Cottidae (sculpins)	
Mottled sculpin	Cottus bairdii
Slimy sculpin	Cottus cognatus
Spoonhead sculpin	Cottus ricei
Deepwater sculpin	Myoxocephalus thompsoni
Catostomidae (suckers)	
Longnose sucker	Catostomus catostomus
Creek chubsucker	Erimyzon oblongus
Northern hog sucker	Hypentelium nigricans
Black buffalo	Ictiobus niger
Spotted sucker	Minytrema melanops
Silver redhorse	Moxostoma anisurum
River redhorse	Moxostoma carinatum
Black redhorse	Moxostoma duquesnei
Shorthead redhorse	Moxostoma macrolepidotum
Greater redhorse	Moxostoma valenciennesi
Ictaluridae (Bullhead, Catfish)	
Stonecat	Noturus flavus
Cyprinodontidae (topminnows)	
Banded killifish	Fundulus diaphanus
Gasterosteidae (sticklebacks)	
Ninespine stickleback	Pungitius pungitius

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix A (continued)

Common Name	**Scientific Name**
Centrarchidae (sunfish)	
Rock bass	Ambloplites rupestris
Smallmouth bass	Micropterus dolomieu
Percidae (perch)	
Eastern sand darter	Ammocrypta pellucida
Rainbow darter	Etheostoma caeruleum
Iowa darter	Etheostoma exile
Least darter	Etheostoma microperca
Orangethroat darter	Etheostoma spectabile
Banded darter	Etheostoma zonale
Channel darter	Percina copelandi

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix B
Michigan Fish Classified as Omnivores

Common Name	Scientific Name
Cyprinidae	
Goldfish	Carassius auratus
Common Carp	Cyprinus carpio
Golden Shiner	Notemigonus crysoleucas
Fathead minnow	Pimephales promelas
Bluntnose minnow	Pimephales notatus
Creek chub	Semotilus atromaculatus
Blacknose dace	Rhinichthys atratulus
European rudd	Scardinius erthropthalmus
Catastomidae	
White sucker	Catostomus commersoni
Quillback	Carpoides cyprinus
Umbridae	
Central mudminnow	Umbra limi
Ictaluridae	
Black Bullhead	Ameiurus melas
Brown bullhead	Ameiurus nebulosus
Yellow bullhead	Ameiurus natalis

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix C
Michigan Fish Classified as Insectivores

Common Name	**Scientific Name**
Acipenseridae (sturgeons)	
Lake Sturgeon	Acipenser fulvescens
Hiodontidae (Mooneyes)	
Mooneye	Hiodon tergisus
Salmonidae (trouts)	
Lake whitefish	Coregonus cupeaformis
Pygmy whitefish	Prosopium coulteri
Round whitefish	Prosopium cylindraceum
Artic grayling	Thymallus arcticus
Cyprinidae (minnows and carps)	
Lake chub	Couesius plumbeus
Bigeye chub	Notropis amblops
Hornyhead chub	Nocomis biguttatus
River chub	Nocomis micropogon
Emerald shiner	Notropis atherinoides
Bigeye shiner	Notropis boops
Ironcolor shiner	Notropis chalybaeus
Common shiner	Luxilus cornutus
Striped shiner	Luxilus chrysocephalus
Central bigmouth shiner	Notropis dorsalis
Blackchin shiner	Notropis heterodon
Blacknose shiner	Notropis heterolepis
Spottail shiner	Notropis hudsonius
Silver shiner	Notropis photogenis
Rosyface shiner	Notropis rubellus
Spotfin shiner	Cyprinella spilopterus
Sand shiner	Notropis stramineus
Redfin shiner	Lythrurus umbratilis
Mimic shiner	Notropis volucellus
Suckermouth minnow	Phenacobius mirabilis
Silverjaw minnow	Notropis buccatus
Finescale dace	Phoxinus neogaeus
Longnose dace	Rhinichthys cataractae
Redside dace	Clinostomus elongatus
Pearl dace	Margariscus margarita
Silver chub	Macrhybopsis storeriana
Pugnose minnow	Opsopoedus emiliae
Cottidae (sculpins)	
Mottled sculpin	Cottus bairdii
Slimy sculpin	Cottus cognatus

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix C (continued)

Common Name	**Scientific Name**
Spoonhead sculpin	Cottus ricei
Deepwater sculpin	Myoxocephalus thompsoni
Catostomidae (suckers)	
Longnose sucker	Catostomus catostomus
Creek chubsucker	Erimyzon oblongus
Lake chubsucker	Erimyzon sucetta
Norther hog sucker	Hypentelium nigricans
Bigmouth buffalo	Ictiobus cyprinellus
Black buffalo	Ictiobus niger
Spotted sucker	Minytrema melanops
Silver redhorse	Moxostoma anisurum
River redhorse	Moxostoma carinatum
Black redhorse	Moxostoma duquesnei
Golden redhorse	Moxostoma erythrurum
Shorthead redhorse	Moxostoma macrolepidotum
Greater redhorse	Moxostoma valenciennesi
Ictaluridae (Bullhead, Catfish)	
Stonecat	Noturus flavus
Margined madtom	Noturus insignis
Tadpole madtom	Noturus gyrinus
Brindled madtom	Noturus miurus
Northern madtom	Noturus stigmosus
Aphredoderidae (pirate perch)	
Pirate perch	Aphredoderus sayanus
Atherinidae (silversides)	
Brook silversides	Labidesthes sicculus
Cyprinodontidae (topminnows)	
Banded killifish	Fundulus diaphanus
Starhead topminnow	Fundulus dispar
Blackstripe topminnow	Fundulus notatus
Gasterosteidae (sticklebacks)	
Brook stickleback	Culaea inconstans
Threespine stickleback	Gasterosteus aculeatus
Ninespine stickleback	Pungitius pungitius
Centrarchidae (sunfish)	
Green sunfish	Lepomis cyanellus
Pumpkinseed	Lepomis gibbosus

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix C (continued)

Common Name	**Scientific Name**
Orangespotted sunfish	Lepomis humilis
Bluegill	Lepomis macrochirus
Longear sunfish	Lepomis megalotis
Redear sunfish	Lepomis microlophus
Percidae (perch)	
Eastern sand darter	Ammocrypta pellucida
Rainbow darter	Etheostoma caeruleum
Iowa darter	Etheostoma exile
Greenside darter	Etheostoma blennioides
Fantail darter	Etheostoma flabellare
Least darter	Etheostoma microperca
Johnny darter	Etheostoma nigrum
Orangethroat darter	Etheostoma spectabile
Banded darter	Etheostoma zonale
Logperch	Percina caprodes
Channel darter	Percina copelandi
Blackside darter	Percina maculata
River darter	Percina shumardi
Ruffe	Gymnocephalus cernuus
Percopsidae (Trout-perch)	
Trout-perch	Percopsis omiscomaycus
Sciaenidae (drums)	
Freshwater drum	Aplodinotus grunniens
Gobiidae (gobies)	
Round goby	Neogobius melanostomus
Tubenose goby	Proterorhinus marmoratus
Poeciliidae (livebearers)	
Western mosquitofish	Gambusia affinis

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix D
Michigan Fish Classified as Piscivores

Common Name	Scientific Name
Spotted gar	Lepisosteus oculatus
Longnose gar	Lepisosteus osseus
Bowfin	Amia calva
American eel	Anguilla rostrata
Channel catfish	Ictalurus punctatus
Flathead catfish	Pylodictis olivaris
Grass pickerel	Esox americanus vermiculatus
Northern pike	Esox lucius
Muskellunge	Esox masquinongy
Burbot	Lota lota
White perch	Morone americana
White bass	Morone chrysops
Rock bass	Ambloplites rupestris
Largemouth bass	Micropterus salmoides
Smallmouth bass	Micropterus dolomieu
Walleye	Stizostedion vitreum
Sauger	Stizostedion canadense

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix E
Michigan Fishes Classified as Tolerant

Common Name	Scientific Name
Amiidae (bowfins)	
Bowfin	Amia calva
Umbridae (mudminnows)	
Central mudminnow	Umbra limi
Cyprinidae (minnows and carps)	
Goldfish	Carassius auratus
Common carp	Cyprinus carpio
Creek chub	Semotilus atromaculatus
Golden shiner	Notemigonus crysoleucas
Fathead minnow	Pimephales promelas
Bluntnose minnow	Pimephales notatus
Blacknose dace	Rhinichthys atratulus
European rudd	Scardinius erythropthalmus
Catostomidae (suckers)	
White sucker	Catostomus commersoni
Ictaluridae (Bullhead, Catfish)	
Yellow bullhead	Ameiurus natalis
Centrarchidae (sunfish)	
Green sunfish	Lepomis cyanellus
Percidae (perch)	
Johnny darter	Etheostoma nigrum
Sciaenidae (drums)	
Freshwater drum	Aplodinotus grunniens

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix F
Michigan Fishes Classified as Simple Lithophilic Spawners

Common Name	**Scientific Name**
Acipenseridae (sturgeons)	
Lake sturgeon	Acipenser fulvescens
Polydontidae (paddlefish)	
Paddlefish	Polydon spatula
Hiodontidae (mooneyes)	
Mooneye	Hiodon tergisus
Cyprinidae (minnows and carps)	
Lake chub	Couesius plumbeus
Bigeye shiner	Notropis boops
Common shiner	Luxilus cornutus
Striped shiner	Luxilus chrysocephalus
Silver shiner	Notropis photogenis
Rosyface shiner	Notropis rubellus
Suckermouth minnow	Phenacobius mirabilis
Southern redbelly dace	Phoxinus erthrogaster
Blacknose dace	Rhinichthys atratulus
Longnose dace	Rhinichthys cataractae
Pearl dace	Margariscus margarita
Catostomidae (suckers)	
Longnose sucker	Catostomus catostomus
White sucker	Catostomus commersoni
Northern hog sucker	Hypentelium nigricans
Spotted sucker	Minytrema melanops
Silver redhorse	Moxostoma anisurum
River redhorse	Moxostoma carinatum
Black redhorse	Moxostoma duquesnei
Golden redhorse	Moxostoma erythrurum
Shorthead redhorse	Moxostoma macrolepidotum
Greater redhorse	Moxostoma valenciennesi
Percidae (perch)	
Rainbow darter	Etheostoma caeruleum
Orangethroat darter	Etheostoma spectabile
Banded darter	Etheostoma zonale
Logperch	Percina caprodes
Channel darter	Percina copelandi
Blackside darter	Percina maculata
River darter	Percina shumardi

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix F (continued)

Common Name	**Scientific Name**
Sauger	Stizostedion canadense
Walleye	Stizostedion vitreum
Ruffe	Gymnocephalus cernuus
Gadidae (codfishes)	
Burbot	Lota lota

Appendix G

The following fish are to be measured to inch group:

Percidae (Perches)	
Yellow perch	Perca flavescens
Sauger	Stizostedion canadense
Walleye	Stizostedion vitreum
Cyprinidae (minnows)	
Creek chub	Semotilus atromaculatus
Pearl dace	Margariscus margarita
Goldfish	Carassius auratus
Common carp	Cyprinus carpio
Common shiner	Notropis cornutus
Hornyhead chub	Nocomis biguttus
River chub	Nocomis micropogon
Golden shiner	Notemigonus crysoleucas

All members of the families:

Catostomidae (suckers)
Lepistosteidae (gars)
Amiidae (bowfin)
Anquillidae (eel)
Clupeidae (herring)
Osmeridae (smelts)
Salmonidae (salmon, trouts, whitefish)
Esocidae (pike)
Ictaluridae (bullheads , catfish)
Percichthyidae (temperate basses)
Centrarchidae (sunfishes)
Sciaenidae (drums)

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix H

Phylogenetic order for macroinvertebrates, the level of taxonomy, and the primary keys to be used for site evaluations.

Phylum	Class	***Order***	*Sub-order*	**Family**
Porifera (Pennak, 1989)				
Platyhelminthes				
	Turbellaria (Pennak, 1989)			
Nematomorpha (Pennak, 1989)				
Bryozoa (Pennak, 1989)				
Annelida				
	Oligochaeta (Pennak, 1989)			
	Hirudinea (Klemm, 1972)			
Arthropoda				
	Crustacea			
		Isopoda (Pennak, 1989)		
		Amphipoda (Pennak, 1989)		
		Decapoda (Pennak, 1989)		
	Arachnoidea			
		Hydracarina (Pennak, 1989)		
	Insecta (Merritt and Cummins, 1996)			
		Ephemeroptera		
				Baetidae
				Baetiscidae
				Caenidae
				Ephemerellidae
				Ephemeridae
				Heptageniidae
				Isonychiidae
				Leptophlebiidae
				Oligoneuriidae
				Polymitarcyidae
				Potamanthidae
				Siphlonuridae
				Tricorythidae
		Odonata		
			Zygoptera	
				Calopterygidae
				Coenagrionidae
				Lestidae
			Anisoptera	
				Aeshnidae
				Cordulegastridae
				Corduliidae
				Gomphidae
				Libellulidae
				Macromiidae

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix H (continued)

Phylum	Class	***Order***	*Sub-order*	**Family**
		Plecoptera		
				Capniidae
				Chloroperlidae
				Leuctridae
				Nemouridae
				Peltoperlidae
				Perlidae
				Perlodidae
				Pteronarcyidae
				Taeniopterygidae
		Hemiptera		
				Belostomatidae
				Corixidae
				Gelastocoridae
				Gerridae
				Mesoveliidae
				Naucoridae
				Nepidae
				Notonectidae
				Pleidae
				Veliidae
		Megaloptera		
				Corydalidae
				Sialidae
		Neuroptera		
				Sisyridae
		Trichoptera		
				Beraediae
				Brachycentridae
				Glossosomatidae
				Helicopsychidae
				Hydropsychidae
				Hydroptilidae
				Lepidostomatidae
				Leptoceridae
				Limnephilidae
				Molannidae
				Odontoceridae
				Philopotamidae
				Phryganeidae
				Polycentropodidae
				Psychomyiidae
				Rhyacophilidae
				Sericostomatidae
		Lepidoptera		
				Noctuidae
				Pyralidae

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix H (continued)

Phylum	Class	***Order***	*Sub-order*	**Family**
		Coleoptera		
				Chrysomelidae
				Curculionidae
				Dryopidae
				Dytiscidae
				Elmidae
				Gyrinidae
				Haliplidae
				Heterocerodea
				Hydrophilidae
				Hydraenidae
				Lampyridae
				Limnichidae
				Noteridae
				Psephenidae
				Ptilodactylidae
				Scirtidae
		Diptera		
				Athericidae
				Ceratopogonidae
				Chaoboridae
				Chironomidae
				Culicidae
				Dixidae
				Dolichopodidae
				Empididae
				Ephydridae
				Muscidae
				Psychodidae
				Ptychopteridae
				Sciomyzidae
				Simuliidae
				Stratiomyidae
				Syrphidae
				Tabanidae
				Thaumaleidae
				Tipulidae
Mollusca				
				Gastropoda (Burch, 1991)
				Pelecypoda (Burch, 1991)

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix I
Surface Dependant Macroinvertebrates

Hemiptera
- All Families

Coleoptera
- All Adults (other than Elmidae and Dryopidae)
- Dytiscidae larvae
- Hydrophilidae larvae
- Hydraenidae larvae
- Heteroceridae larvae

Diptera
- Culicidae larvae
- Ptychopteridae larvae
- Chaoboridae larvae (except Chaoborus sp.)
- Stratiomyidae
- Dolichopodidae
- Syrphidae

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix J

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
SURFACE WATER QUALITY DIVISION

STREAM SURVEY CARD
(Revised - November 1996)

STORET NO.: ________________

STATION NUMBER: ________ INVESTIGATOR(S):____________________ DATE: _____/_____/_____

BODY OF WATER: ____________________ LOCATION: ____________________

COUNTY: ____________ TOWNSHIP: ________________ T _____ R _____ S _____ GPS: ____________

STREAM TYPE: ( )Coldwater ( )Warmwater SURVEY TYPE: ( )PS ( ) NPS ECOREGION: ____________________

WEATHER: ( )Sunny ( )Partly Cloudy ( )Cloudy ( )Rainy AIR TEMP.: ________ WATER TEMP.: ________

AVG. STREAM WIDTH ______ ft. AVG. DEPTH ______ ft SURFACE VELOCITY _______ ft./sec. ESTIMATED FLOW: _______cfs

STREAM MODIFICATIONS:
( ) None
( ) Dredged
( ) Canopy Removal
( ) Snagging
( ) Impounded
( ) Relocated
( ) Bank Stabilization
( ) Habitat Improvement

Attached algae and macrophytes: ____________________
____
____

Nuisance aquatic plant or slimes conditions present? Y / N

STATION SKETCH AND NOTES :

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix J (continued)

Location Sampled____ Date_______________

Length sampled ___________	Time sampled__________	Gear type (circle): bps	stream shocker	boat shocker	other				
Species									
length (in)									In
1									1
2									2
3									3
4									4
5									5
6									6
7									7
8									8
9									9
10									10
11									11
12									12
13									13
14									14
15									15
16									16
17									17
18									18
19									19
20									20
>20									>20

For individuals >20" record actual length

Species									
length (in)									In
1									1
2									2
3									3
4									4
5									5
6									6
7									7
8									8
9									9
10									10
11									11
12									12
13									13
14									14
15									15
16									16
17									17
18									18
19									19
20									20
>20									>20

Number of Anomalies_________ Number/Species of tagged/fin clipped fish____________

Description:

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix J (continued)

Species									
length (in)									In
1									1
2									2
3									3
4									4
5									5
6									6
7									7
8									8
9									9
10									10
11									11
12									12
13									13
14									14
15									15
16									16
17									17
18									18
19									19
20									20
>20									>20

For individuals >20" record actual length

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Species									
length (in)									In
1									1
2									2
3									3
4									4
5									5
6									6
7									7
8									8
9									9
10									10
11									11
12									12
13									13
14									14
15									15
16									16
17									17
18									18
19									19
20									20
>20									>20

Additional station comments

Station Number:
Length Sampled (ft):
Area Sampled (sq ft):

Appendix J (continued)

Sampling Time: # Probes Gear: boat / ss / bps # Passes:

Number of Anomalies:

Comments:

Petromyzontidae (Lampreys)

Sea lamprey (a/l) _____
Silver lamprey (a/l) _____
Northern brook lamprey (a/l) _____
Chestnut lamprey (a/l) _____
American brook lamprey (a/l) _____

Lepisosteidae (Gars)

*Spotted gar _____
*Longnose gar _____

Amiidae (Bowfins)

*Bowfin _____

Clupeidae (Herrings)

*Alewife _____
*Gizzard shad _____

Salmonidae (Salmon/Trout)

*Rainbow trout _____
*Brown trout _____
*Brook trout _____
*Coho _____
*Chinook _____

Umbridae (Mudminnow)

Central mudminnow _____

Esocidae (Pike)

*Grass pike _____
*Northern pike _____
*Muskellunge _____

Cyprinidae (Minnows and Carp)

Central stoneroller _____
Lake chub _____
*Goldfish _____
*Carp _____
Bigeye chub _____
*Horneyhead chub _____
*River chub _____
*Creek chub _____
*Golden shiner _____
Pugnose shiner _____
Emerald shiner _____
Bigeye shiner _____
Ironcolor shiner _____
*Common shiner _____
Central bigmouth shiner _____
Blackchin shiner _____
Blacknose shiner _____
Spottail shiner _____
Silver shiner _____
Rosyface shiner _____
Spotfin shiner _____
Sand shiner _____
Redfin shiner _____
Mimic shiner _____
Brassy minnow _____
Fathead minnow _____
Bluntnose minnow _____
Suckermouth minnow _____
Silverjaw minnow _____
Northern redbelly dace _____
Southern redbelly dace _____
Finescale dace _____
Blacknose dace _____
Longnose dace _____
Redside dace _____
*Pearl dace _____

Cottidae (Sculpins)

Mottled sculpin _____
Slimy sculpin _____

Catostomidae (Suckers)

*Longnose sucker _____
*White sucker _____
*Creek chubsucker _____
*Lake chubsucker _____
*Northern hog sucker _____
*Spotted sucker _____
*Silver redhorse _____
*River redhorse _____
*Black redhorse _____
*Golden redhorse _____
*Shorthead redhorse _____
*Greater redhorse _____

Ictaluridae (Bullhead/Catfish)

*Black bullhead _____
*Brown bullhead _____
*Yellow bullhead _____
Stonecat _____
Tadpole madtom _____
Brindled madtom _____
*Channel catfish _____
*Flathead catfish _____

Aphredoderidae (Pirate perch)

Pirate perch _____

Atherinidae (Silversides)

Brook silverside _____

Cyprinodontidae (Topminnows)

Banded killifish _____
Blackstripe topminnow _____

Gasterosteidae (Sticklebacks)

Brook stickleback _____
Threespine stickleback _____

Perchicthyidae (Temp. bass)

*White bass _____
*White perch _____

Centrarchidae (Sunfishes)

*Rock bass _____
*Green sunfish _____
*Pumpkinseed _____
*Warmouth _____
*Orangespotted sunfish _____
*Bluegill _____
*Longear sunfish _____
*White crappie _____
*Black crappie _____
*Largemouth bass _____
*Smallmouth bass _____

Percidae (Perch)

N. sand darter _____
Rainbow darter _____
Iowa darter _____
Greenside darter _____
Fantail darter _____
Orangethroat darter _____
Johnny darter _____
Blackside darter _____
Logperch _____
*Yellow perch _____
*Walleye _____

Percopsidae (Trout-perch)

Trout-perch _____

Anguillidae (Eels)

*American eel _____

Gadidae (Cod)

*Burbot _____

Sciaenidae (Drums)

*Freshwater drum _____

Cobitidae (Loaches)

Oriental weatherfish _____

Other family/species:

_________________ _____
_________________ _____
_________________ _____
_________________ _____

* = Measured length

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

Appendix J (continued)

BENTHIC
MACROINVERTEBRATES

Station Number:____________
Time Sampled:_____________
Area Sampled:_____________
Comments:________________
____

PORIFERA ______
PLATYHELMINTHES
  Turbellaria ______
NEMATOMORPHA ______
BRYOZOA ______
ANNELIDA
  Hirudinea ______
  Oligochaeta ______
ARTHROPODA
  Crustacea
    Amphipoda ______
    Decapoda ______
    Isopoda ______
  Arachnoidea
    Hydracarina ______
  Insecta
    Ephemeroptera
      Ametropodidae ______
      Baetiscidae ______
      Baetidae ______
      Caenidae ______
      Ephemerellidae ______
      Ephemeridae ______
      Heptageniidae ______
      Isonychiidae ______
      Leptophlebiidae ______
      Metretopodidae ______
      Polymitarcyidae ______
      Potamanthidae ______
      Siphlonuridae ______
      Tricorythidae ______
    Odonata
      Anisoptera
        Aeshnidae ______
        Cordulegastridae ______
        Corduliidae ______
        Gomphidae ______
        Libellulidae ______
        Macomiidae ______
      Zygoptera
        Calopterygidae ______
        Coenagrionidae ______
        Lestidae ______
    Plecoptera
      Capniidae ______
      Chloroperlidae ______
      Leuctridae ______
      Nemouridae ______
      Peltoperlidae ______
      Perlidae ______
      Perlodidae ______
      Pteronarcyidae ______
      Taeniopterygidae ______

Hemiptera
  Belostomatidae ______
  Corixidae ______
  Gelastocoridae ______
  Gerridae ______
  Mesoveliidae ______
  Naucoridae ______
  Nepidae ______
  Notonectidae ______
  Pleidae ______
  Saldidae ______
  Veliidae ______
Megaloptera
  Corydalidae ______
  Sialidae ______
Neuroptera
  Sisyridae ______
Trichoptera
  Brachycentridae ______
  Glossosomatidae ______
  Helicopsychidae ______
  Hydropsychidae ______
  Hydroptilidae ______
  Lepidostomatidae ______
  Leptoceridae ______
  Limnephilidae ______
  Molannidae ______
  Odontoceridae ______
  Philopotamidae ______
  Phryganeidae ______
  Polycentropodidae ______
  Psychomyiidae ______
  Rhyacophilidae ______
  Sericostomatidae ______
  Uenoidae (*Neophylax*) ______
Lepidoptera
  Noctuidae ______
  Pyralidae ______
Coleoptera
  Dryopidae ______
  Dytiscidae ______
  Elmidae ______
  Gyrinidae (a/l) ______
  Haliplidae (a/l) ______
  Heteroceridae ______
  Hydraenidae ______
  Hydrophilidae ______
  Lampyridae (a/l) ______
  Noteridae (a/l) ______
  Psephenidae(a/l) ______
  Ptilodactylidae (a/l) ______
  Scirtidae (a/l) ______

Diptera
  Athericidae ______
  Ceratopogonidae ______
  Chaoboridae ______
  Chironomidae ______
  Culicidae ______
  Dixidae ______
  Dolichopodidae ______
  Empididae ______
  Ephydridae ______
  Muscidae ______
  Ptychopteridae ______
  Psychodidae ______
  Sciomyzidae ______
  Simuliidae ______
  Stratiomyidae ______
  Syrphidae ______
  Tabanidae ______
  Thaumaleidae ______
  Tipulidae ______
MOLLUSCA
  Gastropoda
    Ancylidae ______
    Bithyniidae ______
    Hydrobiidae ______
    Lymnaeidae ______
    Physidae ______
    Planorbidae ______
    Pleuroceridae ______
    Pomatiopsidae ______
    Valvatidae ______
    Viviparidae ______
  Pelecypoda
    Dreissenidae ______
    Pisidiidae ______
    Sphaeriidae ______
    Unionidae ______
    __________ ______
    __________ ______
    __________ ______
    __________ ______

TOC
NEXT PAGE
PREVIOUS PAGE
CITATION

TOC

NEXT PAGE

PREVIOUS PAGE

CITATION

Appendix J (continued)

Habitat Assessment Field Data Sheet

Habitat Parameter	Excellent	Good	Fair	Poor
Bottom Substrate / Available Cover	Greater than 50% rubble, gravel, submerged logs, undercut banks, or other stable habitat.	30-50% rubble, gravel or other stable habitat. Adequate habitat.	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable.	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious.
	16-20	11-15	6-10	0-5
Embeddedness / Siltation	Gravel, logs, cobble, and boulder particles have between 0 and 25% of their surface covered by fine sediment / silt.	Gravel, logs, cobble, and boulder particles have between 25 and 50% of their surface covered by fine sediment / silt.	Gravel, logs, cobble and boulder particles have between 50 and 70% of their surface covered by fine sediment / silt.	Gravel, logs, cobble, and boulder particles have over 75% of their surface covered by fine sediment / silt.
	16-20	11-15	6-10	0-5
Velocity: Depth: pool - <1ft/s >1.5ft shallow pool - <1ft/s <1.5ft run - >1ft/s >1.5ft riffle - >1ft/s <1.5ft	All habitats well represented. None greater than 50% of total area.	Only 3 of the 4 habitat categories present. Or if all 4 are present, one greater than 50% total area.	Only 2 of the 4 habitat categories present.	Dominated by one velocity/ depth category (usually pool).
	16-20	11-15	6-10	0-5
Flow stability	Continual flow all year. Natural water supply substantial.	Seasonal high flows. Low flow constant or nearly so. Some point discharge contributes to flow.	Periodic high and low flows. Irregular flow pattern. Discharges contribute substantially to low flow.	Ephemeral stream. Usually no mid-summer flow. If it flows year-round, discharges form major contribution to low flow.
	12-15	8-11	4-7	0-3
Bottom Deposition / Sedimentation	Less than 5% of the bottom affected by deposition. Hard bottom substrate.	5-30% affected. Some deposition in pools. Soft bottom mainly in pools.	30-50% affected. Deposits, obstructions, constrictions and bends. Some filling of pools with sediments/sand. Soft bottom more common.	More than 50% of the bottom affected. Pools almost absent due to deposition. Only large rocks in riffle exposed. Soft bottom, loose deposits very common, often deep.
	12-15	8-11	4-7	0-3
Pools-Riffles-Runs-Bends	Variety of habitats. Deep riffles and pools.	Adequate depth in pools and riffles. Bends provide habitat.	Occasional riffle or bend. Bottom contours provide some habitat.	Straight stream. Generally all flat water or shallow riffle.
	12-15	8-11	4-7	0-3
Bank Stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%, little potential for future problem.	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40%. Slight erosion potential in extreme floods.	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential in extreme floods.	Unstable. Many eroded areas. Side slopes >60% common. "Raw" areas frequent along straight sections and bends.
	9-10	6-8	3-5	0-2
Bank Vegetative Stability	Over 80% of the stream bank surfaces covered by vegetation or boulders and cobble.	50-79% of the stream bank surfaces covered by vegetation, gravel or larger material.	25-49% of the stream bank surfaces covered by vegetation, gravel or larger material.	Less than 25% of the stream bank surfaces covered by vegetation, gravel or larger material.
	9-10	6-8	3-5	0-2
Streamside Cover	Dominant vegetation is shrub.	Dominant vegetation is of tree form.	Dominant vegetation is grass or forbes.	Over 50% of the stream bank has no vegetation. Dominant material is soil, rock, bridge materials, or mine tailings.
	9-10	6-8	3-5	0-2