UNIFIED PROTOCOLS FOR BENEFICIAL USE ASSIGNMENT FOR OKLAHOMA WADABLE STREAMS

(USE ATTAINABILITY ANALYSIS)

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EXECUTIVE SUMMARY

Oklahoma Water Resources Board is legislatively charged with the assignment and protection of beneficial uses for all Oklahoma waters. In order to accomplish this, a Use Attainability Analysis protocol was developed in the early 1980's. This protocol allowed investigators to visit a stream and subjectively determine what uses were appropriate for that particular waterbody. This process has evolved over the past two decades to remove the subjectivity and become the model to which other states are compared.

The following document contains the procedures and explanations for the chemical, physical and biological assessments necessary to complete the beneficial use assignment for waters of Oklahoma. This document also details the reasons and methods whereby a waterbody, for reasons of water quality, flow or physical conditions, may have its beneficial uses downgraded or removed.

UNIFIED PROTOCOLS FOR BENEFICIAL USE ASSIGNMENT FOR OKLAHOMA WADABLE STREAMS (USE ATTAINABILITY ANALYSIS)

INTRODUCTION

One of the most technically challenging aspects of water quality management in Oklahoma is the assignment of Beneficial Uses as defined in the Water Quality Standards (OAC 785:45). Numerous physical, chemical and biological parameters must be examined in detail in order to determine which beneficial uses are attainable. The uses currently being supported are not as important, from the perspective of the Clean Water Act and the Code of Federal Regulations, as those uses that could be attained if human impacts were minimized through the use of appropriate discharge limits and best management practices.

The process of assigning these uses has evolved from the earliest attempts in the late 1970's through the most recent numerical assignments. Many of these earliest assessments involved objective sensory measurements (appearance, smell, etc.) that have since been replaced by scientific measurement and numeric determination. Permit holders and other stakeholders have also evolved to the point that some are becoming interested in the process of use assignment.

In order to assure that uses can be assigned in a consistent and defensible manner by both state and non-state entities, this document contains the procedures to be used in the assignment of beneficial uses to Oklahoma waters. The methods described in the following text have been used over the past decade by OWRB staff to complete UAAs. Before these protocols can be used by any entity, a review of all methods (to be detailed in the workplan submitted prior to initiating assessment) will be completed by OWRB staff to assure that the data quality objectives can be met.

LEGAL AUTHORITY

The creation and assignment of Beneficial Uses has its foundation in Federal law. Both Clean Water Act and the Code of Federal Regulation (CFR) address the topic with some specificity. 40 CFR §131.10 states:

> *"(a) Each state must specify appropriate water uses to be achieved and protected. The classification of the waters of the State must take into consideration the use and value of water for public water supplies, protection and propagation of fish, shellfish and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation. In no case shall a state adopt waste transport or waste assimilation as a designated use for any waters of the United States.*
>
> *(b) In designating uses of a water body and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters.*
>
> *(c) States may adopt sub-categories of a use and set the appropriate criteria to reflect varying needs of such sub-categories of uses, for instance, to differentiate between cold water and warm water fisheries.*
>
> *(d) At a minimum, uses are deemed attainable if they can be achieved by the imposition of effluent limits required under sections 301(b) and 306 of the*

Act and cost-effective best management practices for non-point source control.

(e) Prior to adding or removing any use, or establishing sub-categories of a use, the State shall provide notice and an opportunity for public hearing under §131.20(b) of this regulation.

(f) States may adopt seasonal uses as an alternative to reclassifying a water body or segment thereof to uses requiring less stringent water quality criteria. If seasonal uses are adopted, water quality criteria should be adjusted to reflect the seasonal uses, however, such criteria shall not preclude the attainment and maintenance of a more protective use in another season.

(g) States may remove a designated use which is not an existing use, as defined in §131.3, or establish sub-categories of a use if the State can demonstrate that attaining the designated use is not feasible because:

(1) Naturally occurring pollutant concentrations prevent the attainment of the use; or

(2) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating state water conservation requirements to enable uses to by met; or

(3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(4) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or

(5) Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or

(6) Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

(h) States may not remove designated uses if:

(1) They are existing uses, as defined in § 131.3, unless a use requiring more stringent criteria is added; or

(2) Such uses will be attained by implementing effluent limits required under sections 301(b) and 306 of the Act and by implementing cost-effective and reasonable best management practices for non-point source control.

(i) Where existing water quality standards specify designated uses less than those which are presently being attained, the State shall revise its standards to reflect the uses actually being attained.

(j) A state must conduct a UAA as described in §131.3(g) whenever:

(1) The State designates or has designated uses that do not include the uses specified in section 101(a)(2) of the Act, or

(2) The State wishes to remove a designated use that is specified in section 101(a)(2) or the Act or to adopt subcategories of uses

specified in section 101(a)(2) of the Act which require less stringent criteria.

(k) *A state is not required to conduct a UAA under this regulation whenever designating uses which include those specified in section 101(a)(2) of the Act."*

State statutory language specifies that the OWRB is to designate beneficial uses, by classification of waters according to their best uses, and the CFR establishes national guidelines for use designation.

Oklahoma law O.S.82§1085.2(16) mandates that the OWRB is "…to adopt, modify or repeal and promulgate standards of quality of the waters of the State and ***to classify such waters according to their best uses*** in the interest of the public under such conditions as the OWRB may prescribe for the prevention, control, and abatement of pollution."

Beneficial uses have been applied to Oklahoma streams and lakes since the initial Water Quality Standards (WQS) were adopted in 1968. These uses are revised periodically as more data are obtained. Oklahoma's WQS specifically list beneficial uses in Appendix A and 785:45-5-3(a) for Oklahoma waters. Uses defined in the WQS include Public and Private Water Supply, Emergency Water Supply, Fish and Wildlife Propagation, Agriculture, Hydroelectric Power, Municipal & Industrial Process and Cooling Water, Primary and Secondary Body Contact Recreation, Fish Consumption, Navigation, and Aesthetics.

Beneficial uses are assigned to Oklahoma Waters by three different methods. They are 1) Existing uses, 2) Assumed uses and 3) Designated uses.

BASIC CONCEPT

The purpose of a Use Attainability Analysis (UAA) is determine if the stream is now or could be capable of supporting (a) specific Beneficial Use(s). To show how the most common Fish and Wildlife Propagation sub-categories of Warm Water Aquatic Community (WWAC) and Habitat Limited Aquatic Community (HLAC) are assigned, the decision tree shown on the following page has been created. The assignment of any BU is to made on the basis of the whether or not the Use **can be attained** with the imposition of appropriate permit limits and non-point source management strategies. A similar decision tree should be pursued for each BU being considered.

EXISTING USES

40 CFR § 131.3(e) states that "*Existing uses are those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards*." Generally, in Oklahoma, existing uses are evaluated through literature surveys of each water body. Very few questions remain concerning Oklahoma streams and their "existing uses". Ultimately, these existing uses become designated uses when they are confirmed through a UAA and included in Appendix A of the WQS Document (OAC785:45).

ASSUMED USES

Oklahoma's WQS, Section 785:45-5-3 (Unlisted surface waters) states:

(1) For those surface waters of the state not listed in Appendix A of this Chapter, excluding lakes, the following beneficial uses are designated:

(A) Agriculture: livestock and irrigation (785:45-5-13),
(B) Industrial and Municipal Process and Cooling Water (785:45-5-15),
(C) Aesthetics (785:45-5-19),
(D) Fish and Wildlife Propagation~~,~~ (Warm Water Aquatic Community) (785:45-5-12), and
(E) Primary Body Contact Recreation (785:45-5-16).

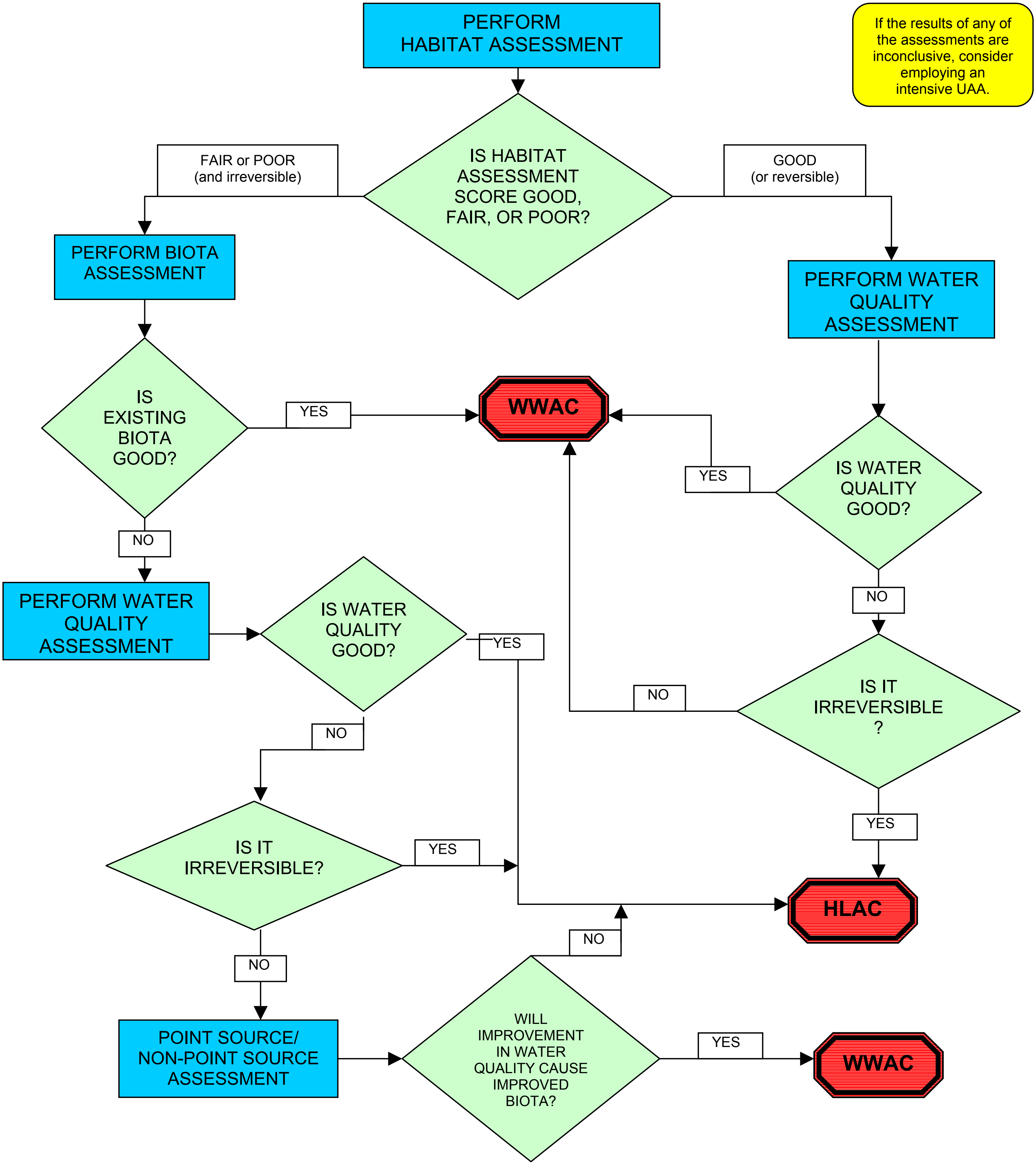
In Oklahoma, both Secondary Body Contact Recreation (SBCR) and Habitat Limited Aquatic Community (HLAC) are subcategories of uses requiring less stringent criteria. Therefore, prior to their designation to a waterbody, a UAA that provides the scientific justification for the SBCR or the HLAC designation must be completed (785:45-5-3(2)). During the 1988 Oklahoma WQS revision, the Environmental Protection Agency (EPA) communicated that the State must meet the requirement of the federal regulation for EPA approval of that section of the standards. Because of the EPA comments that were a re-statement of the applicable regulatory requirements, the Standards were amended to insure that a UAA is conducted prior to regulatory activity that affects the water quality of an unlisted water.

DESIGNATED USES

The process of designating beneficial uses generally involves one of three options that at any point may reveal sufficient information to designate uses. These three options include a literature review, a "one-day" survey, and an intensive survey.

LITERATURE REVIEW

The literature review involves the review of historical chemical, physical and biological data. Although information of this type may be available, it is seldom comprehensive enough to allow the designation of a beneficial use. Consequently, most UAA's in Oklahoma, including the unlisted streams' surveys, utilize a minimum of "one-day" surveys.



DECISION TREE FOR ASSIGNMENT OF AQUATIC LIFE USES

ONE-DAY SURVEYS

One-day UAA have evolved much over the 15-year history of UAA's in Oklahoma. During this period, the concept of a one-day survey has gone from a subjective, sensory inspection (appearance and smells) of the segment to its current state of a quantitative assessment that involves the physical, chemical and biological aspects of a stream.

The main benefit of a one-day UAA is that it takes a short period of time and requires a minimum amount of resource dedication compared to more intensive stream studies. It also provides reliable decision input for dischargers and permit-writers alike.

The methods used to perform one-day UAA's involve evaluating the physical, chemical and biological components of each stream segment surveyed. Designating a beneficial use to a stream calls for an integrated assessment of these biotic and abiotic components. **UAA's should be performed between June 1 and October 1 in order to assess the stream when it is most stressed by abiotic factors such as limited flow and temperature.**

Depending on length of stream and availability of access, one or more sample sites should be selected per stream surveyed. Prior to selection of sample sites, 7½ minute U.S. Geological Survey topographical maps of the entire watershed should be reviewed for watershed characteristics and all potential access points. One to three of these access points should be selected as sites for physical, chemical and biological measurements. If the stream has sufficient access, a site is selected in the lower reaches below any effluent but at least one-quarter mile upstream of its confluence with the next downstream segment. A sample site may also selected near the headwaters and above any effluent discharge if the stream is not effluent-dominated at the point of discharge. If there is no water upstream of the point source discharge then a sample site should be selected somewhere downstream of the outfall and outside of the mixing zone. On longer streams, sites are selected after reconnaissance to allow selection of the least impacted and most representative sites. The length of each sample site where physical and biological data are collected, generally range in length from 200 to 400 meters. Care should be taken to ensure that each site selected is representative of the particular reach of stream being evaluated.

The highest beneficial use classification a stream is capable of attaining without excessive human induced interference or impacts is a function of five physical, chemical and biological factors described by Karr et al. (1986). Since the abiotic components are the limiting factors to the biological potential in any system, it is assumed that the existing biological integrity of a stream is a reflection of its current average physical and chemical conditions. The mechanism for determining the highest biological potential attainable in a stream must look at all abiotic components that currently exist in the system, then determine if the biological community is a true reflection of that potential. Through this mechanism it may be determined if the existing uses are the potentially attainable uses. Due to infinite combinations of environmental factors that may possibly exist in a stream (no two streams are chemically and physically identical), no precise formula has been devised to accurately predict and describe the biological community that should exist there. Only through the evaluation of several watershed, stream habitat, water quality, and biological factors of numerous Oklahoma streams may predictions be made on aquatic life uses attainable for a given set of conditions.

The optimal time of year for conducting a UAA is when a stream's biological community is most limited by its abiotic components. Karr's et al. (1986) five major classes of environmental factors that determine a biological community's performance are susceptible to seasonal perturbations and, for most Oklahoma streams, these environmental factors are generally most limiting to biological community performance between July and September or later if summer-like conditions persist. This is during the period of lowest stream flow that may decrease habitat availability and allow for higher concentrations of point source pollutants. This is also during the period of highest water temperatures, which may exceed the maximum tolerance for some organisms by decreasing dissolved oxygen to near lethal levels.

Another use that must be considered in these surveys includes body contact recreation. Body contact recreation uses include the subcategories of Primary Body Contact Recreation (PBCR) and Secondary Body Contact Recreation (SBCR) which are exclusive of each other within a stream. PBCR involves direct body contact with the water where a possibility of ingestion exists. Typically this involves a water body with sufficient depths for full body immersion to occur such as in swimming. In these cases, the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings. SBCR is designated where ingestion of water is not likely to occur such as in boating or wading. Secondary Body Contact Recreation is therefore not dependent on attainment of physical, chemical and biological characteristics within a stream and therefore the criteria associated with this use are much less stringent.

Still another BU to be considered during a UAA is Public and Private Water Supply (PPWS). This beneficial use is based principally upon water quantity and reliability. Methods used to evaluate the PPWS use are not as elaborate or exhaustive as for fish and wildlife uses. Typically, a base flow in excess of two cubic feet per second is considered the minimum required for maintenance of the PPWS use. In addition, a permit review to determine if water withdrawal records indicate an existing PPWS use is conducted. If an existing public withdrawal use is discovered, the PPWS use is assigned.

It must be stressed that PRIOR to initiating any UAA, the investigating entity should compile a workplan for review and approval by OWRB staff. This workplan should include:

- Details about the receiving stream including a map,
- History of the discharge including pertinent permit information,
- Quality assurance plans including basic data quality objectives,
- Assessment site description,
- Assessment procedures,
- Analytical procedure descriptions including lab certification information and quality checks (blanks, duplicates, spikes, etc.), and
- Equipment descriptions and user-training information.

MATERIALS AND METHODS

SCREENING TOOL APPLICATION

A valuable output of some of the OWRB's FY93 work was the formulation of a screening tool that allows for preliminary examination of some stream variables in order to predict BU assignments without leaving the office. The benefits of being able to assign BU in this manner reduce time and expense associated with UAA's.

The screening tool was based upon the results of 127 UAA's performed between 1990 and 1993 on various sizes of streams located across the state. Flow regime, drainage area and flow augmentation were found to be very closely related to habitat scores and ultimately Fish and Wildlife beneficial use assignment.

To apply the screening tool, determine (1) the drainage area of the receiving stream <u>at</u> the point of discharge, (2) the design flow of the discharge (acquire from the permit writer at DEQ) and (3) the flow isopleth from the map in Appendix 1 by locating the site as closely as possible to its actual location and interpolate the value from the 2 bordering isopleths. Apply the following formula:

$$\textbf{(drainage area (mi}^2\textbf{) x isopleth (cfs/mi}^2\textbf{)) + design flow (cfs)}$$

If the results of the equation are **less than 2.95**, the stream has an 88% probability of being Habitat Limited Aquatic Community. If the results are **greater than 8.43**, the stream has an 88% probability of being Warm Water Aquatic Community. Between these numbers, the stream is "indeterminate" and will require a field investigation to determine the aquatic life use. If the screening model predicts HLAC (equation results <2.95), this result must be confirmed in the field through a UAA.

FISH AND WILDLIFE SUBCATEGORIES

There currently exists in the Oklahoma WQS four subcategories of beneficial uses under the Beneficial Use designation of Fish and Wildlife Propagation. Of these, the highest **attainable** use should be designated through a UAA. All Oklahoma streams have been classified as capable of attaining one of these beneficial uses that are listed as follows:

(1) Warm Water Aquatic Community (WWAC): - A subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality and habitat are adequate to support intolerant climax fish communities (OAC785:45-1-2).

(2) Habitat Limited Aquatic Community (HLAC): - A subcategory of the beneficial use "Fish and Wildlife Propagation" where the water chemistry and habitat are not adequate to support a WWAC. Possible reasons for this inability are limited to (1) Naturally occurring water chemistry prevents the attainment of the use; or (2) Naturally occurring ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of a sufficient volume of effluent to enable uses to be met; or (3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or (4) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or (5) Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of the WWAC beneficial use (40 CFR 131.10).

(3) Cool Water Aquatic Community - A subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality, water chemistry and habitat are adequate to support warm water intolerant climax fish communities and includes an environment suitable for the full range of cool water benthos. Typical species may include smallmouth bass, certain darters and stoneflies (OAC785:45-1-2).

(4)Trout Fishery - A water body that contains trout at least part of the year.

1- PHYSICAL

Physical characteristics of each stream should be measured and inventoried by using the methodologies developed by OWRB in conjunction with Oklahoma Conversation Commission. These are based upon methodologies described by Platts et al. (1983), U.S. Environmental

Protection Agency (EPA)(1983), Karr et al. (1986) and EPA (1989) and are detailed in OWRB Technical Report 99-3.

A data sheet, incorporated into the referenced Technical Report, should be completed for each stream listing specific characteristics under the general headings of hydrology, channel morphology and structure, streambed composition, and bank and riparian condition. These data sheets have evolved through numerous OWRB stream surveys with numerous authors. The function of these sheets is to facilitate describing the true condition of a given stream.

Watershed description characteristics include stream length, watershed area, recent precipitation and rural and urban land use descriptions. Some of this data is entered on site and some completed with the aid of U.S. Geological Survey topographical maps. Stream Order is determined with 7½ minute (1:24,000) USGS maps including intermittent and ephemeral channels (Strahler 1957) as is stream link magnitude (Osborne 1992).

Methods for documenting stream habitat quality are based upon those described in Sections 5.1.1, 5.2.1, 5.2.2 and 5.2.3 of the Rapid Bioassessment Protocol (EPA 1989). Raw data for each site are recorded in the data sheets found in **Technical Report 99-3** (Appendix 2) for later assessment of the habitat metrics outlined in **Technical Report 99-3**.

Hydrology includes discharge (flow) measured with portable flow meter such as a Marsh-McBurney Model 201 and utilizing methods described by Platts et al. (1983). A sheet for recording these data is included in the field sheet package. Water source is noted if possible. Momentary discharge is calculated with this formula:

$$D = \sum_{i=1}^{n} (w_i - w_{i+1}) \frac{v_1 + v_{i+1}}{2} \frac{d_i + d_{i+1}}{2}$$

where:

n	=	the total number of individual sections
w_i	=	horizontal distance from initial point
d_i	=	water depth at location i
v_i	=	measured velocity at location i

Calculation of total discharge can then be accomplished with ease with the aid of a spreadsheet in a similar format to the field sheet. **Flow is the only measurement whose variables (width, depth, velocity) are measured in units of "feet".**

Channel morphology and structure characteristics describe the macrohabitats and large features of the stream by estimating what percentage of each stream was comprised of pools, riffles and runs, descriptions of undercuts, and presence of large in-stream structures and channel alterations. Streambed composition characteristics describe microhabitats by estimating percent composition of streambed material, percent embeddedness, and presence of small and particulate organic material.

Banks and riparian zone characteristics require evaluating streamside cover by estimating percent composition of grasses, shrubs, trees, or other cover, shading by overhead canopy cover, bank material composition, bank slope, and presence of bank erosion. Estimated minimum, maximum and average riparian widths are recorded. Riparian condition, such as unused forest or grazed pasture, is also noted with the designations found and explained in the technical report. Any unusual or human-induced physical changes or impacts are noted in the "comments" section.

Alternative/additional methods supplementing the previously described physical habitat assessment are semi-quantitative estimates of stream morphology and in-stream structure. This procedure is done on wadable streams for the purpose of documenting limiting habitat features. Streams with depths greater than 1.5 m proved too deep for this method. By breaking a site into small segments, features such as depth, stream width, in-stream cover, substrate composition, etc. can be combined on a spreadsheet to derive a more objective description of the in-stream habitat. These methods were similar to, and partly modified from, McCain et al. 1990. Field sheets are photocopied on to all weather paper (e.g "Rite-in-the-Rain") for use while wading.

Distance traveled for these methods is measured with a trailing string distance measurer such as the Chainman II calibrated in 0.1meter increments. With this device, stations are established beginning at a recorded starting point and every five, ten or twenty meters (depending on stream size and homogeneity) for a total of twenty to thirty stations. Total distance assessed should be approximately 30 times the average stream width but no less than 200meters. Generally, this is done wading along the center of the stream.

At each station, stream depth should be measured to the nearest 0.1 meter at the right ¼, center and left ¼, stream width is estimated to the nearest meter using a 1½ - 2 meter staff as reference, habitat type (pool, run, riffle, or dry) is noted and percent composition of each substrate type is estimated. In-stream cover such as logs, undercutting, roots and trash is also noted. The percent embeddedness is estimated normally using the line that forms between the normally darker buried part of a rock and the normally lighter-colored exposed portion.

Raw data can then entered in a spreadsheet to easily calculate mean habitat depths, maximum depth, depth distribution, percent habitat types and substrate composition. This information is used to supplement the previously described field sheets.

All physical characteristic information should be supplemented by **photographic documentation** and included with the data sheets as soon as possible after leaving the site. Include photos of the area surrounding the start point, the area from which water chemistry data and samples are taken, and any unusual characteristic or evidence of impact.

Upon returning from the field, the recorded information is used to make an assessment of combined physical characteristics of a stream by means of the habitat assessment metric sheet modified from EPA (1989). The habitat assessment metric sheet is used to obtain an empirically derived habitat score for each stream.

2- CHEMICAL

Chemical components of the stream are measured to obtain existing water quality information for several purposes. Usually, water quality is measured to detect natural and man-induced limitations to attaining Fish and Wildlife Propagation, body contact recreation and PPWS beneficial uses. In most cases water quality is measured at sites upstream and downstream of a discharge effluent mixing zone to measure impacts resulting from the discharge. **All downstream sampling should be done well outside the regulatory mixing zone. Investigators should attempt to position the sampling site(s) at least ½ kilometer downstream of the point of discharge.**

Chemical characteristics measured at most sites include temperature, dissolved oxygen, pH, specific conductance, alkalinity, total hardness, total ammonia, nitrate, and orthophosphate. These parameters are measured at one to four sites on each stream, depending on presence and proximity of effluent discharges to sampling sites and proximity to other sampling sites. All measurements are made between late morning and late afternoon hours.

For temperature, pH, specific conductance, DO and certain other parameters, the use of a Hydrolab multi-probe datalogger or similar instrument is most expedient way to collect data for some parameters. Other parameters, such as nutrients, hardness, and alkalinity, will require other methods such as titration using methods derived from "*Standards Methods of Water and Wastewater Analysis"* (1995). At least 2 versions of a portable colorimeter or spectrophotometer available for use in the field that allow for accurate and precise measurements of many parameters. **It is important to note that all equipment should be maintained and calibrated in compliance with manufacturers' suggestions and requirements. All equipment must be thoroughly rinsed with deionized water between measurements. Regular washing in the lab is recommended but extreme care must be taken to rinse all detergent residues from the probes, containers and glassware.**

3- BIOLOGICAL

In order to determine existing beneficial uses and biological integrity of a stream; aquatic macroinvertebrates and fish are sampled at all sites. Aquatic macrophytes and algae may also be sampled if appropriate. Currently-supported beneficial uses are indicated by the presence or absence of an intolerant climax fish community and a full range of aquatic macroinvertebrates, both of which help define a WWAC. A stream capable of supporting an WWAC is one with *"... water quality and habitat are adequate to support intolerant climax fish communities and includes an environment suitable for the full range of warm water benthos*" (OWRB 1999). Therefore, as part of the procedure to determine the existence of a WWAC, fish samples are analyzed to determine fish community composition. If the sample consists of game fishes or other sensitive species that require specific or narrow ranges of high quality environmental conditions, then the community is considered an existing WWAC and is recommended for that beneficial use designation. Fish tolerances to habitat and water quality degradation as listed by Jester et al. (1992) are used to make this determination. Abundance is considered with age class structures in order to compile a more complete picture of the community. Other statistics may be incorporated as necessary to reflect the structure and characteristics of the community. **The segment sampled must be the same one used for physical assessment. Details of sampling protocols are explained within OWRB Technical Report 99-3 found in Appendix 2**.

Fish sampling is done by at least two crew members pulling a six foot tall, ¼ inch (or smaller) mesh seine for 5 to 10 meters at a time for no less than 200 meters through all available habitat types throughout the sample site. The length should be dictated by the width of the stream but should never be any longer than a crew of three can safely handle. Normally, the seine length will be between 10 and 25 feet. Riffle dwelling species are sampled by holding the lead-line of the seine on the substrate across the lower end of the riffle while one or two crew members agitated the substrate with their hands and feet for several square meters upstream of the seine. Electrofishing gear consisting of a Smith-Root backpack shocking unit (or similar) used in instances where representative sample sites are readily accessible. All sampled species and relative abundance are noted for each sample site with samples of unidentifiable species preserved in 10% formalin solution for later identification. Identification is done utilizing keys by Miller and Robison (1980) and Robison and Buchanan (1989) by qualified taxonomists.

The presence of a full range of warm water benthos in a stream is also supporting and indicative of an existing WWAC. If the aquatic macroinvertebrate community consists of several species that collectively require a variety of microhabitats, then it was assumed that the habitat was suitable for the full range of warm water benthos. This is determined by utilizing methods described by EPA

(1989) for Rapid Bioassessment Protocol I (Benthic Macroinvertebrate methodologies) that is designed to detect the presence of an impact to a stream. These methods require sampling from all available habitat types to detect presence and estimate relative abundance of various macroinvertebrate taxa. **Details on macroinvertebrate sampling are explained in OWRB Technical Report 99-3 found in Appendix 2.**

Sampling of aquatic macroinvertebrates is a two-step process. The first part is done with a 34 cm wide (or similar) D-shaped, fine-mesh (no larger than 650μm) dip net. The net is dragged through all types of aquatic vegetation, undercut banks, root wads, deadfall, leaf mats and brush piles. Continue sampling until all types of habitats have been sampled. Practice will improve the efficiency and effectiveness of this sampling technique. For riffles, a $1m^2$ seine with a mesh size of 500-650μm is used. The seine is held perpendicular to the substrate at the downstream end of the riffle while the upstream riffle substrate is agitated to at least 3 inches to release many of the clinging organisms to drift into the net. This is repeated 3 times; first at the bottom, then the middle and lastly the upper end of the riffle for a $3m^2$ total sample. **Always move upstream when riffle seining for invertebrates**. This prevents sediments and other debris from floating downstream and disturbing the rest of the riffle prior to being sampled. All aquatic macroinvertebrates are identified to the order level and as many as possible identified to the genus. Aquatic macroinvertebrates are quantitatively assessed by identifying and counting in the lab after collection, preservation with 90% ethanol in the field and sub-sampling according EPA RBP's and OWRB technical protocols. Statistical assessment may include diversity, relative abundance, taxa-specific indices (e.g. EPT, % Dipterans, etc.), taxa tolerances (Hilsenhoff, 1988) and community similarities if reference conditions are known.

The final steps in the process of assigning a beneficial use designation to a stream involves an analysis of the biotic and abiotic factors comprising the stream and watershed. A stream is assigned a WWAC beneficial use unless the water chemistry and habitat were not adequate to support it as described in Oklahoma's WQS definitions for HLAC (OWRB 1994). Streams with a low habitat assessment score are assumed not capable of supporting a WWAC regardless of water quality and streams with a high habitat assessment score are assumed capable of sustaining a WWAC unless precluded by naturally occurring water quality or irreversible impact. In complying with 40 CFR §131.12(a)(1), if a WWAC type of community is found to currently exist in a stream, then that stream is designated a WWAC in order to protect that existing beneficial use even if it received an intermediate habitat assessment score. If, however, a stream receives a low habitat assessment score but is found to contain an existing WWAC, the stream is reassessed to determine if an error was made in assessing the habitat or if the fish sampled are actually an anomaly to the system, such as relics from farm pond washouts. If evidence indicates that a low habitat assessment score is a result of an impact to the habitat then a stream is more closely evaluated to determine if removal of the impact will allow the existence of a WWAC. In the event of lower than expected biological integrity for a given habitat assessment score, a water quality problem may be present which may be limiting the attainment of a WWAC. In this case a determination is made as to whether or not available habitat could support a WWAC if the cause of the poor water quality is removed. This is done by utilizing biological and water quality data collected upstream from possible sources of pollution or from a nearby reference stream to make the final beneficial use recommendation.

BODY CONTACT RECREATION SUBCATEGORIES

Body contact recreation uses include the sub-categories of Primary Body Contact Recreation (PBCR) and Secondary Body Contact Recreation (SBCR) which are mutually exclusive. PBCR involves direct body contact with the water where a possibility of ingestion exists. Typically this involves a water body with sufficient depths for full body immersion to occur such as in swimming. In these cases, the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings. SBCR is designated where ingestion of water is not likely to occur such as in boating or wading. Secondary Body Contact Recreation uses are therefore not dependent on attainment of physical, chemical and biological characteristics within a stream.

For evaluating the physical characteristics of a stream for Body Contact Recreation classifications, a minimum criterion in which "... *direct body contact with the water where a possibility of ingestion exists*..." (OWQS) is used for classifying a stream as either PBCR or SBCR. **The guideline used for determining PBCR is thalweg water depth equal to or exceeding 0.5 meters in at least 20% of the stream segment**. This criterion was established in order to permit an objective decision to be made for body contact recreation classifications. In-stream logjams, boulders, and brush piles must not be taken into consideration. This BU is more concerned with potential bacterial contamination and human health issues than physical safety. Occasionally, a stream may be encountered that does not meet the established criteria for PBCR throughout most of its length but has a short section suitable for that classification. This exception is taken into consideration where appropriate. Additionally, the presence or absence of access points such as private residential property abutting the stream and public easements (bridges, etc.) to the stream should be noted as potential limiting factors. If people can’t get to the stream, the probability of ingestion of stream water decreases dramatically.

Body contact uses can be assigned through observation also. A stream segment may still be assigned PBCR even if its aquatic life use is assigned HLAC if it can be demonstrated that humans use the segment for recreational purposes. Children will frequently use small streams as play areas even if these areas will not support much of an aquatic community.

OTHER POTENTIAL USE DESIGNATIONS
Public and Private Water Supply beneficial use is based principally upon water quantity and reliability. Methods used to evaluate the PPWS use are not as elaborate or exhaustive as for fish and wildlife uses. Typically, **a base flow in excess of two cubic feet per second is considered the minimum required for maintenance of the PPWS use**. However, this type of information may require an extensive investigation of historical flows from several data sources. These sources may include USGS gauging stations and other monitoring activities for other purposes. The investigation should look into the existence of a municipal treatment works discharge on the segment. State and federal requirements exist for placement of water withdrawal points in relation to upstream discharge points. In addition, a permit review to determine if water withdrawal records indicate an existing PPWS use should be conducted. If an existing public withdrawal use is discovered or allocated, the PPWS use is assigned.

Agriculture is another BU that does not require extensive investigation or assessment in order to justify the assignment. Because of the nature and history of Oklahoma agriculture practices, Agriculture is a beneficial use that is assumed to be existing in most case. If the investigator can show (1) the presence of a permitted, active irrigation operation for crops or livestock involving stream-water withdrawal, or (2) there is a permit on file with OWRB for such an operation regardless if it actually is witnessed, or (3) livestock have ready access to the stream for the purposes of watering, one can safely presume that the Agriculture Beneficial Use is an existing use and designate it as such. The concept of “observed uses” is applicable here also.

PUBLIC PARTICIPATION PROCESS/DESIGNATING DETERMINED USES
Upon completion of the UAA field work and report development phases, uses are designated in the Oklahoma's WQS Appendix 2 through the WQS revision process following the Administrative Procedures Act. In general, proposed uses are presented to affected industries, municipalities and the public at an informal meeting. During this meeting, the UAA process is presented along with recommended beneficial uses. During the subsequent WQS revision process, public meetings and hearings are conducted during which comments are received, and addressed, from all concerned parties.

INTENSIVE SURVEYS
MATERIALS AND METHODS
In rare instances, it is not possible to designate uses to a waterbody based upon a one-day survey due to inconclusive or incongruous assessment results. In these instances, a more intensive survey is required.

These intensive studies generally involve more exhaustive chemical, physical and biological analysis as well as a greater dedication of resources and a larger investment. Continuous recording of physio-chemical parameters and the deployment of periphytometers and benthic macroinvertebrate substrates are commonplace. Because of the time and manpower commitment required to perform intensive studies, they are undertaken only when one-day studies do not render defensible beneficial use assignments.

Methods to perform an intensive UAA are based on those found in EPA's "WQS Handbook" (originally published in December 1983). Oklahoma has refined these methods over the last decade, especially as illustrated by the OWRB's one-day survey. Additional documentation is available through the OWRB. Because of the effectiveness of these one-day surveys, it is seldom necessary to undertake an intensive survey. Occasionally, after a single sampling season, a stream’s uses may be inconclusive. A reevaluation the next summer will usually allow the designation of uses.

Intensive UAA's are nevertheless invaluable tools in the designation of uses. Through the use of more exhaustive field and laboratory methods, uses can be more specifically assigned. The following are general intensive UAA methods.

PHYSICOCHEMICAL

Physical and chemical variables are measured throughout the study to characterize water quality and detect potential limiting conditions for aquatic life. Water quality data may be obtained using two types of sampling: on-site, *in-situ* measurements (hereafter referred to as field measurements) and more exhaustive laboratory analysis. Most water quality data originate from field measurements. Several replicates of field measurements (to document temporal variability across the representative reach) are taken to allow statistical analysis among sites. Methods for field and laboratory measurements are given below.

FIELD MEASUREMENTS

The same parameters should be measured during an intensive on-site investigation as were done in the one-day assessment. Dissolved oxygen, water temperature, pH, specific conductivity, total hardness, total alkalinity, and nutrients are all critical in determining the current status of the stream as well as deriving the average conditions for the segment being assessed. The Hydrolab instrument, as well as all other measurement devices, must be calibrated prior to use using manufacturer's standards and methods. In addition, accuracy of Hydrolab dissolved oxygen measurements should be verified by comparison with Winkler titration results using split samples. Seven to nine replicate field measurements should be taken at all sites during July through September.

Continuous monitoring of dissolved oxygen, pH, temperature, and conductivity (hourly readings around the clock) during 3-4 days should be conducted using a Hydrolab DataSonde (or similar) continuous recorder. The purpose of this sampling is to determine diel variability of critical water quality parameters. Continuous monitoring should be conducted from July - September, or during critical conditions. Pre-dawn measurements are taken and compared to late morning values to determine if limiting dissolved oxygen conditions are present at any site.

LABORATORY MEASUREMENTS

Water samples at all sites should be collected and preserved for laboratory analysis. At a minimum, the following parameters should be analyzed from these samples: minerals (chlorides, sulfates and TDS), bio-chemical oxygen demand (BOD), chemical oxygen demand (COD), nutrients including nitrite N, nitrate N, ammonia N, Kjeldahl N, total phosphorus, ortho-phosphorus, turbidity, total suspended solids (TSS), fecal coliform, fecal Enterococci, and metals of concern. Procedures for analysis should follow those in *Methods for Chemical Analysis of Water and Wastes* (latest edition) and *Standard Methods for the Examination of Water and Wastewater* (latest edition). Quality assurance procedures should be detailed in the laboratory's Quality Management Plan, a required document for Oklahoma Department of Environmental Quality (ODEQ) lab certification.

HYDROLOGICAL

Flow measurements are taken using a top-setting flow rod and portable flow meter or other acceptable method detailed in the workplan. Instantaneous cross sectional flows may be taken at various fixed-distance intervals depending upon overall stream width but no less than 15 fixed-distance points. This means using the same interval for the entire width of the stream. Utilizing instantaneous velocity (feet/second) and depth at each point, a volume may be calculated in cubic feet per second (cfs) using the same formula and recommended spreadsheet as detailed in the section for One-Day methods.

Time should be spent looking at the watershed and long-term flow records if available. The critical low flow for the segment may not be the only hydrologically limiting factor to consider. Remember, parts of the Cimarron and Canadian Rivers become a series of pools over the hottest parts of the summer and the are both still designated WWAC. **Even If there is no measurable flow during summer, the may still be refugia pools to which the fish can retreat during low flow periods**. Consequently, the achievable WWAC may be assigned.

HABITAT

Both habitat quality and availability play major roles in the type and quantity of organisms in an aquatic community. However, quantification of this qualitative parameter is difficult because habitat requirements for aquatic life uses vary among regions of the State and aquatic communities representative of each sub-category of the Fish and Wildlife Beneficial Use.

EPA's Rapid Bioassessment Protocol requires that habitat quantity and quality observations be made by field personnel. After being transcribed into known assessment metrics, the result is an assignment of numerical values to a series of habitat questions. These numerical scores are then summed to achieve an overall habitat ranking score. This habitat assessment concept and methodology has been incorporated into the forms and metrics found in Appendix 2. These habitat-ranking forms have been modified to more accurately reflect Oklahoma conditions. The use of these forms is described in the one-day survey method. For a more detailed description of this habitat assessment method, see the EPA publication *Rapid Bioassessment Protocols For Use In Streams And Rivers: Benthic Macroinvertebrates And Fish* (EPA/444/4-89/001, May 1989 or subsequent updates).

To retain some consistency within the State in habitat evaluations, OWRB habitat evaluation data sheets should be the only ones utilized. These data sheets enable a knowledgeable investigator to evaluate in-stream habitat, bank habitat, erosion potential, etc. **Although pair-wise habitat comparisons need not be completed for these studies, the use of un-impacted (or least impacted) reference conditions can provide a definitive evaluation of extant aquatic habitat for the area and is strongly encouraged**.

BIOLOGICAL

I. Periphyton

Periphyton (attached algae) are useful indicators when assessing the environmental characteristics of a site. Periphyton analysis can be important when determining the overall health of a stream, assessing enrichment, or as an aid in evaluating other measurements such as dissolved oxygen or pH. Relative pollution levels may be estimated through taxonomic identification. For collection of periphyton, these studies should utilize periphytometers deployed at each site for a two-week colonization period. Generally, periphyton will not be collected for one-day surveys. Collections and analysis are time consuming and costly.

Four replicate periphytometers are placed at each site following EPA methods (EPA, 1973). Sample locations are selected to maintain comparable shading and velocity among sites. These are standardized by placement in pool habitats and areas of similar canopy. Metal posts are driven into the substrate and periphytometers are attached using wire. Care should be taken to avoid heavily traveled roads (to prevent vandalism) and areas prone to rapid water level fluctuations during rainfall events.

Each periphytometer contains six standard microscope slides, giving a total of 24 separate slides per site. Three sets of five are then randomly sorted into three separate plastic containers. One replicate per site should be preserved with Lugols iodine for taxonomic identification and enumeration in the laboratory (EPA, 1973). Data from these samples are reported as total individuals, total species, density (individuals / unit area), and species diversity (Wilhm and Dorris, 1968; and Patten, 1962).

The Oklahoma Conservation Commission has developed alternative periphyton methods that utilize glass rod, instead of slides, as the periphyton colonization substrate. These have proven effective.

II. Benthic Macroinvertebrates

Benthic macroinvertebrates are often reliable indicators of environmental quality. Because of their limited mobility and diverse habitat requirements, the quality and quantity of benthic organisms may be used as indicators of water quality when assessing the best present and potential beneficial uses of a stream.

UAA's should utilize Hester-Dendy artificial substrates methods of invertebrate collection, as well as the traditional riffle seine and sweep net techniques.

Hester-Dendy artificial substrate samplers are constructed according to Hester and Dendy (1962). These samplers are standardized by placement in areas of comparable shading and stream velocity. At these sites, metal posts are driven into the substrate with sampler attachment approximately 10 cm from the substrate. Each site utilizes four separate Hester-Dendy samplers and allowed a six-week colonization period. Overall construction of each sampler should be equal to each other and at least 600cm^2 in total surface area.

After this six-week colonization period, the samplers are collected, resident organisms removed and field-preserved for laboratory analysis. Sub-sampling, using RBP methodologies, is allowed and usually recommended. Removal of the Hester-Dendy samplers must be done carefully to avoid loss of any of the organisms residing there. The investigator(s) should slowly remove the sampler from the water and immediately place it in a sieve bucket with a mesh size of no more than 650µm. There, the sampler can be washed free of all resident organisms which can then be transferred to a jar for preservation. An alternative to this method is to preserve the entire sampler in alcohol without washing it and remove the organisms in the lab.

III. Fishes

Fishes are sampled by both seining and electro-fishing to collect as many different fish species as possible at each site because the singular use of one method may bias the sample (seining biases toward smaller fish and electro-fishing toward larger fish). **A thorough sampling should be done to collect the majority of fish species present at each site**. This sampling involves re-sampling high productivity areas until each re-sampling effort yields no additional results.

Seining is generally accomplished using a ten-foot long, six-foot tall, ¼ inch square mesh minnow seine following methods described by OWRB (OWRB Technical Report 99-3). Seine size may need to be altered depending upon the conditions in the stream. The seine should be slightly longer than the width of the stream (where reasonable) and tall enough to cover the depth of the pools. Approximately 200 meters are seined at each site. A variety of habitats must be included such as pools, riffles, runs, logjams and undercut banks. Because the goal of fish collection in UAA sampling is to obtain an estimate of fish species at a site, more time is expended in those areas which prove to be the most productive in terms of species richness.

Electrofishing consists of positive and negative handheld electrodes that discharge a manipulated DC electrical current. Electrical pulse width, frequency, and voltage are manipulated with selectors built into the unit (Cofelt or Smith-Root). In general, a three-man team requires approximately one hour of actual sampling time to adequately sample each site.

Every effort should be made to standardize both seining and shocking procedures among sites. **It is strongly advised that the unified collection protocols found in OWRB Technical Report 99-3 be utilized.** It is important to note that the seining and shocking must occur during the same site visit and across the same area as the physical assessment.

All fishes collected in the field are preserved in a 10% formalin solution and transported to the lab for identification and enumeration. Those individuals too large for proper preservation and/or easily identifiable in the field are identified, weighed, checked for diseases, parasites or abnormalities, noted and released. In the event that a large individual (>0.2 kg) must be taken for identification, it should be slit up the ribs (to preserve the belly scales) and immersed in the formalin solution for preservation. Specimens should be transported to the lab in large (ex: 1 gallon), wide-mouth, sealable plastic jars. **The jars should also contain site information, written in pencil on water-proof paper, that includes site location (lat/long, legal), collectors names, date and sample type (seine or shock).**

Fishes are subsequently identified from the keys of Miller and Robison (1973), Pfliger (1968), Robison and Buchanan (1984) or other documents found to be appropriate by the trained taxonomist.

IV. Evaluation

Several indices, formulas and coefficients may be utilized in an effort to gain an understanding of the biological data. This understanding is important in establishing each sites relative quality, and both existing and potential aquatic life uses. They include:

Sorensens coefficient (Index of Similarity) (1948)

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

where:
a = number of taxa in community a
b = number of taxa in community b
c = number of taxa common to both

Coefficient of Community (Johnson and Brinkhurst, 1971 and Jaccard, 1912)

$$S_{cc} = \frac{a}{a+b+c}$$

where:

a =	number of taxa in community a
b =	number of taxa in community b
c =	number of taxa common to both

Margalefs Index (1958)

$$D_m = \frac{s-1}{\ln N}$$

where:

s =	number of species in population sampled
N =	number of individuals in population

Menhinicks Index (1964)

$$d = \frac{s}{\sqrt{N}}$$

Shannon-Weaver Index (H)(1949)

$$H = -\sum\left(\frac{n_i}{N}\ln\frac{n_i}{N}\right)$$

where:

n_i =	number of individuals in a species i of a sample population
N =	number of individuals in a sample population

Hurlberts PIE (1971)

$$PIE = \left(\frac{N}{N-1}\right)\left(1-\sum P_i^2\right)$$

where:

N =	number of individuals in a population
P_i =	the fraction of a sample of individuals belonging to species i (n_i / n)

Other indices may provide additional insights, and many are given in numerous OWRB and EPA publications. **A thorough understanding of each of the indices used will be important in determining what each can tell you**.

FINDING OF IRREVERSIBLE IMPACT

According to 40CFR131.10(g), there are those cases in which a use may be removed or a lower (less stringent) use may be assigned due to "*(3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place".* In order to show that this section is pertinent, the investigator must demonstrate both parts of the section. First, the impact must be anthropogenic. Second, and most difficult, is show that the impact is irreversible. This will not be an easy task.

The claim of irreversible must be substantiated through extensive investigation and documentation. The presence of a concrete-lined channelized drainage ditch does not, in itself, mean that a WWAC could not exist in the stream. The concrete ditch portion of the stream may only represent a small percentage of the entire stream length. However, if a significant amount of the stream length is in this condition, and housing development has replaced the riparian area, it may be safe to consider this segment irreversibly altered.

For the second possibility of "…*cause more environmental damage to correct than to leave in place",* the investigator must consider the nature of the contaminant(s) as well as the processes necessary to remedy the contamination. The presence of large of amounts of trash (appliances, car parts, fencing, etc.) does not meet this requirement. The investigator must consider the long-term (i.e. decades) impact of leaving the material in-place. In the case of large trash items, this may actually serve as habitat or a bank stabilizing influence. Since most of the metallic items described here will rust away if left, this would not be considered irreversible. Even most chemical spills, such as petroleum, can be effectively and efficiently remedied with modern techniques.

It is possible, however, to have a small segment within a segment assigned a lower use. For example, several streams are currently split at some fixed point above which the stream is designated HLAC and the downstream portion is designated WWAC.

PUBLIC PARTICIPATION PROCESS/DESIGNATING DETERMINED USES

Upon completion of the UAA field work and report development phases, uses are designated in the Oklahoma's WQS Appendix A through the WQS revision process following the Administrative Procedures Act. In general, proposed uses are presented to affected industries and municipalities at an informal meeting. During this meeting, the Use Attainability Analysis process is presented along with recommended beneficial uses. During the subsequent WQS revision process, public meetings and hearings are conducted during which comments are received, and answered, from all concerned parties.

References

Abel, P. D. 1989. *Water Pollution Biology*. Ellis Harwood Limited. Chichester, England. p 99.

APHA. 1988. *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association., Washington, D.C.

Ball, J. 1982. Stream Classification Guidelines for Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Bartsch, A. F, and W. M. Ingram. 1959. "Stream Life and the Pollution Environment." *Public Works*, 90 (1959): 104-110.

Bode, R. W. 1988. *Quality Assurance Workplan for Biological Stream Monitoring in New York State*. N. Y. State Dept. of Environmental Conservation.

Cairns, J., Jr., and K. L. Dickson, 1971. "A Simple Method For the Biological Assessment of the Effects of Waste Discharges on Aquatic Bottom-Dwelling Organisms." *Journal Water Pollution Control Federation*, Washington, D. C. 43:755-772.

Cleve-Euler, A. 1951. "Die diatomer von Schweden and Finnland." *Almquist and Wicksells Boktryckiri*. A. B. Stockholm, Sweden.

Elwood, J. W., J. D. Newbold, A. F. Trimble and R. W. Stark. 1981. The limiting role of phosphorous in a woodland stream ecosystem: Effects of P enrichment on leaf decomposition and primary producers. Ecology, 62(1):146-158.

Federal Water Pollution Control Administration. 1968. *Keys to Water Quality Indicative Organisms*. Edited by Fred Parrish. U.S. Dept. of the Interior.

Hach Company. 1988. Digital Titrator Model 16900-01 Manual. Loveland, CO.

Hamilton, K. and E. P. Bergersen. 1984. Methods to Estimate Aquatic Variables. Environmental Evaluation Project No. DPTS-35-9. Bureau of Reclamation, Denver Federal Center, Denver CO.

Hester, F. E. and Dendy, J. S. 1962. "A Multiple Plate Sampler for Aquatic Macroinvertebrates." *Am. Fisheries Society Trans.*, V.91, no. 4, pg. 420-421.

Hilsenhoff, W. L. 1988. "Rapid Field Assessment of Organic Pollution with a Family Level Biotic Index." *J. of N. Am. Benthol. Soc.* 7(1):65-68.

Hurlbert, S. H. 1971. "The non-concept of Species Diversity: A Critique and Alternative Parameters." *Ecology*, Vol. 52, pp. 577-586.

Illinois Environmental Protection Agency. 1987. *Quality Assurance and Field Methods Manual*. Division of Water Pollution Control, Section C: Macroinvertebrate Monitoring. Springfield, Ill.

Jaccard, P. 1912. "The distribution of flora in an Alpine Zone." *New Phytol.*, 11:37.

Jester, D. B., A. A. Echelle, W. J. Mathews, J. Pigg, C. M. Scott, and K. D. Collins. Unpublished manuscript. The fishes of Oklahoma, their gross habitats, and their tolerance of water quality and habitat degradation. Oklahoma Water Resources Board, Oklahoma City, Oklahoma.

Johnson, M. G. and R. O. Brinkhurst. 1971. "Associations and species diversity in Benthic Macroinvertebrates of bay of Quninte and Lake Ontario." *Journal Fish Resources Board*. Canada, 28 :1683.

Karr, J. R. 1981. "Assessment of Biotic Integrity Using Fish Communities." *Fisheries* 6:21.

Karr, J. R., K. D. Fausch, P.L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing Biological Integrity In Running Waters: A Method And Its Rationale. Special Publication 5. Illinois Natural History Survey.

Kendeigh, S. C. 1974. *Ecology with Special Reference to Animals and Man*. Prentice-Hall, Inc. Englewood Cliffs, N. J.

Lafferty, B. 1987. A procedure for evaluating buffer strips for stream temperature protection under the Forest Protection Act. Pg. 70-77 in *Managing Oregon's Riparian Zone For Timber, Fish and Wildlife*. Technical Bulletin N.C.A.S.I. #514.

Lowe, R. L. 1974. *Environmental Requirements and Pollution tolerance of freshwater diatoms*. EPA-670/4-74-005, U.S. EPA, Cincinnati, OH.

McIntosh, R. P. 1967. "An Index of Diversity and the relation of Certain Concepts to Diversity." *Ecology*. 48:392-404.

Margalef, R. 1958. "Information Theory in Ecology," *Gen. Syst. Vol. 3*, pp 36-71.

Menhinick, E. P. 1964. "A Comparison of Some Species - Individuals Diversity Indices Applied to Samples of Field Insects." *Ecology*. 45:859-881

Merritt, R. W. and K. W. Cummins. 1984. *An Introduction to the Aquatic Insects of North America*. Kendall/Hunt Publishing Co., Dubuque, Iowa.

Miller, R. J. and H. W. Robison. 1980. *The Fishes of Oklahoma*. Oklahoma State University Press. Stillwater, Oklahoma.

Patrick, R. and C. W. Reimer. 1966. *The Diatoms of the United States, Vol. I and II*. Academy of National Science Philadelphia Mono, No. 13. Philadelphia, PA.

Platts, W. S., W. F. Megahan, and G. W. Minshall. 1983. Methods For Evaluating Stream, Riparian, And Biotic Conditions. General Technical Report INT-138. U.S. Department of Agriculture, U.S. Forest Service, Ogden, UT.

Reash, R. J. and T. M. Berra. 1989. "Incidence of fin erosion and anomalous fishes in a polluted stream and a nearby clean stream." *Water, Air, and Soil Pollution*. 47:47-63.

Robison , Henry W. and Thomas M. Buchanan. 1987. *Fishes of Arkansas*. University of Arkansas Press, Fayetteville, Ark.

Schlosser, I. J. 1981. "Effects of Perturbations by Agricultural Land Use on Structure and Function of Stream Ecosystems." Ph.D. Dissertation, Univ. of Illinois, Champaign Urbana, Ill.

Schueler, T. R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP's*. Publication No. 87703. Metropolitan Washington Council of Government. Washington D.C.

Shannon, C. E. and E. Weaver. 1949. *The Mathematical Theory of Communication*. University of Illinois Press, Urbana, Ill. pp. 82-83 and 104-107.

Simpson, E. H. 1949. "Measurement of Diversity." *Nature*. Vol 163:688.

Sokal, Robert R. and F. James Rohlf. *Biometrics*. W. H. Freeman Co. 1981.

Sorensen, T. 1948. "A method for establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analysis of vegetation on Danish commons." *Biol. Skr*. 5,1-34.

Triska, F. J., V. C. Kennedy and R. J. Avanzino. 1983. Effect of simulated canopy cover on regulation of nitrate uptake and primary production by natural periphyton assemblages. In: *Dynamics of Lotic Ecosystems*, Ed. by T. D. Fontaine, III and S. M. Bartell. Ann Arbor Science. Ann Arbor, MI. Pg. 129-159.

U. S. Department of the Interior. 1967. "Environmental Requirements of Blue-green Algae." *Proceedings of a Symposium by the Univ. of Wash. and the Fed. Water Poll. Control Admin*. Corvallis, OR.

U. S. Department of the Interior. 1973. *Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples*. U.S. Geological Survey.

U. S. Environmental Protection Agency. 1973. *Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents*. EPA-670/4-73-001, U.S. EPA, Cincinnati, OH.

U. S. Environmental Protection Agency. 1982. *Methods for Chemical Analysis of Water and Wastes*. U. S. E. P. A., Washington, D.C. EPA/600/4/82/055.

U. S. Environmental Protection Agency. 1983. *Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analysis*. Office of Water Regulations and Standards, Washington D. C.

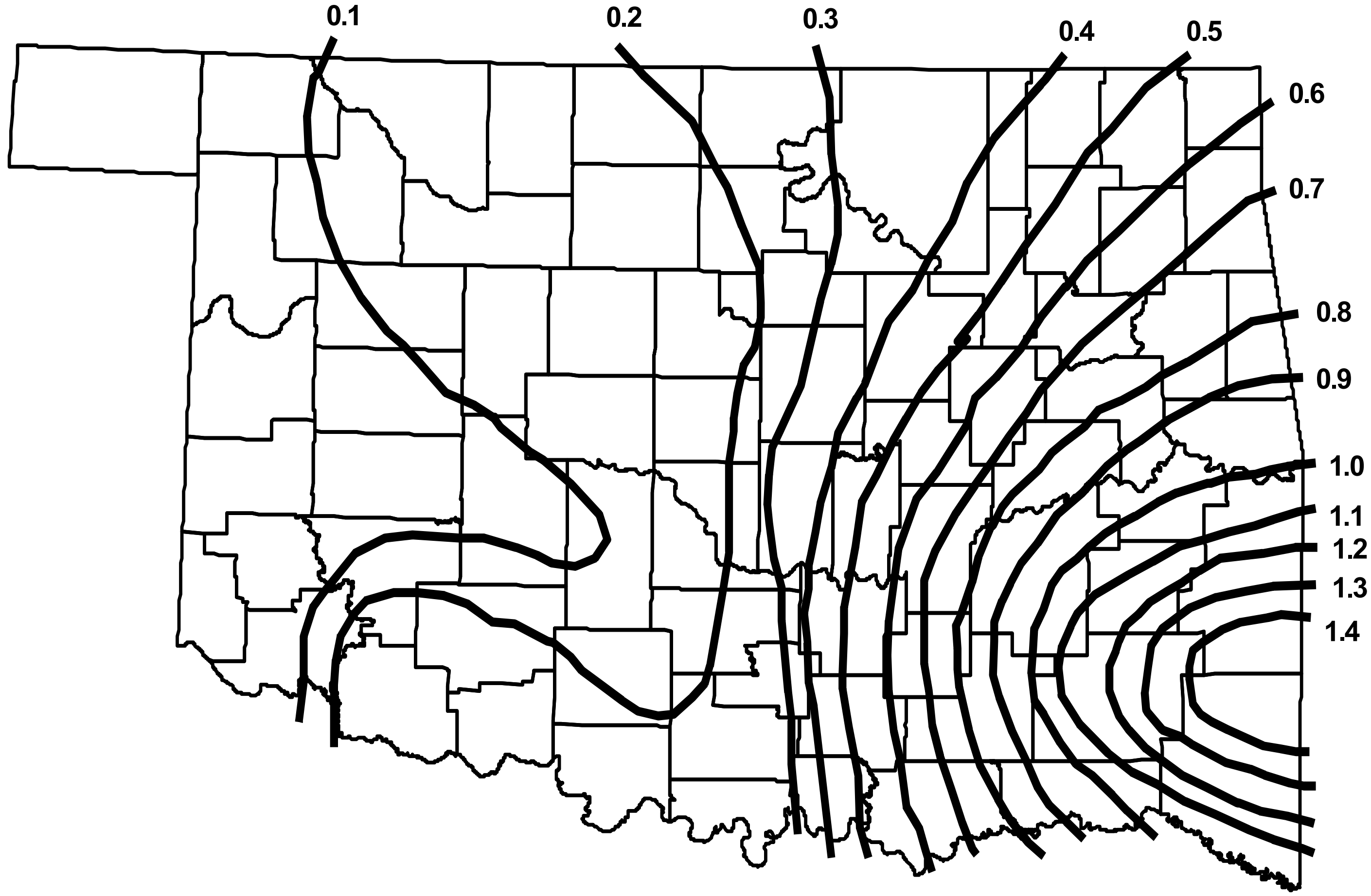
U. S. Environmental Protection Agency. 1989. *Rapid Bioassessment Protocols for use in Streams and Rivers*. Office of Water Regulations and Standards, Washington D.C. EPA/444/4-89/001.

Washington, H. G. 1984. "Diversity, Biotic, and Similarity Indices, A review with Special Interest to Aquatic Ecosystems." *Water Res*. 18:653-694.

Wetzel, R. G. 1975. *Limnology*. Saunders College Publishing.

APPENDIX 1

Statewide Isopleth Map of Flow/Area (cfs/mi^2)



Isopleth map of instream flow per area - Q_u/A_d (cfs/mi^2) from OWRB Technical Report 96-2.

APPENDIX 2

OWRB TECHNICAL REPORT 99-3

OWRB TECHNICAL REPORT 99-3

Standard Operating Procedures

For Stream Assessments and Biological Collections

Related to Biological Criteria

in Oklahoma

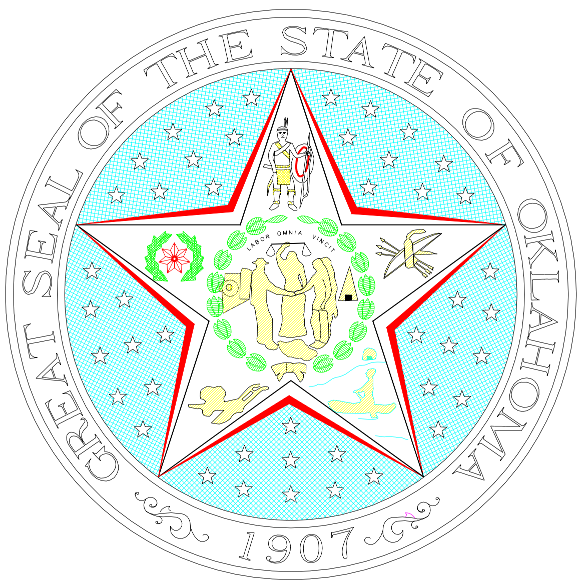
April 5, 1999

Standard Operating Procedures

For Stream Assessments and Biological Collections

Related to Biological Criteria

in Oklahoma



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EXECUTIVE SUMMARY OF STANDARD OPERATING PROCEDURES FOR STREAM ASSESSMENTS AND BIOLOGICAL COLLECTIONS RELATED TO BIOLOGICAL CRITERIA IN OKLAHOMA

The thrust of U.S.E.P.A criteria development over the past several years has been to encourage states to develop and adopt, at a minimum, narrative biological criteria. EPA has also encouraged all states to follow the lead of a few states in developing and adopting numeric biological criteria. Biological criteria for Oklahoma have yet to be developed. The development process, however, is continuing and this protocol is another step in that process.

This protocol is the result of the cumulative efforts of numerous representatives from several state agencies and universities. Approximately four years have been invested in the development of these procedures and field tests have repeatedly validated them.

The intended application of this protocol is establishment of a uniform biological assessment through which aquatic communities of similar streams can be compared. Any section of the protocol (physical, chemical or biological) is capable of being used separately. However, a complete picture of the biological condition of any given stream necessitates that each section be applied in conjunction with the others. Agencies, universities, independent entities and individuals are not required to employ these protocols for their own projects unrelated to biological criteria. Separate, project-driven or agency-devised protocols are acceptable for other purposes. Only when results are to be used in biological criteria applications related to Oklahoma's Water Quality Standards will these protocols be required.

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Chuck Potts, Oklahoma Water Resources Board

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Derek Smithee, Oklahoma Water Resources Board

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Phil Moershel, Oklahoma Conservation Commission

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Dave Dillon, Oklahoma Department of Environmental Quality

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Mark Howery, Oklahoma Department of Wildlife Conservation

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INTRODUCTION

For the past several years, EPA has been moving toward and encouraging the development of biological criteria (biocriteria) in conjunction with numeric water quality criteria. The use of endemic organisms and communities as indicators of long-term water quality has been recognized by biological researchers for decades. Only recently has the concept begun moving into the regulatory arena. Several states have implemented some form of biocriteria over the past decade and Oklahoma is aggressively moving toward that same goal.

Oklahoma Water Resources Board (OWRB) staff, in conjunction with a Technical Advisory Committee, have developed the following Standard Operating Procedures (SOPs) for assessments involving or relating to biological criteria. This group was comprised of individuals representing several agencies and universities in order to gain as much insight and as many different perspectives as possible. These protocols are the culmination of years of development and testing.

These protocols are required for use during any project where the biological component of a stream is to be compared to reference conditions or other biocriteria results. For biocriteria-related projects, four major classes of parameters must be sampled. These are as follows:

1. Physico-chemical parameters of the water. These include temperature, pH, specific conductivity, dissolved oxygen, percent oxygen saturation, turbidity, instantaneous discharge, hardness, alkalinity, ammonia, phosphates, and nitrates.

2. Habitat Assessment.

3. Macroinvertebrate community structure.

4. Fish community structure.

SOP's for these parameters will be detailed in the following pages. These SOPs are designed and intended to be used outside of the mixing zone of the receiving stream. **ALL ASSESSMENTS AND BIOLOGICAL COLLECTIONS SHOULD ONLY OCCUR AFTER AT LEAST 13 STREAM WIDTHS DOWNSTREAM OF THE POINT OF DISCHARGE.**

STANDARD OPERATING PROCEDURES

CHEMICAL PARAMETERS

All chemical testing follows protocols from the 18th edition of Standard Methods for the Examination of Water and Wastewater (American Public Health Association et al., 1992). Any modifications to these protocols must comply with USEPA regulations and approval.

Parameters to be tested during any sampling event, and associated requirements, will include:

- -temperature (^{o}C thermometer)
- -pH (standard units)
  - pH meter or standard titration
- -specific conductivity (µS)
  - conductivity meter or calibrated instrument such as Hydrolab or YSI
- -dissolved oxygen (mg/L)
  - modified Winkler titration or calibrated DO meter
- -percent oxygen saturation (%)
  - calibrated instrument such as YSI or Hydrolab or conversion from solubility chart (such as from Benson and Krause, 1980 or Hach, 1992 as attached)
- -turbidity (NTU's)
  - calibrated instrument such as YSI, turbidimeter or colorimeter
- -instantaneous discharge(flow measured as CFS)
  - calibrated instrument such as Marsh-McBirney Flomate model 2000 and appropriate calculation
- -total hardness (mg/L equivalent $CaCO_3$)
  - EDTA titration or colorimeter
- -alkalinity (mg/L equivalent $CaCO_3$)
  - sulfuric acid titration or colorimeter
- -ammonia (mg/L)
  - Nesslers' titration, colorimeter or colorimetric kit
- -phosphates (mg/L total orthophosphate)
  - ascorbic acid colorimetric method or colorimetric kit
- -nitrate (mg/L)
  - cadmium reduction colorimetric method or colorimetric kit

All references to colorimeter or colorimetric methods should be interpreted as meaning following manufacturers instructions for each parameter being tested with the colorimeter or spectrophotometer.

All references to equipment such as Hydrolab or YSI refers to the multi-parameter recording dataloggers available from both companies. All manufacturer's instructions should be followed for calibration and maintenance of the equipment.

All references to colorimetric kits refer to those kits from reputable companies such as LaMotte. These kits have proven reliable through prolonged use by volunteer monitors.

All references to collection equipment manufacturers such as Smith-Root are for reference and comparison only. Mesh sizes in nets, seines and sieves are the only required specifications for equipment intended to be used.

SITE SELECTION

The site chosen for chemical testing should be one that is free of obvious trash and surface materials (e.g. scums, oil sheens, foams, etc.). A site which is close to the road may be preferable for convenience but may not be representative of conditions in the stream as a whole. Select a site that has sufficient depth to submerge the Hydrolab or YSI monitor, lacks excessive turbulence and appears to be similar to most of the visible stream reach to be assessed.

SAMPLE COLLECTION

When collecting a water sample for laboratory analysis, how the sample is taken can be as important to the results as the chemical composition of the water. In most cases, a simple grab sample is sufficient for chemical analyses. It is recommended that all grab samples be taken **BELOW** the surface to prevent contamination by surface materials that may be present. Submerge the sample container inverted and turn it upright once the container is fully submerged. When collecting D.O. samples for titration, **DO NOT** allow bubbles to interfere with the analysis. This can be prevented by submerging the D.O. bottle on its side allowing the water to enter the bottle gradually without causing bubbles to form. Submerge the bottle completely so that the neck of the bottle is full and water will be expelled when putting the cap on. This prevents additional oxygen from being dissolved into the sample from the space at the top of the bottle. This procedure is not necessary if the Hydrolab or YSI is equipped with a D.O. sensor.

Samples transported to the lab must be preserved. In most cases, samples can be preserved using ice and a covered ice chest if analysis is to occur within 24 hours. The dark and cold will prevent algal and chemical activity and possible alteration of chemical composition of the sample. The sample container should be covered at least to the lid by ice to ensure rapid and continuous cooling. If taking more than one sample during any particular trip, ensure that each sample container is labeled with the date, collectors names and appropriate site identification information (e.g. stream name, legal location, county name, etc.).

Some types of analysis (nitrate and ammonia) require that samples be preserved with acid if analysis cannot be performed within approximately 24 hours. In these cases, using approximately 2ml sulfuric acid per liter of sample will reduce the pH of the sample sufficiently to allow storage for up to 14 days (for nitrate) and 28 days (for ammonia) **in refrigeration** ($<4^{o}$ C). Samples will still need to be iced when transporting from the field after preservation and in the laboratory until analysis is completed.

Using the form in Figure 1 will help ensure consistent record-keeping. The table found in Figure 2 can be used to approximate oxygen saturation percentage by dividing the D.O. results in sample by the saturation concentration found on the table. Be sure to know the temperature and barometric pressure at the time of sampling.

STREAM____

COUNTY____

LEGAL____

DATE____________ ANALYZERS______________________

	SITE 1 (A)	SITE 2 (B)	SITE 3 (C)	SITE 4 (D)
water temp (^oC)				
dissolved oxygen (mg/L)				
oxygen saturation (%)				
carbon dioxide (mg/L)				
pH				
turbidity (NTU)				
specific conductance (μS)				
ammonia (mg/L)				
nitrate (mg/L)				
phosphates (mg/L)				
hardness (mg/L)				
alkalinity (mg/L)				
flow (CFS)				

SITE DESCRIPTIONS

(A)

(B)

(C)

(D)

Figure 1: Water chemistry data sheet used in OWRB biocriteria assessments.

	Pressure in Millimeters and Inches Hg								
	775	760	750	725	700	675	650	625	mm
TEMP (oC)	30.51	29.92	29.53	28.54	27.56	26.57	25.50	24.61	inches
0	14.9	14.6	14.4	13.9	13.5	12.9	12.5	12.0	
1	14.5	14.2	14.1	13.6	13.1	12.6	12.2	11.7	
2	14.1	13.9	13.7	13.2	12.9	12.3	11.8	11.4	
3	13.8	13.5	13.3	12.9	12.4	12.0	11.5	11.1	
4	13.4	13.2	13.0	125.5	12.1	11.7	11.2	10.8	
5	13.1	12.8	12.6	12.2	11.8	11.4	10.9	10.5	
6	12.7	12.5	12.3	11.9	11.5	11.1	10.7	10.3	
7	12.4	12.2	12.0	11.6	11.2	10.8	10.4	10.0	
8	12.1	11.9	1.7	11.3	10.9	10.5	10.1	9.8	
9	11.8	11.6	11.5	11.1	10.7	10.3	9.9	9.5	
10	11.6	11.3	11.2	10.8	10.4	10.1	9.7	9.3	
11	11.3	11.1	10.9	10.6	10.2	9.8	9.5	9.1	
12	11.1	10.8	10.7	10.3	10.0	9.6	9.2	8.9	
13	10.8	10.6	10.5	10.1	9.8	9.4	9.1	8.7	
14	10.6	10.4	10.2	9.9	9.5	9.2	8.9	8.5	
15	10.4	10.2	10.0	9.7	9.3	9.0	8.7	8.3	
16	10.1	9.9	9.8	9.5	9.1	8.8	8.5	8.1	
17	9.9	9.7	9.6	9.3	9.0	8.6	8.3	8.0	
18	9.7	9.5	9.4	9.1	8.8	8.4	8.1	7.8	
19	9.5	9.3	9.2	8.9	8.6	8.3	8.0	7.6	
20	9.3	9.2	9.1	8.7	8.4	8.1	7.8	7.5	
21	9.2	9.0	8.9	8.6	8.3	8.0	7.7	7.4	
23	9.0	8.8	8.7	8.4	8.1	7.8	7.5	7.2	
22	8.8	8.7	8.5	8.2	8.0	7.7	7.4	7.1	
24	8.7	8.5	8.4	8.1	7.8	7.5	7.2	7.0	
25	8.5	8.4	8.3	8.0	7.7	7.4	7.1	6.8	
26	8.4	8.2	8.1	7.8	7.6	7.3	7.0	6.7	
27	8.2	8.1	8.0	7.7	7.4	7.1	6.9	6.6	
28	8.1	7.9	7.8	7.6	7.3	7.0	6.7	6.5	
29	7.9	7.8	7.7	7.4	7.2	6.9	6.6	6.4	
30	7.8	7.7	7.6	7.3	7.0	6.8	6.5	6.2	
31	7.7	7.5	7.4	7.2	6.9	6.7	6.4	6.1	
32	7.6	7.4	7.3	7.0	6.8	6.6	6.3	6.0	
33	7.4	7.3	7.2	6.9	6.7	6.4	6.2	5.9	
34	7.3	7.2	7.1	6.8	6.6	6.3	6.1	5.8	
35	7.2	7.1	7.0	6.7	6.5	6.2	6.0	5.7	
36	7.1	7.0	6.9	6.6	6.4	6.1	5.9	5.6	
37	7.0	6.8	6.7	6.5	6.3	6.0	5.8	5.6	

Figure 2: Oxygen saturation table from Hach (1992). All measurements are reported in mg/L.

STANDARD OPERATING PROCEDURE

Macroinvertebrate Collection

Macroinvertebrate collections made for purposes of stream assessment are made from the community which requires or prefers flowing water. Reasons why this community is sampled rather than various lentic communities include:

1. The flowing water community is routinely exposed to the average water quality of the stream.

2. The metrics designed to analyze the macroinvertebrate community of streams were designed for the flowing water community. There is no evidence that they work when applied to lentic communities.

3. The database of pollution tolerance of macroinvertebrates found in Oklahoma is much larger for lotic communities.

Lotic communities in streams require a substrate of some type to attach to. The most common substrates of this type which are encountered are rocky riffles, streamside rootmasses, and woody debris. Where possible, a rocky riffle should be sampled, but if it is not present, or is of dubious quality, or rocky riffles cannot be found in all streams of a given ecoregion, both of the other two alternate habitats should be sampled. At present, it appears that the streamside rootmasses are superior to woody debris but until that is definitely established, both should be sampled.

Collection of Benthic Macroinvertebrates from Rocky Riffles

When sampling the invertebrate communities within a lotic environment, the investigator must remember that the organisms have adapted to moving water and will not be easily dislodged. Care must be taken to thoroughly examine any and all material that is being sampled but not taken back to the lab (large rock, large woody debris, etc). Large debris and rock in the sampling zone can be scrubbed and thrown aside. After completing the sampling event, replace the debris in the riffle.

I. **Suitable Substrates -** A riffle is defined as any sudden change in the level of the streambed such that the surface of the water becomes disrupted by small waves. For this collection method the substrate of the riffle must be composed of gravel, or cobble from 2cm-30cm in the longest dimension. Riffles with substrates of bedrock or tight clay are not suitable.

II. **Method of collecting the sample -** Support a $1m^2$ kicknet (number 30 mesh (650 µm)) in such a way that any organisms dislodged from the substrate will be carried into it by the current. The bottom of the net should be tight against the bottom of the stream and the current must be sufficient to insure that dense organisms such as small molluscs will be carried into the net from the sampling area. It is usually best to lean the net backward (downstream) so that currents caused by the presence of the net will not carry organisms around the sides of the net.

    Beginning at the farthest downstream point of the riffle, vigorously agitate the substrate of a $1m^2$ area of the bed of the riffle immediately upstream of the net until all rocks and sediment to a depth of at least ten centimeters have been thoroughly scraped against each other and the organisms living between and upon the rocks have been dislodged and carried into the net by the current. Continue agitation until it can be seen that the area being sampled is producing no new detritus, organisms, or fine sediment.

At this point, rinse leaves, sticks and other large debris caught in the net in the current so that organisms on them are carried into the net. When the volume of the sample is reduced enough that three such samples will fill a 1 liter sample jar three fourths full or less, remove all of the material from the net and place it in the sample jar. If there is still too much debris to fit into the jar with 2 more samples, remove a portion of the debris and record the estimated percentage of the sample that went into the jar. Care should be exercised in removing the organisms from the net. Dislodge as much material as possible from the sides of the net by splashing stream water up the sides of the net and allowing the water to wash material down to the bottom. Continue this process until the debris and organism sample is collected into a small region. Seine samples can then be carefully picked up and transferred into the jar.

ALWAYS THOROUGHLY RINSE ALL EQUIPMENT AND HANDS BETWEEN SAMPLINGS TO AVOID CROSS-CONTAMINATION OF SAMPLES!

III. **Where to sample the riffle** - Three 1 m^2 areas of the riffle must be sampled. They can be square, rectangular or trapezoidal so long as each area equals 1 m^2 in area. One should be in the fastest part of the riffle where the largest rocks and the smallest amount of interstitial sediment will generally be found. The second should be in the slowest part of the riffle, often near the edge of the stream where the smallest rocks and the greatest amount of interstitial sediment will be found. The third sample should be in an area intermediate between the first two.

IV. **When to sample**- All sampling should occur when the stream has a relatively constant flow **at or near base flow**. This will usually require knowing the hydrologic history of the stream but a safe estimate of base flow will be limiting sampling events to periods between late May and mid-October. **Do not sample within a week of a substantial rain event (>0.5 inch).**

V. **Preservation**- All sample containers should have approximately 3-5 cm of space at the top of the container. All samples should be preserved in 90% ethanol until identification can occur. Insure that ethanol covers all sample material.

VI. **Processing of the Sample** - The sample should be processed and picked according to the USEPA Rapid Bioassessment Protocol (RBP 5).

Collection of Macroinvertebrates from streamside and emergent vegetation

I. **Suitable substrates** - Any streamside or emergent vegetation which offers structure for invertebrates to dwell within or upon is suitable. The vegetation being sampled must include materials in the current so that it offers suitable habitat for organisms which collect drifting particles or which need flowing water for other reasons. This habitat will often be found along the undercut banks of runs and bends where the fine roots of grasses, sedges, and trees, such as willow and sycamore, hang in the water.

II. **Method of collecting the sample** - This type of sample should be collected with a dip net made of #30 size mesh material. The net should be placed around or immediately downstream of the vegetation being sampled. The organisms can be dislodged from the roots either by vigorously shaking the net around the roots or by shaking the roots with your hand while the roots and your hand are inside the net.

ALWAYS THOROUGHLY RINSE ALL EQUIPMENT AND HANDS BETWEEN SAMPLINGS TO AVOID CROSS-CONTAMINATION OF SAMPLES!

III. **Where to sample -** Sampling should continue for five minutes of actual collection time. Do not count the time while you are walking between areas you sample.

IV. **When to sample**- All sampling should occur when the stream has a relatively constant flow **at or near base flow**. This will usually require knowing the hydrologic history of the stream but a safe estimate of base flow will be limiting sampling events to periods between late May and mid-October. **Do not sample within a week of a substantial rain event (>0.5 inch).**

V. **Preservation**- All sample containers should have approximately 3-5cm of space at the top of the container. All samples should be preserved in 90% ethanol until identification can occur. Insure that ethanol covers all sample material.

VI. **Processing of the samples** -The sample should be processed and picked according to the USEPA Rapid Bioassessment Protocol (RBP 5). Follow identification protocols found at the end of this section.

Collection of macroinvertebrates from woody debris

I. **Suitable substrates -** Any dead wood with or without bark in the stream is suitable as long as it is in current fast enough to offer suitable habitat for organisms which collect drifting particles or which need flowing water for other reasons. The final sample should consist of organisms collected from an even mixture of wood of all sizes and in all stages of decay.

II. **Method of collecting sample**- This type of sample should be collected with a dip net made of #30 mesh material. The net should be placed around or immediately downstream of the debris being sampled. The organisms can be dislodged from the debris either by vigorously shaking the net around the woody debris or by shaking the debris with your hand while the debris and your hand are inside the net. Large logs which are too big to shake should be brushed or rubbed vigorously by hand while the net is held immediately downstream.

ALWAYS THOROUGHLY RINSE ALL EQUIPMENT AND HANDS BETWEEN SAMPLINGS TO AVOID CROSS-CONTAMINATION OF SAMPLES!

III. **Where to sample -** Sample for a total of five minutes counting only the time that debris is actually being agitated. Include as many types of debris in the sample as possible. These types often include wood which is very rotten and spongy with bark, wood which is fairly solid which has loose and rotten bark, and wood that is solid with firmly attached bark. They should range in size from 1cm to about 20cm in diameter.

IV. **When to sample**- All sampling should occur when the stream has a relatively constant flow **at or near base flow**. This will usually require knowing the hydrologic history of the stream but a safe estimate of base flow will be limiting sampling events to periods between late May and mid-October. **Do not sample within a week of a substantial rain event (>0.5 inch).**

V. **Preservation**- All sample containers should have approximately 3-5cm of space at the top of the container. All samples should be preserved in 90% ethanol until identification can occur. Insure that ethanol covers all sample material.

VI. **Processing the sample** -The sample should be processed and picked according to the USEPA Rapid Bioassessment Protocol (RBP 5). Follow identification protocols found at the end of this section.

VII. **Identification of organisms**- Once the samples have been returned to the lab, picked, and sorted, identification can proceed at the convenience of the investigator. It is recommended that only personnel appropriately trained in invertebrate taxonomy be involved in the identification phase of the assessment. Recommended taxonomic keys include Merritt and Cummins' "*Introduction to the Aquatic Insects of North America"* (no earlier than 2nd ed., 1988) and Pennack's "*Freshwater Invertebrates of North America"* (2nd ed., 1984). The second edition of Pennack's publication is preferable to the third edition for use with insects because the insects have been eliminated from the third edition. Pennack's third edition possesses updated taxonomy for use with non-insect taxa. Use of multiple editions of the same work should be approached with care as revisions and corrections to taxonomy may produce conflicting results.

All identifications should be taken to as restrictive a level as possible but all organisms should be identified to at least family level.

VIII. **Archiving samples**- Each individual agency and/or school generally employs a method of archiving that involves saving and cataloging data and samples or individual specimens of both fish and macroinvertebrates. In some cases, arrangements can be made with local universities to store specimens. Many already have some form of museum collection and will be open to such arrangements. It is recommended that entities undertaking biocriteria sampling develop a location and a procedure whereby collections can be archived for future reference. Data archiving will involve either hardcopy or electronic version. Each individual stream that is assessed and sampled for the purposes of biocriteria must be documented and archived for future reference.

STANDARD OPERATING PROCEDURE

Fish Collection in Streams

Variations of habitat, types of fish, and water chemistry dictate the use of different collection techniques both within and among streams. For purposes of conducting a statewide assessment which allows for the comparison of one stream to another, we use a combination of seines and a backpack shocker in every stream. The width and length of the seine being used will vary according to the stream width and the depth of pools. **All seines used are to be no larger than 1/4" mesh**.

Specific techniques for, and relative advantages of seining and electrofishing vary considerably according to stream type, and conductivity and are discussed in detail in <u>Fisheries Techniques</u> (edited by B.R. Murphy and D.W. Willis and published by the American Fisheries Society, 1996).

The following procedure is recommended for collecting fish in streams for biocriteria-related projects.

A. **Training Procedures**

If you have not already done so, read the chapters in <u>Fisheries</u> <u>Techniques</u> which deal with streams, seines, and electroshockers.

B. **Field Collection Methods**

1. <u>Distance of stream to be sampled</u>. Distance should be no less than 200 meters up to 400 meters until, using the best professional judgement of the sampling team, all types of available habitat have been sufficiently sampled and the team leader feels that additional sampling will not significantly affect the results of the survey.

2. <u>Collection Procedures</u>

THE SEGMENT SAMPLED MUST BE INCLUDED IN THE SEGMENT ASSESSED FOR HABITAT QUALITY!

a. <u>Seining</u>. A stream should be seined before it is shocked since fish that utilize cover in the stream will generally not leave the area when disturbed. These fish are most efficiently collected by shocking and will still be there when electroshocking commences.

Seine sizes may range from 3 to 6 foot seines in 10, 20, and 30 foot lengths. Seine height is dictated by water depth, and length is determined by width of the water being sampled. If possible the seine should be 15-25% longer than the width of the waterbody being sampled and about 25% higher than the depth of the water. This will allow the center of the net to form a bag behind the operators where the fish are more likely to stay in the net. **REMEMBER that the longer the seine is, the more difficult it will be to control in stream currents.**

The leadline should be kept on the bottom, and in front of the float line.
If there are many obstructions on the bottom, the leadline will become caught or bounce, and most fish will escape underneath the bottom of the net. If this

happens use a smaller net that allows you to avoid obstructions, roll up the ends of the existing net to make it more manageable, or go to electroshocking.

The brailles of the net should be used to disturb the area under any undercut banks or beds of macrophytes near the edge in order to scare fish hiding in cover out towards the middle of the net.

Under ideal conditions the net should be pulled through the water in the manner described above for about 10 meters and dragged out of the water on a gradually sloping preselected beach. The person pulling the seine on the side of the stream opposite the beach should swing ahead of the other person so that the seine is pulled out on the beach stretched over the same distance it was stretched in the stream.

If the stream doesn't have gradually sloping banks, the dip method should be used. This method consists of sweeping around and through the area to be sampled, keeping a wide bag and moving the lead line as much under the undercut bank as possible. Use the brailles to probe repeatedly as far as possible into the undercut area working towards each other until the brailles overlap. The seine should then be swiftly stretched and lifted vertically from the water. An alternative method of retrieving fish under these conditions is to slowly turn the brailles to wind the net up once they have overlapped to form an enclosure. This may wind up the fish with the net and allow them to be lifted out of the water with the rolled up net. **RECORD THE TIME SPENT SEINING AND SEINE MESH SIZE ON THE FIELD DATA SHEETS.**

b. Electroshocking. A Smith-Root Backpack Electrofisher model 115-B POW with a Honda model EX-350 generator is recommended for use in collecting fish. Always use this equipment in accordance with manufacturer instructions.

[**BEFORE OPERATING OR ASSISTING** with the shocker, **READ** and **UNDERSTAND** the manuals for the generator and the shocker. Starting procedures, safety procedures and troubleshooting are well documented in these manuals and are not detailed here. The manuals can be obtained from the manufacturer.

The shocker consists of a trailing stainless steel cable electrode and a ring electrode mounted on the end of a PVC pole.

The shocking team must consist of at least two people. One will carry and operate the shocker while the other(s) will net stunned fish. The shocker is most useful where a seine cannot be used effectively in areas such as brushpiles, rootwads and cobble substrates. The forward electrode should be gradually passed back and forth over and in these areas as the team walks upstream. As fish are stunned, they will usually roll over and become more visible, allowing the netters to see and capture them.

In very dense brush or root cover, fish often sense the presence of the team before they are close enough to be stunned and then retreat so deeply into cover that it is impossible to net them when they are stunned. It is often better in situations such as these to insert the electrode into the brush before it is turned on, give the fish a minute or so to get used to the new situation and then turn the current on. Many fish will be much closer to the edge of brushpile when they are stunned in this manner. **RECORD THE TIME SPENT ELECTROSHOCKING ON THE FIELD DATA SHEET.**

c. Preservation and Field I.D.

Currently, there is discussion concerning the ethical treatment of the fish specimens collected for any reason. In the future, amendments to this protocol may require an anesthetizing agent be added to the formalin prior to introduction to the fish sample. There is no current requirement for the use of or agreement on the necessity of such an agent.

In general all fish should be placed in 10% formalin immediately after captureand returned to the lab for identification. There are a few exceptions made for large (>100 g) fish which can be positively identified in the field. If all team members agree on the identification of such a fish, it can be returned to the water far enough away that recapture is unlikely. However, if the specimen is unusual or rare (e.g. eels, bowfins, obvious or gross abnormalities, etc.), it too should be preserved regardless of size.

Fish much larger than 0.3 to 0.4 Kg, which cannot be identified in the field, should be sliced open along the ribs when preserved in order to allow the formalin to penetrate the body cavity fast enough to prevent decay.

Formalin is a carcinogen and can also cause permanent damage to mucous membranes and eyes. Care must be taken when placing fish in formalin so that the fish does not flop around and splash formalin onto people near the jar. The fish should be put into the jar with the lid tilted open away from the operator so that the lid shields the face and body of the operator. Flood any skin exposed to formalin with plenty of water as soon as possible. Safety glasses should be worn by those handling formalin. If it gets in your eyes, flood the eyes with water immediately and go to the doctor immediately after that.

d. Sample Identification

Write date, stream name, type of sample (seine or electrofishing), time spent sampling, seine mesh size and legal location on the front of each jar using a wax pencil or an indelible marking pen (e.g. Sharpie). All specimens can identified using a reputable taxonomic reference such as “Fishes of Arkansas” (Robinson and Buchanan, 1988). Attempts are currently underway to update and republish “The Fishes of Oklahoma” which has not been in print since the 1960's.

e. Field Data

At all sites where fish are collected, a stream habitat evaluation **must** be performed. It does not have to be done on the same day as the fish are collected, but should be done before major floods change the habitat.

f. Safety

1. Primary responsibility for safety while electroshocking rests with the team leader. All crew members should receive training in First Aid and CPR. Electro-fishing units have a high voltage output and may deliver dangerous electrical shock. While electrofishing, avoid contact with water unless sufficiently insulated against electric shock. Use chest waders with non-slip soles and water-tight rubber (or electrician's) gloves. **Avoid contact with anode at all times. <u>At no time while electrofishing should a crewmember reach into the water for any reason.</u>** The electrofishing equipment is equipped with a 45 degree tilt switch which interrupts the current. Do not make any modifications to the electrofishing unit which would make it impossible to turn off the electricity.

2. General safety guidelines should be observed. If waders or gloves develop leaks, leave the water immediately. Avoid operating electrofishing equipment near people, pets or livestock. Discontinue any activity in streams during thunderstorms or heavy rain. Rest if crew becomes fatigued.

3. Gasoline is extremely volatile and flammable. Its vapors readily ignite on contact with heat, spark or flame. Never attempt to refill the generator while it is running. **<u>Always allow the generator to cool before refilling.</u>** Keep gasoline out of direct sunlight to reduce volatilization and vapor release. Always wear gloves and safety glasses when handling gasoline. Keep gasoline only in approved containers.

4. Decision to use electrofishing equipment will depend on size of site, flow, conductivity and turbidity. If conductivity is below 10 or over 1200 μS, if flow is too high, site too deep or water is too turbid to assure safe footing or locate stunned fish, the team leader may consider use of seine only or determine that site is "Unsampleable". <u>THIS IS A SAFETY DECISION.</u>

STANDARD OPERATING PROCEDURE

STREAM HABITAT ASSESSMENT

THE SEGMENT SAMPLED FOR BIOTA MUST BE INCLUDED IN THE SEGMENT ASSESSED FOR HABITAT QUALITY!

In the past we have used two separate assessments for streams and riparian areas. Because of the importance of intact riparian areas to stream habitat and water quality there is really no reason to separate these two assessments. We are now merging them, and this SOP describes the correct method of filling out the new assessment form.

Record all measurement data in meters. This includes height of eroded bank, width of riparian zone, depth of pools, size of cobbles or boulders, width of stream and anything else you measure **except** **flow**. All measurements used to calculate instantaneous discharge are in feet.

If you use feet or inches in any measurement except flow, you will be responsible for converting it to meters before can be compared to other sites or historic data.

1. **Name of stream on USGS 7-1/2 minute map**. If the county map, soil map, or other map has a different name, the USGS 7-1/2' map takes precedence. If a stream is unnamed on the USGS map, but named on another map, use that name, but write the name of the map in parentheses beside the stream name.

2. **Names of people doing assessment**. [Don't use initials.]

3. **Direction--circle the appropriate word**. If you go upstream from the start point, circle upstream.

4. **Date the assessment is done.**

5. **Water Body number**. If the stream has site letters assigned to it, use the site designation of the start point also.

6. **Flow--enter the flow in CFS.** Flow should be taken during base flow conditions or as close as possible. **Never measure within a week of a significant rain event (>0.5 in)**

7. **Start Point**. A description, legal or otherwise, of where the assessment is started. Someone else should be able to locate this point from your description.

8. **Legal description of the portion of stream assessed** to the nearest 1/4 section.

9. **Latitude/Longitude of the start point in the format 00"00"00"/00"00"00".**

10. **Channel sinuosity**. This measurement must be completed in the office using a planimeter. When the assessment is completed, you will know exactly how far up or downstream you have walked. In the office, using the planimeter, measure that distance on a USGS 7-1/2 minute map along the portion of the stream you walked, starting at the point you started at in the stream. For example, if you started the assessment at a bridge on the east boundary

of section 9 T9N R8W and walked upstream for 200 meters, you get out the 7-1/2 minute map containing section 9 T9N R8W and set your planimeter wheel on the bridge from which you started. Being very careful to keep the planimeter wheel on the stream, follow the stream upstream from the bridge until you reach the point on the map where the planimeter reads 200 meters. **Mark this point.**

Next, draw a straight line (using a ruler) from the point where you ended the survey to the point from which you started the survey, and measure this distance using the planimeter.

Channel Sinuosity is the ratio of in-stream channel length divided by the straight line distance. It will always be >1.

11. **Distance**. **The distance from the start point as measured by the hip chain**. A stream must be assessed a minimum of 200 meters. Parameters 12 through 37 should all be measured at the start point and recorded to the right of the start (0) point. Generally we assess streams in conjunction with a bioassessment. For this purpose, **parameters 12-37 will be measured and recorded every 10 meters along the stream**. Instruction for their measurement follow.

12. **Depth**. Depth of water is measured in meters to the nearest 0.1 meter. **<u>The left bank of the stream is that on your left as you face downstream</u>**. The left ¼ (L1/4) is the depth of water midway between the center of the stream and the left bank. Center (C) is the depth of water in the center of the streambed . Right ¼ (R1/4) is the depth of water midway between the center of the stream and the right bank.

13. **Width WTR & Width BNK** are the width of the water in meters to the nearest 1 m, and the width of the lower bank in meters to the nearest 1 m. The lower bank extends from the water's edge at summer low flow to the top of the normal high water line. The normal high water line is usually marked by the beginning of well-established perennial vegetation. Below this line will be gravel and bare soil. There may be a sparse covering of annual vegetation below this line. The lower bank width is the distance between the tops of the left and right lower banks.

14. **Substrate**. This is an estimate of the substrate of the stream at the point where measurements are taken from the edge of the water on one side to the edge on the other side. The total of all substrate components should add up to 100 percent. The categories include the following:

a. **S.& C** Loose silt and clay.
b. **SND** Sand or rock particles; 0.1 to 2mm.
c. **GVL** Gravel; rocks from 2 mm to 50 mm.
d. **CBL** Cobble; rocks from 50 mm to 250 mm.
e. **BLD** Boulder; rocks > 250mm.
f. **BRK** Bedrock or hardpan clay.
g. **POM** Particulate organic matter--rotten leaves and fragments of stick and logs.
h. **HPC** Hardpan clay

15. **Habitat Type**. Check the box that is most applicable to the habitat type present at the station. A **riffle** has surface which is definitely broken and usually makes a sound. A **pool** has a smooth surface, no or very little current and can be deep or shallow. A **run** has an obvious current, may be deep or shallow and often has a surface which may be slightly broken, but doesn't make any noise. Check **dry** if the stream has no water in it at the point being measured.

If there are two obvious habitat types at the cross section you are measuring, check both boxes. An example is when a backwater pool is encountered beside a run or riffle.

16. **Instream Cover Area**. This category attempts to quantify the amount of cover present for fish in the section of stream from the previous station to the present one. For example, if the section was 20 meters long and averaged 6 meters wide, its area would be 120m^2. A submerged log about 3 meters long by 0.5 meters wide would offer 1.5m^2 cover, and you would note that the LWD (large woody debris) category offered 1.5/120 or 1.3 percent cover. Waterwillow, an emergent aquatic macrophyte, might be growing in shallow water along the edge of the stream. If both edges had a zone about 1 meter wide where it grows, there would be (1 meter) (20 meters) (2 sides)=40m^2 of EAV (emergent aquatic vegetation in the 120m^2 section of stream and you would check 40/120 or 33 percent in the EAV column. **Note that the totals of the "percent cover" columns for each row will rarely add up to 100 percent and may often be 0 percent**.

The categories are:

a. **UCB** Undercut banks
b. **LWD** Large woody debris--woody debris in the water > 10 cm. in diameter.
c. **SWD** Small woody debris-- woody debris in the water <= 10 cm. in diameter.
d. **RTS** Roots--these are submerged root wads of trees. If single or occasional roots are encountered, count them in one of the woody debris categories.
e. **BRL** Bedrock ledges--underwater bedrock ledges not forming part of an undercut bank.
f. **SAV** Submerged aquatic vegetation.
g. **EAV** Emergent aquatic vegetation.
h. **TV** Terrestrial vegetation which is currently underwater. An example would be tree branches or grass leaves that are actually hanging down into the stream.
I. **CBG** Cobble, Boulder and Growth. This is an estimate of the percent coverage of cobble and boulder in the 20 meter section. It may not be the same number as the percent composition of cobble and boulder in the cross section where you estimated substrate since they represent different areas.

17. **EMB - Embeddedness**. This quantifies the amount of silt, clay and sand which has been **DEPOSITED**. If there is no fine material surrounding the cobble and gravel, and there is at least some free space under the rocks, that is 0 percent embedded. If the free space under the rocks is filled but the sides are untouched, count that as 5 percent embedded. As the level of fines rises up the cobble sides, estimate the percentage of the total height of the cobbles that is covered. This is your embeddedness estimate. You can often see this line quite distinctly if you lift the rocks out of the water.

18. **CAN - Percent Canopy Cover**. At each measuring station, estimate the percent canopy cover in the previous segment. It can range from 0 to 100 percent, but if you can see any sky directly overhead, that part is not covered and your estimates should be less than 100 percent.

19. **PTB - Point Bar**. If a recently formed point bar is present, that is, it has no or little vegetation, put a check in this box.

20. **D&S - Deposition and Scouring**. If there is evidence of scouring (smooth, clean bedrock or
hardpan clay) or deposition (loose, shifting bottoms of fine sand or silt or filled in pools) in the previous segment surveyed, check this box.

21. **BVC - Bank Vegetative Cover**. Record an estimate of the total area on both banks that is protected from erosion by well established **perennial** vegetation. Soil doesn't have to be covered as long as it's stable. If banks are covered with rip-rap or large gravel, they can still be stable. Remember to note this in the "Comments" section.

22. **DV - Dominant Vegetation**. Place an S (shrub), T (tree), or G (grasses and forbs) in the box indicating which type of vegetation is most dominant **ON THE BANKS** in terms of percent of ground protected. For our purposes, shrubs are any woody plant whose trunk and branches are <= 10 cm in diameter. If the vegetation is mixed but each of the three groups contribute at least 20% of the total put an M in the box.

23. At each measurement point **record the average % of streambank that is actively eroding** for both the left bank and the right bank of the stream segment you just walked. Measure from the edge of the lower bank to the edge of the upper bank. [The upper bank is usually the edge of the flood plain.]

REMEMBER THAT THE LEFT BANK IS THE BANK TOWARDS THE LEFT AS YOU FACE DOWNSTREAM so if you are walking upstream the left bank will be the one on your right side.

24. Record the **average height of the eroding banks** on either side of the stream segment you just walked. Measure from the lower edge of the bank to the upper edge of the bank.

25. Record the average % slope of the banks in degrees. Measure from the lower edge of the bank to the upper edge of the bank.

26. Record the **typical substrate of each bank**, use the same substrate abbreviations that are used in the stream assessment form.

27. Record the **average width of the riparian vegetation** for each side of the segment you just walked. The riparian zone for our purposes extends from the top of the upper bank outwards from the stream. (Remember that you have already described the size and vegetative state of the banks in columns 21, 22, 24, & 25.) For our purposes, the riparian zone ends where the unmanaged (i.e. not plowed or mowed) portion of land ends. Riparian vegetation is typically bottomland hardwood forest when in a natural state, but mixtures of trees and herbaceous plants are frequently encountered. These will grade from a fairly dense forest with sparse grasses to land that is mostly pasture with a few scattered trees.

If WOODY SHRUB AND SAPLING GROWTH CAN BE CONTROLLED USING A 6' BRUSHHOG AND A MEDIUM SIZE TRACTOR IN BETWEEN THE LARGER TREES, THE LAND WILL BE LABELED PASTURE AND MAY OR MAY NOT BE INCLUDED IN THE RIPARIAN ZONE. IF THE LARGE TREES ARE SO DENSE THAT A TRACTOR AND MOWER OF THIS SIZE CAN'T BE USED FOR BRUSH CONTROL, THE LAND SHOULD BE LABELED AS FOREST AND INCLUDED IN THE RIPARIAN ZONE. Remember that the riparian zone stops where pasture or crop management begins.

28. As stated earlier, natural riparian vegetation is typically bottomland hardwood forest, but when disturbances have been or are present there will be varying amounts of herbaceous plants and bare soil also. In these two columns you are asked to decide whether the majority of the land in the riparian zone on either side of the stream is grassland or forest. USE THE CRITERIA FROM CATEGORY 27 FOR THIS DETERMINATION. You are also called upon to decide how much bare soil is exposed. In grassy areas, this is a straight forward determination and is done by estimating the average % of bare soil you see as you walk the 10 meter riparian zone in question. Forest, while not expected to have grasses & forbs covering the ground, is expected to have a layer of spongy duff composed of organic matter in various states of decay covering the soil. This layer is usually covered by a layer of recently fallen leaves or annual herbaceous vegetation that haven't yet started to decay, so you will have to move these leaves or vegetation out of the way to determine if the duff layer is present. Soil not covered by duff should be counted as bare. Estimate the % bare soil exposed in forest as you walk the area in question.

THE RIPARIAN ZONE ON BOTH SIDES OF THE STREAM SHOULD BE PLACED IN ONE OF THE FOLLOWING CATEGORIES. Write "W" after the condition class if at least 5 meters of riparian area depth appear to be wetland based on the presence of standing water or saturated soil after at least a week of dry conditions, or dominance by sedges, rushes, button bush or willow.

1A	STABLE FOREST	<1% bare soil exposed
1B	MODERATELY USED FOREST	1-10% of surface is bare soil
1C	HEAVILY USED FOREST	>10% of surface is bare soil
2A	GOOD CONDITION GRASSLAND	<1% bare soil exposed
2B	FAIR CONDITION GRASSLAND	1-5% bare soil exposed
2C	POOR CONDITION GRASSLAND	>5 <20% bare soil exposed
2D	BAD CONDITION GRASSLAND	>20% bare soil exposed

29. **Cattle excluded from the stream.** Put a check mark in the box if this statement is true for the last 10 meters.

30. **% of land trampled.** This is an estimate of land where livestock trampling is evident within one meter either way of the transect. In other words, you are looking at a 2 meter wide strip that runs from the top of the right upper bank across the stream to the top of the left upper bank.

31. **# cow pies.** This is the number of cow pies in the 2 meters wide transect of column 30.

32. **# trails.** This is the number of livestock trails on both banks that reach the stream over the entire 10 meter transect. A single trail that crosses the stream and goes up the other side counts as two trails.

33. **Class of cow trails.** Each cow trail should be placed in one of the following classes and the class of each trail recorded in this column.

1. < .75m wide
2. > .75, < 1.5m wide
3. > 1.5, < 2.5m wide
4. > 2.5m wide

There should be as many numbers listed here as there were cow trails in column 32. Separate each number by a comma.

34. If a road is contributing excess sediment to the stream, or a pipe is discharging to the stream or there is a dump present or any other thing that you deem significant is present, record it in the comment block at the end of the page.

OWRB STREAM HABITAT ASSESSMENT FORM

1. STREAM: ______________________________ 2. INVESTIGATORS: __________________ 3. DIRECTION: UPSTREAM DOWNSTREAM ____________

4. DATE: ______________________________ 5. WBNUMBER: ______________________

6. FLOW: ______________________________ 7. START POINT: ____________________ 8. LEGAL: ______________________

9. LAT/LONG: ______________________________ 10. CHANNEL SINUOSITY: ____________

11. DIST	12. DEPTH			13. WIDTH		14. SUBSTRATE								15. HABITAT TYPE				16. INSTREAM COVER % AREA									17	18	19	202122
	L1/4	C	R1/4	WTR	BNK	Si & C	SND	GVL	CBL	BLD	BRK	POM	HPC	RIF	PL	RN	DRY	UCB	LWD	SWD	RTS	BRL	SAV	EAV	TV	CB&G	EMB	CAN	PtB	D+SBVC DV
10																														
20																														
30																														
40																														
50																														
60																														
70																														
80																														
90																														
100																														
110																														
120																														
130																														
140																														
150																														
160																														
170																														
180																														
190																														
200																														

STREAM HABITAT ASSESSMENT

1. STREAM: ______________________________

4. DATE: ________________________________

5. WB NUMBER:_________________________

	23. % ERODED BK		24. HT. ERODED BK		25. SLOPE BK		26. SUBSTRATE BK		27. RIP. WIDTH		28. RIP. COND.		CATTLE					
	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	29. EXCL	30. %TRAM	31. # CP	32. TRAILS	33. CLASS	COMMENTS
10																		
20																		
30																		
40																		
50																		
60																		
70																		
80																		
90																		
100																		
110																		
120																		
130																		
140																		
150																		
160																		
170																		
180																		
190																		
200																		

STREAM HABITAT ASSESSMENT

#		OPTIMAL	ADEQUATE	FAIR	POOR
1	Instream Cover	Greater than 50% mix of stable habitat. Includes rubble, gravel, boulder and cobble, submerged logs, undercut banks, submerged appliance and autos, etc., etc. 100% 50% 20 points 16 pts	30% to 50% mix of stable habitat. 49% 30% 15 points 11 pts	10% to 30% mix of stable habitat. 29% 10% 10 points 6 pts	Less than 10% stable habitat. 9% 0% 5 points 0 pts
2	Pool Bottom Substrate Score by % Si&C and presence of, but not percent of desirable substrate	Mixture of desirable substrates with gravel and firm sand prevalent; root mats, CPOM and submerged aquatic vegetation common, cobble, gravel, firm sand, submerged aquatic vegetation, root mat, and CPOM all present and ≥ 80% of pool bottom. Mud and loose sand and bedrock may make up to 19% of bottom. 0% silt, clay & bedrock 19% 20 pts 16 pts	Firm sand, gravel, CPOM root mat and aquatic vegetation present. Mud, bedrock and loose sand, make up 20% TO 50% of bottom 20% silt, clay & bedrock 49% 15 points 11 pts	Any three types of stable substrate present. Mud, loose, sand and bedrock make up 51% to 80% of pool bottom. 50% silt, clay & bedrock 79% 10 points 6 pts	1 or 0 types of stable habitat present. Mud, loose sand and bedrock make up 81 to 100% of pool bottom. 80% silt, clay & bedrock 100% 5 points 0 pts
3	Pool Variability deep= > .5 meter shallow= <.5 meter	Even mix of deep and shallow pool present. deep pools >40% and shallow pools >40% 20 points deep pools>30% and shallow pools > 30% 16 pts	Majority of pools large and deep very few shallow. deep pools > 71% 15 points deep pools = 100% 11 pts	Shallow pools much more prevalent than deep pools. deep pools > 29% 10 points deep pools > 10 % 6 pts	Majority of pools shallow or pools absent. deep pools < 10% 5 points deep pools = 0% 0 pts
4	Canopy Cover Shading	Mixture of conditions where some areas of water surface fully shaded, some fully exposed and others receiving various degrees of filtered light. Avg % canopy cover ... Avg % canopy cover 45 to 55 or 55-60 · 40-45 or 60-65 · 35-40 or 65-70 · 30-35 or 70-75 · 25-30	Covered by sparse canopy Avg canopy < 25% 15 points Avg canopy ≥ 10% 11 pts	Covered by dense canopy Average Canopy Cover > 75% = 100% 10 points 6 pts	Lack of canopy. Average Canopy Cover < 10% =0 % 5 points 0 pts

#		OPTIMAL	ADEQUATE	FAIR	POOR
		20 pts 19 pts 18 pts 17 pts 16 pts			
5	Presence of Rocky runs or riffles. Don't count gravel ≤ 2 cm screen. At least 50% of substrate in riffles and runs must be gravel, cobble, boulder or bedrock to count as a rock riffle or run.	Rocky riffles or runs dominant and make up at least 60% of stream > 80% >60% 20 points 16 pts	Rocky riffles and runs common. 59% 30% 15 points 11 pts	Rocky riffles and runs infrequent. 29% 6% 10 points 6 pts	Rocky riffles and runs rare or absent. 5% 0% 5 points 0 pts
6	Flow at representative low flow	> .6 cms > .15 cms (20 cfs) (5 cfs) 20 points 16 pts	≤ .15 cms > .05 cms (5 cf) (2 cfs) 15 points 11 pts	≤ .05 cms >.03 cms (2 cfs) (1 cfs) 10 points 6 pts	≤ .03 cms ≥ 0 cms (1 cfs) (0 cfs) 5 points 0 pts
7	Channel alteration	Little or no enlargement of islands or point bars. 5% pt bars or islands 20% pt bars or islands 15 points 12 pts	Some increase in new bar or island formation, 21% pt bars or islands 40% pt bars or islands 11 points 8 pts	Moderate deposition of new gravel and sand on old and new bars. Pools partially filled with silt. 41% pt bars or islands 60% pt bars or islands 7 points 4 pts	Heavy deposition of fine material most pools filled with silt 61% 100% 3 points 0 pts
8	Channel sinuosity	Instream channel length 3 to 4 times straight line distance 4 3 15 points 12 pts	Instream channel length 2 to 3 times straight line distance. < 3 2 11 points 8 pts	Instream channel length 1.2 to 2 times straight line distance. < 2 1.2 7 points 4 pts	Channel almost straight to straight < 1.2 = 1 3 points 0 pts
#		OPTIMAL	ADEQUATE	FAIR	POOR
9	Bank stability a	Bank erosion absent or infrequent 0% to 19% of bank eroded. Avg bank slope 5-20%, avg height of eroded	Erosion quite evident but not the dominant feature of the banks. 20% to 49% of bank	Moderate amount of bank erosion (50-100%) of stream with slope of 40-59% whose	Nearly all of stream has at least one eroded bank (100-200%) that is ≥ 60%

	(b)(c)(d) where a= avg. water width b= avg. bank slope % c= avg eroded bank ht. d= % of stream with eroded banks up to 200% for both left and right banks	banks 5-19% of water width. bank stabilization score 400 126 10 points 8 pts	eroded with average bank slope of 20 to 39%, and avg height of eroded banks 20 to 49% of water width. bank stabilization score 125 10 8 points 6 pts	avg height is 50% to 79% water width. bank stabilization score 10 2.1 5 points 3 pts	slope, whose avg height is 80% of avg water width. bank stabilization score 2 1 2 points 0 pts
10	Bank vegetation stability. Don't count bedrock or concrete - soil doesn't have to be covered as long as it's stable. % right bnk stable + % lft bnk unstable	0% unstable 10% unstable 10 points 9 pts	11% unstable 20% unstable 8 points 6 pts	21% unstable 40% unstable 5 points 3 pts	41% unst. >100% unst. 2 points 0 pts
11	Streamside cover count only vegetation within 10 ft of waters edge. shrub = woody stemmed plants ≤ 10 cm dbh	Dominant vegetation is shrub 100% shrub 34% shrub 10 points 9 pts	Dominant vegetation is tree. 100% 34% 8 points 6 pts	Dominant vegetation is grass and forbs. 100% 34% 5 points 3 pts	Dominant cover is rock, concrete, bridge material, etc. 34% 100% 2 points 0 pts

HABITAT ASSESSMENT PART 2

STREAM NAME: **DATE:** **STREAM ORDER:**
FACILITY/COUNTY:
SITE # : **LINK MAGNITUDE:**

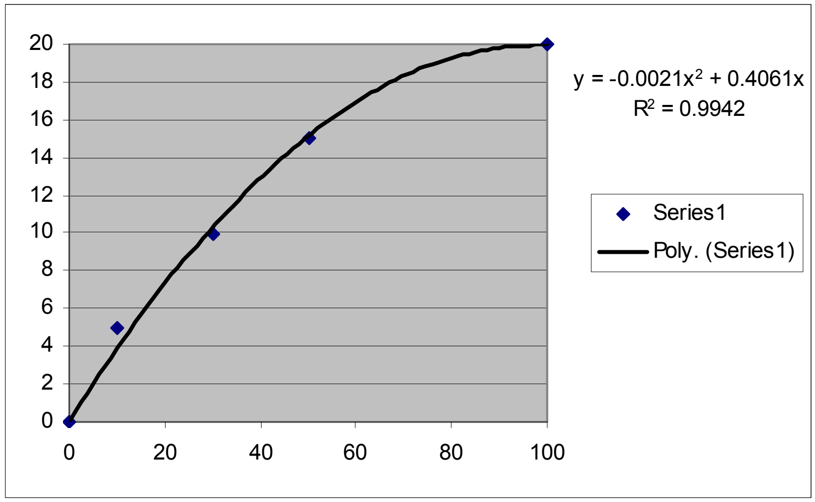
HABITAT PARAMETERS:	SCORE	DATA SUMMARY:				
1. Instream cover *(Part 1 No. 15)*		Instream Structures and Occurrence *% Areal Coverage*				
		undercut banks	lg. woody debris	sm. woody debris	roots	
		bedrock ledges	submer. aqua. ve	emer. aqua. veg.	ter. veg.	
2) Streambed/substrate Composition *(Part 1 No. 13)*		bedrock	boulder	cobble	gravel	
		sand	silt	clay	POM	
		Packed clay				
3. Pool Variability *(For Glide/Pool prevalence)*		AVG % Embeddedness:				
		Pool variability	% deep pools	% shallow pools		
4. Canopy cover (shading)		Overhead Canopy				
		open	partly open	shaded	average	
5. Riffle/ROCKY run prevalence		Channel Morphology and Structure				
			riffle	pool	run	dry
		% of sample site				
6. Flow at representative level		CFS				
7. Channel alteration		POINT BARS	ISLANDS			
8. Channel sinuousity		SINOUSITY				
9. Bank stability		*Bank Slope*				
		flat (<15)	mod(15-30)	steep(30-60)	vertical(>60)	
10. Bank vegetative stability		Bank Erosion				
		evident	potential	unlikely		
11. Streamside cover		Banks and Riparian Cover				
		devoid of cover	grasses and forbs	shrubs	trees	mixed
		value	value	value	value	value
TOTAL SCORE	0.0					

WATER QUALITY EVALUATION			
D.O. (mg/L)	Temp. (deg. C)	Alkalinity (mg/L)	Hardness (mg/L)
pH	Cond. (umhos)	Ammonia (mg/L)	FLOW

HABITAT ASSESSMENT METRIC SCORING GRAPHS

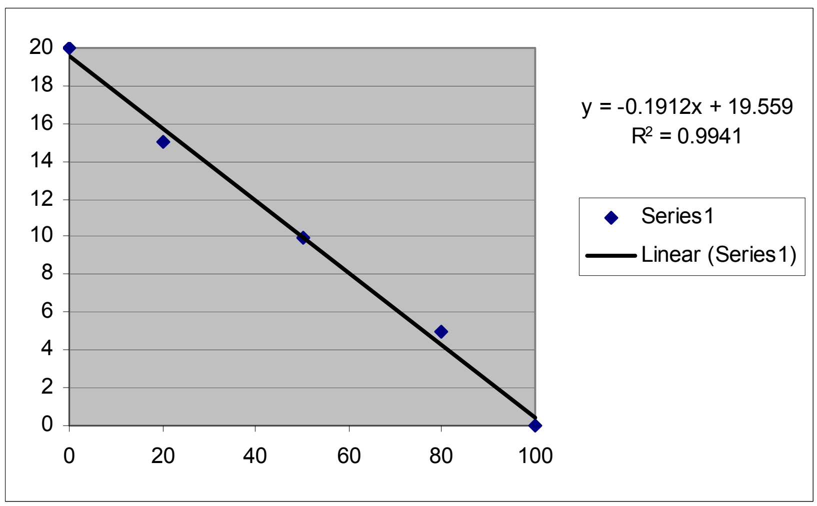
Metric 1
Instream Cover

Value	Score
100	20
50	15
30	10
10	5
0	0



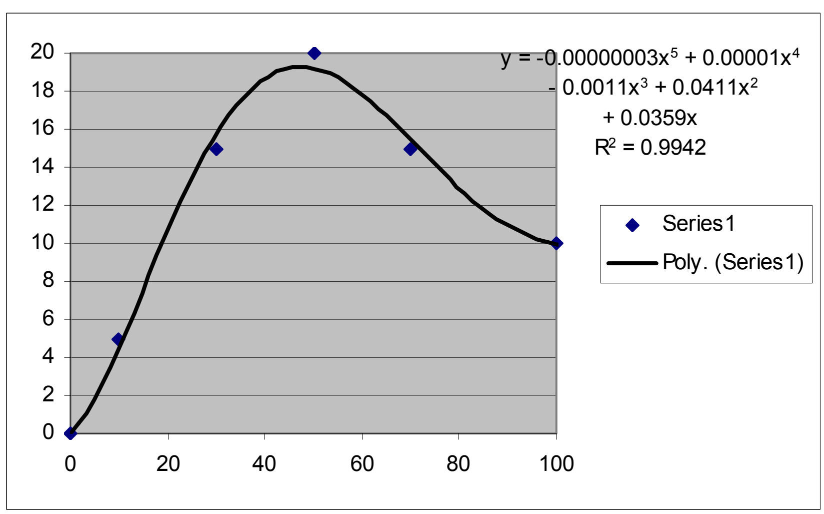
Metric 2
Pool Bottom
Substrate

Value	Score
0	20
20	15
50	10
80	5
100	0



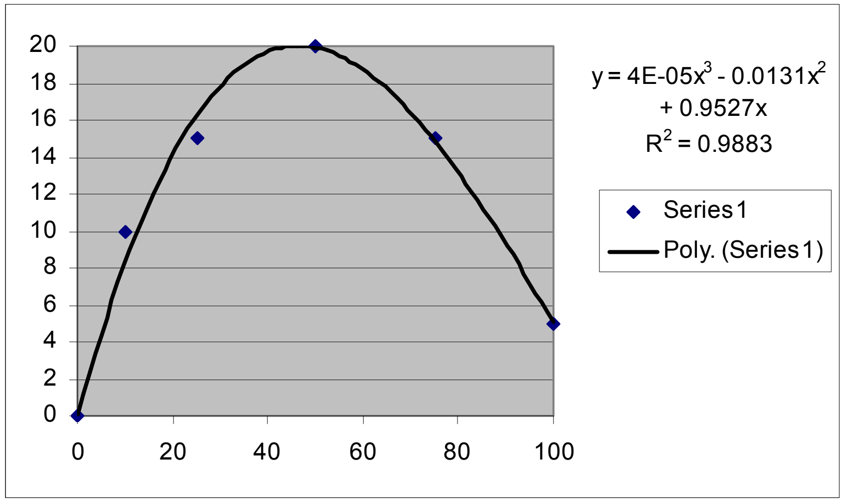
Metric 3
Pool
Variability

Value	Score
0	0
10	5
30	15
50	20
70	15
100	10



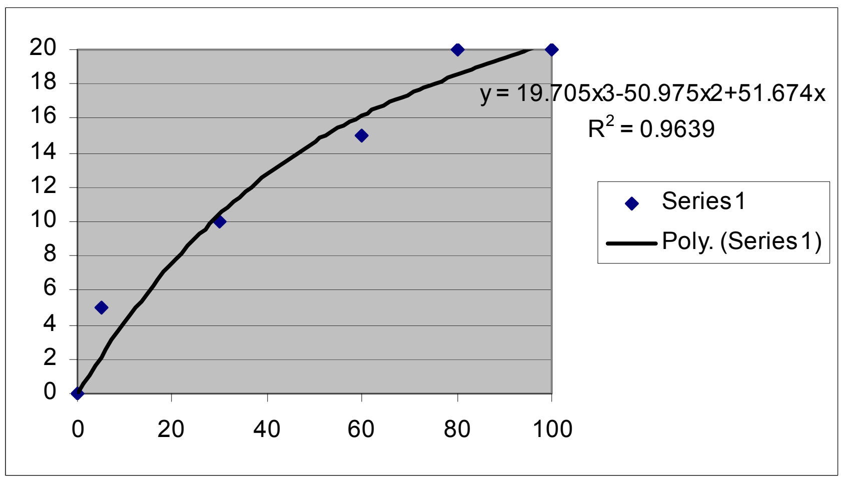
Metric 4 Canopy Cover / Shading

Value	Score
0	0
10	10
25	15
50	20
50	20
50	20
75	15
100	5



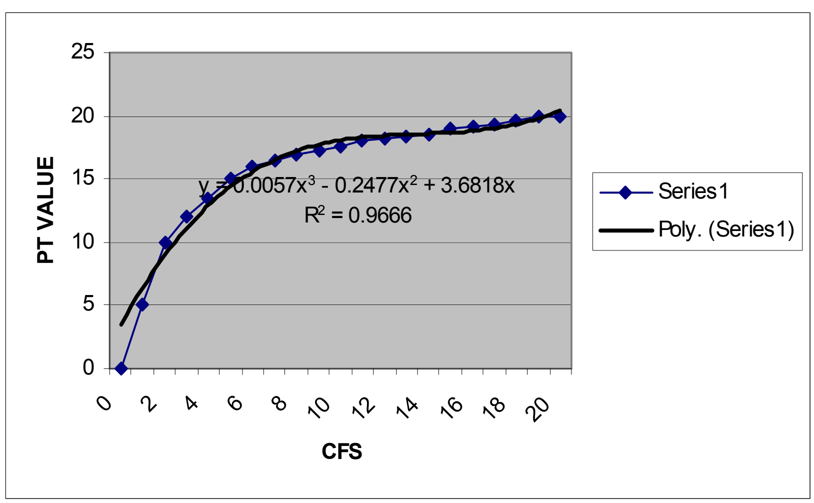
Metric 5 Rocky Runs /Riffles

Value	Score
0	0
5	5
30	10
60	15
80	20
100	20



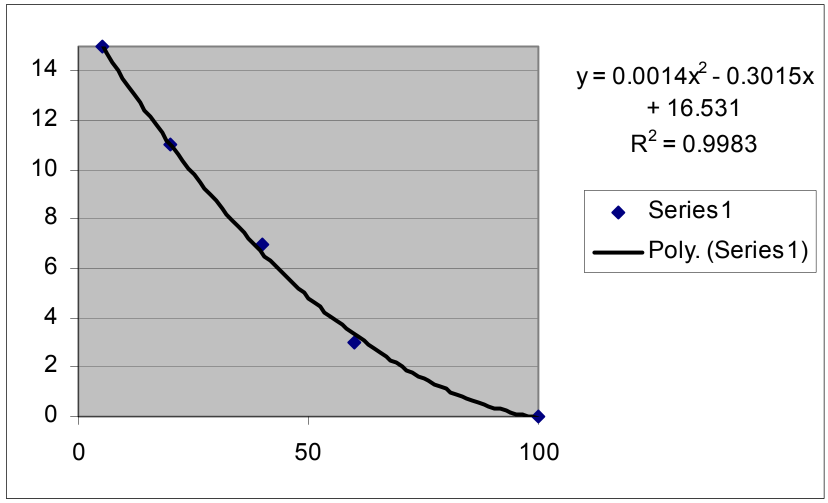
Metric 6 Flow

Value (CFS)	score
0	0
1	5
2	10
5	15
20	20



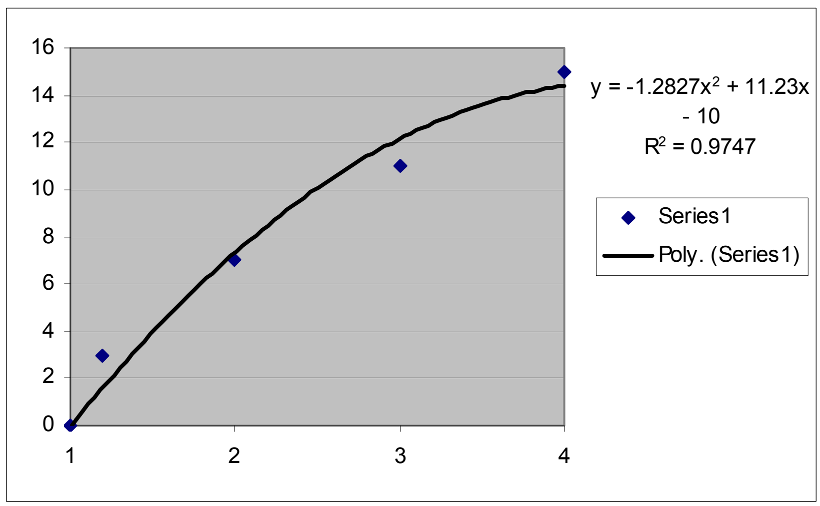
Metric 7 Channel Alteration

Value	Score
100	0
60	3
40	7
20	11
5	15



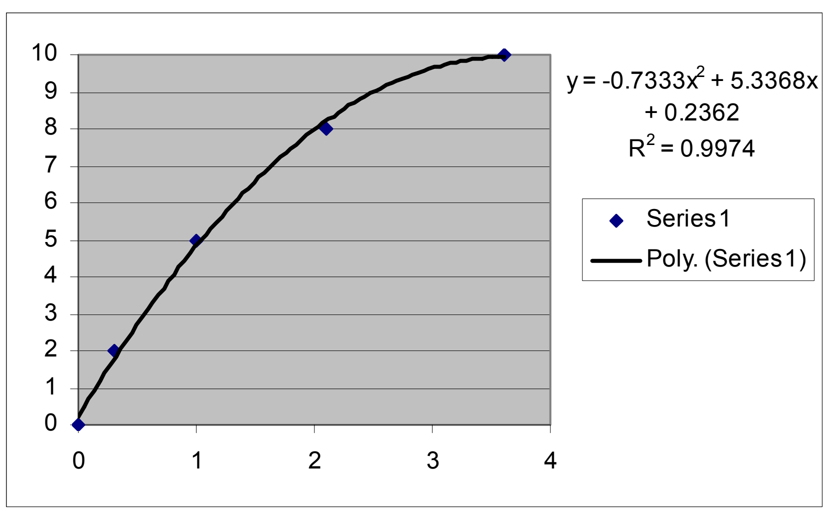
Metric 8 Sinuosity

Value	Score
1	0
1.2	3
2	7
3	11
4	15
> 4	15



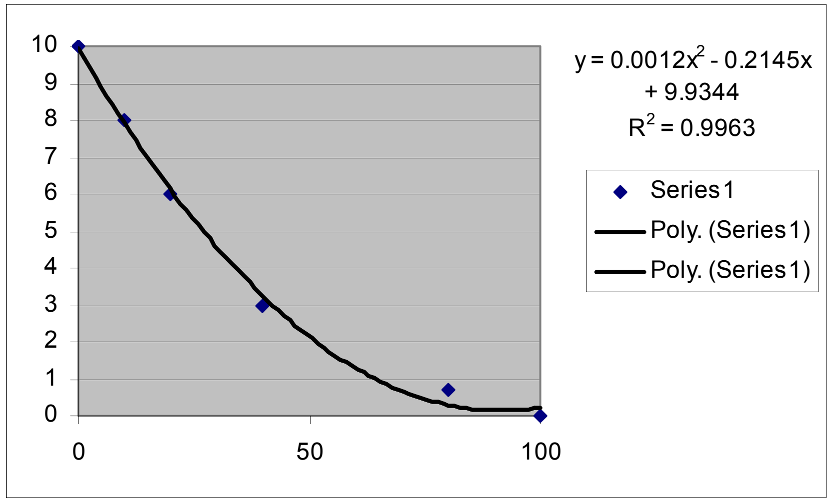
Metric 9 Bank Stability

Value	Score	Log of value
1	0	0
2	2	0.301
10	5	1
125	8	2.096
4000	10	3.602



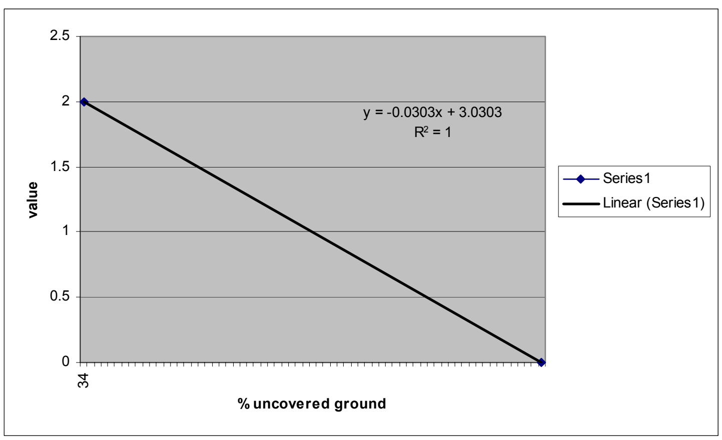
Metric 10 Bank Vegetation

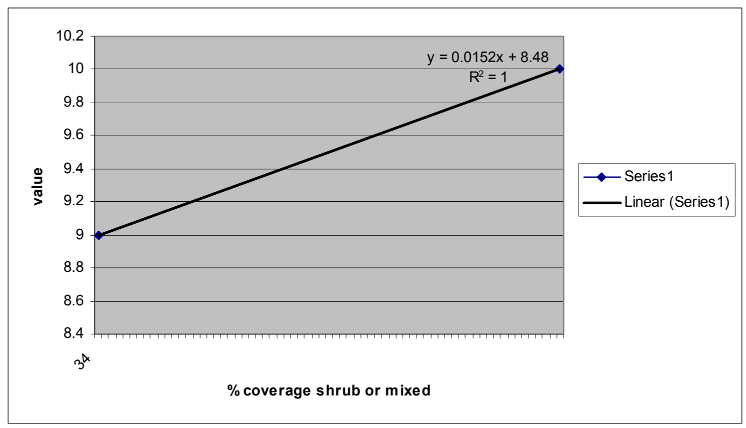
Value	Score
100	0
40	3
20	6
10	8
0	10

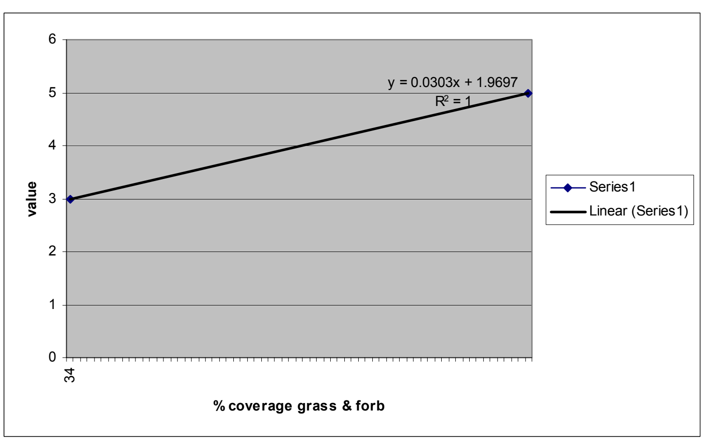


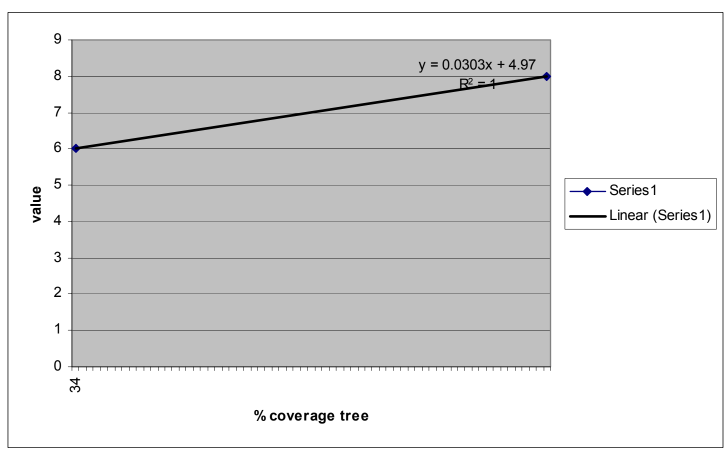
Metric 11 Linear Interpolation

Streamside Cover









STANDARD OPERATING PROCEDURE

MEASUREMENT OF STREAM FLOW WITH MARSH-MCBIRNEY MODEL 2000

I. General Information.

This SOP will provide a general discussion of flow measurement practices and detailed information concerning operation of the Model 2000 flowmeter. Before the meter is taken into the field, each operator should read the instrument manual as it contains much more information concerning such topics as error messages and those unusual situations that you might run into. Play special attention to the correction page in the beginning as it corrects some mistakes, especially in regard to instrument calibration. Another very good source of information is the USGS manual on "Discharge Measurements at Gaging Stations". This manual will help to better explain flow calculations if you find them confusing.

Flowmeters, such as the model 2000, measure velocity through changes in the magnetic field about the sensor as caused by water flow. Although the sensor does not have moving parts, it should be protected from bumps as it does contain electronic sensors. The sensor should be kept clean, especially of oils or grease. The probe should be cleaned with soap and water.

The meter operates on two D-cell batteries and will run for about 20 hours. The meter will indicate when the batteries are low. The meter will shut off automatically when it is out of the current for five minutes.

The obtainment of accurate flow measurements is more a matter of physical technique than it is of instrument operation. Each stream will present you with a unique physical situation; therefore, it is not possible to describe to you what to do under any situation. The following instructions are presented as guidelines but you will have to exercise considerable judgement in the field to obtain good results.

II. Operation.

a. Sensor Mounting

The sensor attaches to the wading rod by means of a thumb screw. The thumb screw must be placed over the recessed portion of the sensor mount. **THE SCREW THREADS CAN BE EASILY STRIPPED - DO NOT OVER-TIGHTEN**. (The sensor does not need to be tightly attached and, since the sensor should be removed during transport, it will be put on and taken off frequently.)

b. Wading Rod

The wading rod is a top adjusting model which makes it much easier to use. To move the rod up or down, press the metal tab at the top of the rod handle and slide the smaller of the two rods up or down.

The rod is divided into feet and tenths of feet (not inches). Velocity should be measured at different depths, dependent upon the depth of the water column. The velocity should be measured at 60% of the depth from the surface.

To calculate 60% of depth from the top:

> Determine depth of segment to be measured (ex. 1.4 feet)
> Slide smaller rod up until the "1" on the rod lines up with the four on the rod handle moving the sensor to 0.6 feet.

c. Stream site locations

The portion of the stream where flow is to be measured should be as uniform as possible. The ideal shape is a rectangle which can be found under some cement bridges. Avoid stagnant areas or those with irregular bottoms, turbulent flow, standing waves, or strongly sloping bottoms. For small streams, the narrowest portions are generally best as velocities will be higher and fewer measurements will be required.

The stream should be divided into a number of segments. The more segments, the more accurate the results. The ideal to shoot for is to divide the stream so that each segment accounts for 5% of the flow. Using this method, if one measure is inaccurate it will not significantly affect the results. In any case, an attempt should be made to measure flow at least every foot, when the width is $\leq$20 feet with a minimum of twenty measurements. If the stream is extremely narrow, the flow should not be measured at increments less than 0.5 feet.

In many streams, the first foot or so of stream is very shallow and stagnant. There are two approaches to dealing with this problem. The first is to ignore the shallow portion while the second involves averaging the depth and velocity between the bank and the first sample point. The best approach is to take the first measurement at the closest point where depth and flow are adequate. Any stream area closer to the shore than one-half the segment width from this point is ignored.

Stretch a measuring tape from bank to bank on the stream cross section to be sampled. Measure velocity at the first point where measurement is possible and then at some regular distance from the first measurement at the prescribed depth. Point the head of the sensor directly into the current and hold steady. Stand to the side and away from the wading rod.

III. Meter operation

a. Calibration

Before each sampling trip, the meter should be checked to see if it is reading “0.0" under zero discharge. To do this, first clean sensor with soap and water. Place sensor (attached to wading rod for stability) in a five-gallon bucket as near center as possible and at least three inches from any side or bottom. Wait ten minutes to insure that the water is absolutely still before starting measurement. Turn meter on by pressing ON/C button. Press the STO and RCL keys at the same time and a 3 will appear on the display. Reduce this figure to zero with the down arrow key (You must press the arrow key within five seconds of the time that the 3 is displayed or you will get an error message. If this occurs, press the OFF key and start over.) After you have reduced the value to zero, a 32 will be displayed which will automatically drop to zero, at which time the meter is zeroed.

b. Measurement
Turn meter on by pressing ON/C key.

In order to dampen the meter's reading tendency to fluctuate, the meter can be adjusted to either filter the reading (time constant filtering - rC) or average the reading (fixed point averaging - FPA). By filtering the reading, the meter only reads every so many seconds, as specified by the user. The other setting averages the signal over some period, as specified by the user. Either method can be used; however, for the greatest accuracy, the averaged reading method is best. The rC filter period can be set from 2-30 seconds while the averaging period (FPA) can be set from 2-120 seconds. The period can be changed using the up and down arrow keys. For the FPA setting an average of 15 seconds should be adequate.

The meter will store up to 19 data points. To store a reading, press the STO key. The meter will indicate which store reading that you are on. To recall a reading, press the RCL key and scroll through the readings with the up and down arrows. To clear the memory, press the ON/C and STO keys at the same time.

c. Instructions for completing field sheet

1. In the first row, mark EOS (Edge of Stream) in the width square.

2. Write down the corresponding depth and velocity in the rest of the line. These will often be 0, but if your stream has rock ledge banks or you're under a bridge abutment the edge of the stream will have a depth and possibly a velocity.

3. Proceed measuring flow as you have been until you have recorded your last measurement that falls on a whole distance interval.

4. The final measurement should be marked EOS in the left margin. This width may be less than all the other intervals and the depth and velocity may be 0 or >0. Record the depth and velocity of the edge of the stream no matter whether they are zero or not, and in the width column, record the distance to the edge of the stream from the last measurement point. Please use decimal increments of feet for this distance.

Field sheet is shown on the following page.

The following formula is to be used in determining flow (average discharge).

$$Q = \sum_{i=1}^{n} (w_{i+1} - w_i) \frac{d_i + d_{i+1}}{2} \frac{v_i + v_{i+}}{2}$$

where “w” is the distance from the previous point, “d” is the depth measurement and “v” is the velocity measurement.

Stream ______________________________ Legal

W.B. # ________ Lat/Long ____________________ Date
Time __________ G.H. _______________________ Name

FLOW MEASUREMENT

DISTANT FROM INITIAL POINT	WIDTH	TOTAL DEPTH	VELOCITY	DISCHARGE