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AGRICULTURAL WATER QUALITY INDEX

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EXECUTIVE SUMMARY

Water is a unique resource because it is essential for all life and it constantly cycles between the land and the atmosphere. The same water that is used for crop and animal production is also shared with the public and the aquatic and terrestrial ecosystems. The movement of water is organized in hydrologic drainage units called watersheds. Within a watershed, the strong relationship between land use water quality has been clearly demonstrated by contemporary scientific research. All watersheds respond differently to changes in land use because of complex associations between topography, soil types, climate, hydrologic cycles, and meteorological events. Embedded within these factors are variables related to land use that shape or re-shape the hydrologic cycle in a watershed and change the chemical and biological characteristics of the surface waters. These changes can be broadly summarized into two outcomes:

- Natural hydrologic cycles that maximize the infiltration of precipitation into both shallow and deep groundwater aquifers. Natural buffers are also present that limit overland flow, filter nutrients, and stabilize the stream bank. This type of cycle maximizes nutrient utilization by trapping nitrogen and phosphorous compounds, effectively incorporates nutrients into biomass, and provides a stable, well-filtered water supply to lakes and streams.

- Altered hydrologic cycles that limit the natural processes listed above. Altered hydrologic cycles typically result in an increase in overland flow that exports nutrients and sediment to surface water, decreases the rate of groundwater recharge, and increases the magnitude of a river's response to individual rain events. In this scenario, the resulting increases in soil erosion rates will be detrimental to both the agricultural industry and the quality of the surface water.

Agricultural producers recognize the significance of climate, soil types, and topography and employ specific practices on a regional basis to maximize yields and lower operating costs. These strategies are called Best Management Practices (BMPs) and form the foundation for sustainable agriculture. BMPs are designed to ensure the successful future of agriculture by minimizing soil, nutrient, and chemical losses that are expensive to the individual producer and detrimental to the environment.

Sustainable agriculture must rely on assessment methodologies that are capable of measuring the effect of agricultural practices on water quality. Most existing assessment protocols only provide an indication of the water quality at the sampling location. Since the water quality a given location is a function of the local and the upstream conditions in the watershed, a poor assessment ranking may not be related to an adjacent agricultural operation. In addition, most water quality assessment protocols provide minimal information that can be used to improve problem areas. The Agricultural Water Quality Index (AWQI) is an assessment protocol that is specifically designed to evaluate the relationship between agricultural operations and water quality in agroecosystems. It can be implemented by moderately trained agricultural technicians and does not require complex chemical and biological analyses of water quality. The AWQI is based on a series of assessments that evaluate important land use and environmental variables that are related to water quality and the integrity of the terrestrial and aquatic ecosystems. Assessments are performed in the following areas:

- **Soils and Land Use.** Does the relationship between soils, topography, and land use promote infiltration or encourage erosion?
- **Riparian Zone Condition.** Is the riparian zone sufficient to buffer surface runoff and enhance the function of the stream bank?
- **Stream Channel.** Can the stream channel support a balance of aquatic life or is it impacted by sedimentation from upstream and/or local sources?

In addition, the AWQI assessment scores are presented in the form of general management recommendations that can be implemented to improve problem areas. The AWQI will also provide individual producers with the option to visually display the potential outcome of a recommended management strategy. In summary, the AWQI can provide an assessment of the degree of impact a facility has on the aquatic environment and evaluate changes in farm management that are recommended to achieve the goals of sustainable agriculture.

A major focus of modern sustainable agriculture is natural resource protection. Soil loss from wind and water erosion, nutrient export without the benefit of crop utilization, and damage to farmland from frequent flood events are all general factors that limit agricultural production and reduce water quality. The AWQI can assist individual farm operations by providing meaningful information that decreases nutrient and soil losses that threaten both the agricultural industry as well as the environment. As the world's population continues to increase, the future will depend on our ability to sustain valuable land and water resources. Agriculture will have to produce more food with less land and operate in a manner that does not adversely effect the environment. The same water that sustains agricultural production becomes part of the surface water and groundwater resources that sustains mankind and the environment. The AWQI will help agriculture address these challenges by providing meaningful information that is readily accessible and aimed at soil and water quality enhancement.

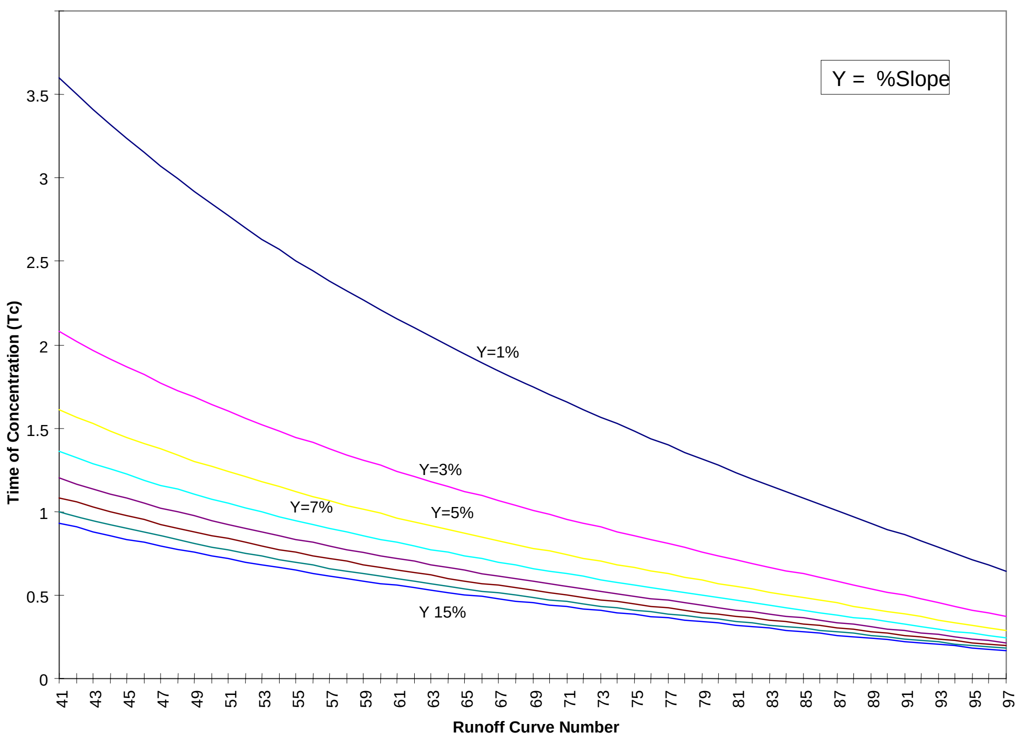
INTRODUCTION

Agroecosystems dominate the landscape in many areas of the nation, particularly in the highly productive Midwest region (Oberle and Burkart 1994). They are complex environmental systems involving interactions between the components and processes of natural ecosystems and activities associated with agricultural production. Historic productivity gains in agriculture have sometimes been associated with practices that rely heavily on external inputs of energy and chemicals. The intensity to which the environment has been modified to increase productive capacity has resulted in the degradation of the soil and water resources that sustain these ecosystems (Clark et al. 1985, U.S. EPA 1987, and Macharis 1985). Agriculture has recently shifted its focus to practices that emphasize resource sustainability instead of short-term economic gain (Carnegie Commission 1992). The principles of sustainable agriculture recognize the importance of maintaining the integrity of the land and water resources necessary for future production. Therefore, assessment tools that are designed specifically for agroecosystems are necessary to accurately evaluate the relationship between land use, farm management, and water resources.

The assessment of agroecosystems requires an understanding of ecological functions and the potential impacts from farm management practices. A wealth of scientific literature exists to describe changes in hydrologic cycles, sediment transport, and alterations to aquatic habitats that have resulted from various forms of agriculture (Waters 1995). The development of abatement strategies for these adverse impacts is based on a series of Best Management Practices (BMPs) related to runoff control, farm management, and ecosystem enhancement (U.S. EPA 1992 and Wolf 1995). However, effective BMP implementation requires consideration of the complex relationships between land use, soils, topography, hydrology, and ecology on a watershed basis (Montgomery et al. 1995).

While scientists and regulators possess volumes of technical information related to ecosystem dynamics, agricultural impacts, and abatement strategies, much of this information is not designed for direct use by producers or the public. For this to occur, technical data must be condensed into concise, scientifically credible information that is readily understood and used by decision-makers at all levels of society.

An indicator is defined as a measured or observed property that provides managerially useful information about trends in the state of the environment and in human activities that affect the environment (U.S. EPA 1996). Indices represent aggregates of indicators that summarize large amounts of data and prioritize future actions. There are a number of stream assessment indices that incorporate specific land and water evaluations that determine the health or quality of a system (Plafkin et al. 1990, MDNR 1991, Pfankutch 1975, and U.S. EPA 1996). Each of these methods requires the assessor to assign a numeric score to some aspect of the stream or riparian zone that has an influence on water quality. Many such indices place a heavy emphasis on stream biota and do not include general watershed conditions that influence the final assessment. As a result, these indices rely on an elevated level of expertise by the individual(s) performing the assessment and offer little constructive information that can be used to improve the ecosystem and enhance the interaction between land use and water quality.


Y = %Slope
Y=1%
Y=3%
Y=7%
Y=5%
Y 15%
Time of Concentration (Tc)
Runoff Curve Number

PURPOSE OF THE AGRICULTURAL WATER QUALITY ASSESSMENT INDEX

The primary purpose of the Agricultural Water Quality Index (AWQI) is to provide the agricultural community with a practical technical method for conducting cost-effective water quality assessments of rivers and streams in agroecosystems. The protocols presented have been derived from extensive literature review and the results of field research in agroecosystems performed during the summer of 1997 by the authors of this index. This assessment tool is not intended to replace those already in use by state agencies or to be used without regional modifications.

The AWQI is classified as a habitat survey since it evaluates the terrestrial and aquatic environments in addition to the interaction of adjacent land use on both systems. This index incorporates portions of rapid bioassessment protocols that have been developed by Barbour et al. (1997) and state agencies to evaluate water quality. These survey methods have been used to:

- characterize the existence and severity of water resource impairment,
- identify sources and causes of impairment,
- evaluate the effectiveness of control actions and restoration activities, and
- support use attainability studies and cumulative impact assessments.

The addition of soils, topography, and land use sections to the AWQI links water quality with nature and degree of land use modification. The individuals performing the habitat survey can evaluate the effect of implementing mitigation strategies by re-scoring the evaluation with desired changes to the habitat or land use components. Some of the advantages of using habitat and biological surveys for this type of monitoring are as follows.

- Habitats and biological communities integrate to reflect the effects of different stressors and thus provide a broad measure of their accumulative impact.
- Communities integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions.
- Routine monitoring of biological communities can be relatively inexpensive particularly when compared to the cost of assessing toxic pollutants, either chemically or with biological toxicity tests.
- The status of biological communities is of direct interest to the public as a measure of environmental quality, whereas reductions in chemical pollutant loadings are not as readily understood by the layperson as positive environmental results.
- Where criteria for specific ambient impacts do not exist (e.g., nonpoint source impacts that degrade habitat), biological communities may be the only practical means of evaluation.

HISTORY OF THE RAPID BIOASSESSMENT PROTOCOLS

The need for cost-effective habitat and biological survey techniques for monitoring and assessment was realized in the mid-1980s due to limited economic resources available to states with miles of unassessed streams. It was also recognized that it was crucial to collect, compile, analyze, and interpret environmental data rapidly to facilitate management decisions and resultant actions for control and/or mitigation of impairment. Therefore, the conceptual principles of Rapid Bioassessment Protocols (RBPs) were:

- cost-effective, yet scientifically valid procedures,
- provisions for multiple site investigations in a field season,
- quick turn-around of results for management decisions,
- easily translated to management and the public, and
- environmentally benign procedures (Barbour et al. 1997).

The Riparian, Channel, and Environmental (RCE) Inventory for Small Streams (Petersen 1992) is one form of a RBP that places an emphasis on the land use type along the stream corridor, the width of riparian buffer zone, and the types of vegetation included within this buffer. It also evaluates parameters within the channel itself such as undercut banks, substrate materials, retention devices, and macroinvertebrate diversity. In this manner, the RCE was one of the first protocols to add the evaluation of terrestrial habitat to a bioassessment survey.

Petersen (1992) found that the visual inspection information selected for the RCE Inventory produced results that were correlated with more detailed environmental assessments. However, while Petersen recognized that landscape and land use were critical components of overall stream quality, the RCE considered land use and soil associations outside of the riparian zone a minor component of the total assessment. In addition, the output was limited to a numerical score that provided no information to assist in developing strategies aimed at improving water quality.

Recent research describing the importance of a watershed based approach to stream management has highlighted the significant role that landscape, geomorphology, and land use play in determining the characteristics of individual riverine systems (Poff 1997, Wiley et al. 1997) as well as the anthropogenic effects that influence water quality (Roth et al. 1996, Richards et al. 1997). While many assessment methods currently exist that focus on the riparian zone and channel area, few describe land use, slope, and soils much less attempt to link their impact to water quality.

Descriptive metrics that evaluate sources of stream impacts in agricultural watersheds and suggest areas where efforts to improve aquatic habitat could be focused are clearly needed. Once an index for agricultural watersheds is constructed and verified, it can be used to prioritize existing problem areas, determine the effectiveness of abatement strategies, and predict the effect of future land use changes. This type of planning will be a key component in sustaining our vital agricultural economy while abating nonpoint source (NPS) pollution.

The Agricultural Water Quality Index is designed to measure land use impacts on water quality. This index is also designed to help identify and prioritize management strategies to protect water quality in watersheds that contain agroecosystems.

Water quality is directly linked to habitat characteristics, topography, and land use patterns within the terrestrial environment of a watershed. It becomes necessary, therefore, to understand the nature of soil interaction, topography, and terrestrial habitat on aquatic environments and how agricultural land use patterns influence local and regional water quality.

An evaluation of habitat structure is critical to any assessment of ecological integrity and should be performed as an important part of the AWQI. In the truest sense, "habitat" incorporates all physical, biological, and chemical aspects of the environment. The definition of *habitat* in the AWQI is narrowed to the quality of in-stream and riparian zone features that influence the structure and function of the aquatic community in a stream. The assessment performed by this and many other water resource agencies includes:

- a general description of the site,
- a visual assessment of in-stream and riparian habitat quality,
- a physical characterization of the fauna and flora present, and
- a water quality assessment.

Together these data provide a comprehensive and integrated picture of the biological condition of a stream system.

Once the relationship between habitat and biological potential is understood, water quality impacts can be objectively discriminated from habitat effects so that control and rehabilitation efforts can focus on the most important source(s) of impairment.

THE FUNCTION OF WATERSHEDS IN DETERMINING WATER QUALITY

Watersheds (also called *hydrologic units*, *catchments*, or *catchment basins*) are individual geographical drainage units. They are natural components of the landscape and function to drain water toward a central collection point, usually a lake or the confluence with a larger river or stream. Water deposited on the land as precipitation, if it is not lost to processes such as evaporation, will infiltrate the soils and recharge groundwater systems or move downhill as collected surface flows called rivers, streams, or creeks. Even before the visible origin of these flows (called headwaters) begin to form, complex physical and biological processes begin to determine the physical and chemical characteristics that a body of water will assume. Nutrients and various forms of organic carbon (mostly from terrestrial vegetation) are collected and efficiently utilized by plants and algae, macroinvertebrates (aquatic insects and other assorted small invertebrates) and a diverse microbial community. Through different utilization processes, this biotic community efficiently removes the vast bulk of these nutrients and organic compounds. Stream ecologists use the term *processing* to collectively describe the complex interactions that reduce and remove organic material and recycle nutrients from our rivers and streams.

Because each watershed is unique, the quality and quantity of carbon and other nutrient materials collected and the nature and rate of in-stream processing will be different. High gradient mountain streams with little riparian vegetation to act as shade will have larger amounts of algae that serve as a source of energy (food) and nutrients (Winterbourn et al. 1981). Subsequently, a biota that can best utilize this resource will dominate and facilitate carbon and other nutrient processing. Midwestern watersheds typically occur in deciduous forested areas that contribute large amounts of organic carbon and nutrients (from vegetation) to rivers and streams. Again, a biotic community will develop that is capable of efficiently processing this material, removing it from the water. Even in natural prairie areas, floodplain forests develop along streams, shading and protecting their banks, acting as sediment traps and nutrient filters, and adding carbon in the form of leaf litter.

Midwestern watersheds existing in agroecosystems have undergone extensive changes with many streams partially or, in some cases, totally removed from the forested borders that once provided both the physical and biological interaction that maintained water quality. The sum total of these changes have altered and reduced natural processing cycles and water quality.

While each watershed and its accompanying stream is unique in its appearance, each river "system" is similar in its overall function which includes a strong dependency on the landscape that:

- determines flow volume, velocity, and temperature and, therefore, greatly influences the biotic nature of the stream (characteristics such as a coldwater trout stream vs. a warm water bass or bluegill stream);
- provides a direct or indirect supply of organic carbon and nutrients;
- determines the quantity and quality of these organic substances;
- provides the substrate characteristics (e.g. rock, cobble, or sand) of each stream; and

- determines the quality of the biotic community that utilizes individual stream characteristics to ultimately produce efficient biological systems that purify water by processing nutrient and organic inputs.

In summary, the surrounding landscape heavily influences stream characteristics, which subsequently determine the in-stream processing rates necessary for maintaining good water quality.

Research in stream ecology has identified a strong correlation between land use and subsequent changes in stream function (Roth et al. 1994, Richards et al. 1993, Richards and Minshall 1992). Radical changes in vegetation have also been shown to alter the amount of water in a stream, the timing and magnitude of response to rain events, temperature characteristics, and substrate materials (Dunne and Leopold 1978, Likens 1984, Schlosser 1991). These modifications produce massive changes in the biotic community that immediately alter the stream's ability to process organic and nutrient inputs. As a result, nutrient concentrations begin to increase as processing rates become less efficient in removing organic carbon and other nutrient compounds from the water.

Water quality characteristics begin to change as concentrations of carbon and other nutrient compounds exceed the stream's processing ability. High nutrient concentrations facilitate excessive plant and bacterial growth. This growth contributes to an increase in organic material that frequently results in diminished oxygen supplies, limiting the biotic community. In addition, sand and sediment inputs to the stream cover, and/or possibly bury, hard substrate materials that are critical to sustain the biological fauna and flora necessary for efficient processing rates. The end result is a stream where inputs exceed processing rates and diminished water quality results.

THE AGRICULTURAL WATER QUALITY INDEX

The AWQI is based on a series of watershed characteristics that serve as indicators to broadly reflect the health of the stream environment. While a detailed series of chemical and biological parameters can be used to accurately characterize the health of an aquatic environment, a comprehensive investigation is only feasible when a substantial amount of funds and highly trained technicians are committed to a project. This type of detailed approach cannot be implemented routinely on a farm by farm basis.

Water quality and ecosystem health is reflected by certain watershed characteristics that can be used as indicators and measured by visual inspection. The careful selection of these indicator parameters is therefore critical in developing an assessment index that accurately describes the relationship between land use, soil types, riparian characteristics, and water quality. The AWQI was developed using these types of data collected from more than 75 locations in over 20 agricultural watershed and sub-watershed basins in western Michigan. These locations provided a cross section of soil, stream, and agricultural conditions that were used to develop this index. In addition to these data, current literature was reviewed and incorporated to supplement our observations and fill any gaps.

The AWQI is divided into a *Physical Inventory* and a *Watershed Assessment*. The Physical Inventory is a questionnaire used to record important information related to the conditions present at the sampling location and surrounding watershed area. This information serves as the basis for the actual assessment.

The Watershed Assessment incorporates a series of measurements (metrics) that describe the function and health of the agroecosystem and watershed. The output of each metric is summarized by a numeric score that describes the potential for environmental impact. This section is divided into three components that describe various soil and land use conditions, riparian zone characteristics, and the stream channel. An optional fourth section utilizes aquatic macroinvertebrate information to reinforce the AWQI assessment results and provide additional information relating to water quality. The scores for each section are weighted to reflect the potential influence to the stream environment. The individual weights are based on data analysis from this study and research results described in current scientific literature.

Scores derived from the AWQI have been designed to describe the potential impact from conditions observed adjacent to the stream channel as well as distinguish between local and upstream influences to existing water quality. In addition, and perhaps most importantly, the AWQI provides recommendations to improve or enhance existing conditions and the ability to re-score assessment results that will reflect future outcomes from changes in farm management strategies.

The degree in which agricultural operations influence water quality depends on the quantity of soil and nutrients that are contained in the overland runoff and the nutrient composition of local groundwater supplies. As discussed previously, the AWQI is designed to function as a rapid assessment tool based on visual environmental quality indicators. Visual indicators of soil condition and slope are used in the index to describe the potential for the current operations to influence water quality.

The potential for nutrient loss from agricultural land also depends on the rate in which fertilizer and manure are applied to the soil. Appropriate applications are typically referred to as "agronomic rates". These calculated rates are based on the nutrient content of a fertilizer or manure, the desired crop yield, nutrient assimilation capabilities, and existing soil conditions. These parameters and not readily described by visual indicators and require a level of detail that is beyond the scope of the AWQI. A greater potential for nutrient export to the stream by overland runoff and groundwater infiltration exists if fertilizer and/or manure are applied in excess of agronomic rates. Additional information relating to the proper and safe use of fertilizer and manure products is discussed later in this report. However, for the intended purpose of the AWQI, we assume that the farm in question is operating under agronomic rates for fertilizer and manure application and following a farm management plan. If these conditions are not present, the AWQI may underestimate the impact of the facility on the stream environment.

Physical Inventory/Water Quality Field Data Sheets

The AWQI is intended for use during the active growing season, approximately mid-May through September in the Midwest, and begins with a separate physical inventory of the site to be assessed. The information in this section is standard to many aquatic studies and allows for some comparison among sites. Additionally, conditions that may significantly affect aquatic biota are documented. Seasonal variations (current temperature and recent weather events) as well as observations that relate to local conditions are helpful to fully understand the relationship between land use and water quality. An example of the data sheet used to describe the physical characteristics and water quality of a site is shown in <u>Appendix A</u>.

This physical inventory described below includes documentation of general land use, description of the stream origin and type, summary of the riparian vegetation features, and measurement of in-stream parameters such as width, depth, flow, and substrate. Additional measurements of certain parameters, such as temperature, dissolved oxygen, and turbidity, can be taken over a day-long cycle and will require instrumentation that can be left in place for extended periods or collects water samples at periodic intervals for measurement. Under certain conditions it may be advantageous to analyze water samples for selected chemicals as part of a chemical-monitoring program. The combination of this information, physical characterization and water quality, will provide insight as to the ability of the stream to support a healthy aquatic community, which will maximize nutrient and organic processing (from Barbour et al. 1997).

<u>Station Identifier</u>

The header information is identical on all data sheets and requires sufficient information to identify the station and location where the assessment was conducted, date and time of assessment, and the investigators responsible for the quality and integrity of the data. The stream name and river basin identify the watershed and tributary while the location of the station is described in the narrative. In addition, the use of a local map indicating the location of the survey may be important for future consideration. The intent of good location information is to help identify access to the station for repeat visits. A station number may be assigned by the agency that will associate the sample and survey data with the station. The explanation provided under *Reason For Survey* is sometimes useful to an agency that conducts surveys for various programs and purposes.

Weather Conditions

Note the present weather conditions on the day of the assessment and those immediately preceding the day of the assessment. This information is important to interpret the effects of storm events on the sampling effort. In general, streams should not be assessed immediately following a significant rain event. Aquatic macroinvertebrates should not be sampled for several days following a high water event to allow for displaced populations to re-stabilize.

Site Location/Map

To complete this phase of the bioassessment, a photograph may be helpful in identifying station location and documenting habitat conditions. Any observations or data not requested yet deemed important by the field observer should be recorded. A hand-drawn map is useful to illustrate major landmarks or features of the channel morphology or orientation (e.g., vegetative zones and buildings) that might be used to aid in data interpretation.

Stream Characterization

Stream Subsystem: Note if the stream is perennial or intermittent, or where tidal influences on the stream will alter the structure and function of stream communities.

Stream Type: Biological communities inhabiting coldwater streams are markedly different from those in warmwater streams. Many states have established water quality standards that differentiate these two stream types.

Stream Origin: Note the origin of the stream under study, if it is known. As the size of the stream or river increases, include the origin of additional tributaries as they occur.

Watershed Features

Collecting this information may require considerable effort for each station. Subsequent assessments within the same watershed will require verification of possible changes in land use; however, features such as soil types and slope will remain constant and need not be re-described.

Predominant Surrounding Land Use Type**:** Document the prevalent land-use type in the catchment of the station, noting any other land uses in the area which, although not predominant, may potentially affect water quality. This documentation may be accomplished by a careful visual inspection of the area or by using current land use information that has been compiled by local agriculture and/or natural resource agencies.

Local Watershed Nonpoint-Source Pollution**:** Describe potential problems in the watershed. Nonpoint-source pollution is defined as diffuse agricultural and urban runoff. Other compromising factors in a watershed that may affect water quality include feedlots, constructed wetlands, septic systems, dams and impoundments, mine seepage, and a variety of others.

Local Watershed Erosion**:** The existing or potential detachment of soil within the local watershed, the portion of the watershed or catchment that directly affects the stream reach or station under study, and its movement into the stream is noted. Erosion can be rated through visual observation of watershed and stream characteristics. Note any point sources of pollution that are present in the area and any turbidity observed during water quality assessment that follows.

Riparian Vegetation

The riparian zone is an interactive area between the stream and current land use that serves to protect the stream from excessive runoff that adds sediment and nutrients to the active channel. Accepted buffer widths are variable and based on land use, soil types, and slope. The vegetation within the riparian zone is documented here as the dominant type and species, if known.

In-stream Features

Estimated Stream Width (feet)**:** Estimate the distance from bank to bank at a transect representative of the stream width in the reach.

Measure Stream Depth (feet)**:** Measure the vertical distance from water surface to stream bottom at a representative depth to obtain average depth.

Proportion Of Reach Represented By Stream Form Types**:** The proportion represented by riffles, runs, and pools should be noted to describe the channel and flow diversity of the reach.

Estimated Length Of Stream Surveyed**:** This information is important if variable length reaches are surveyed and assessed.

Velocity**:** Measure the surface velocity in an area of the channel that contains the main body of flow (thalweg) within a representative run area. If measurement is not performed, estimate the velocity as slow (less than one foot/second) or fast (greater than one foot/second).

Stream Channel**:** Indicate whether or not the stream channel is undisturbed or has been channelized to accommodate agricultural drainage needs. Channelization refers to any alteration of channel shape to promote drainage such as straightening or dredging.

Dam Present**:** Indicate the presence or absence of a dam upstream or downstream of the sampling reach or station. If a dam is present, include specific information relating to alteration of flow.

Lakes And Ponds**:** Indicate the presence of ponds or lakes that are directly connected to the stream channel.

Canopy Cover**:** Note the general proportion of open to shaded area, which best describes the amount of cover at the sampling reach or station.

High Water Mark (feet)**:** Estimate the vertical distance from the stream bank to the peak overflow level, as indicated by debris hanging in riparian or floodplain vegetation and deposition of silt or soil. In instances where bank overflow is rare, a high water mark may not be evident.

Aquatic Vegetation

The general type and relative dominance of aquatic plants are documented in this section. Only an estimation of the extent of aquatic vegetation is made. Besides being an ecological assemblage that responds to perturbation, aquatic vegetation provides substrate, refugia, and food for aquatic fauna. List the species of aquatic vegetation, if known.

Water Quality

Temperature**:** Measure and record values. Note the type of instrument and unit used.

Water Odors**:** Note those odors described, or include any other odors not listed, that are associated with the water in the sampling area.

Water Surface Oils**:** Indicate the term that best describes the relative amount of any oils present on the water surface. You should note that iron sulfides may cause an "oil-like film" on the surface of the water; however, this film will fracture when touched while an oil film will remain intact.

Turbidity**:** If turbidity (water clarity) is not measured directly, note the term which best describes the amount of material suspended in the water column based upon visual observation.

Sediment/Substrate

Sediment Odors**:** Disturb sediment in pool or other depositional areas and note any odors described, or include any other odors not listed, which are associated with sediment in the sampling reach.

Sediment Oils**:** Note the term which best describes the relative amount of any sediment oils observed in the sampling area.

Sediment Deposits**:** Note those deposits described, or include any other deposits not listed, that are present in the sampling reach. Also indicate whether the undersides of rocks not deeply embedded are black, which generally indicates low dissolved oxygen or anaerobic conditions.

Inorganic Substrate Components**:** Visually estimate the relative proportion of each of the seven-substrate/particle types listed that are present over the sampling reach.

Organic Substrate Components**:** Indicate relative abundance of each of the three-substrate types listed.

Watershed Assessment

The second portion of the AWQI is composed of three general categories plus an optional fourth category. Each category is divided into three to five *metrics* or statements that describe an existing habitat condition. The first category, *Land Use And Soil Characteristics,* involves features outside of the immediate riparian zone that impact water movement through the watershed. These features include soils and landforms, current land use, and the soil and surface condition. These parameters will collectively influence the pathway water follows as it migrates toward the stream.

The second category, *The Riparian Zone*, is intended to evaluate the ability of the riparian area (the uncultivated area between the stream channel and current land use) to filter sediment, nutrients, and stormwater as well as provide sufficient shade, woody debris, and organic carbon to the stream channel. These metrics include riparian zone width which is an estimate of the distance between the stream bank and current land use. The completeness of the riparian zone describes weak areas in the riparian vegetation that result from roads, cattle paths, game trails, or erosion sites. These weak points along the buffer's continuum can bypass the protective characteristics of the riparian zone. Riparian vegetation type is an additional metric intended to measure the buffer strip's effectiveness by describing the plant diversity found within.

The third category involves the *Stream Channel*. These metrics describe the flow status which addresses the amount of water in the channel during base flow conditions and flow stability, which evaluates the streams response to rain and runoff events. Channel sinuosity and structure are metrics that describe both the type of streambed materials available, such as rock, cobble, sand, or woody debris, as well as the streams ability to capture and retain materials for processing by stream biota.

An additional and optional category with only one metric is a qualitative measure of existing *Aquatic Macroinvertebrates*. The goal of this final metric is to identify the presence or absence of tolerant versus intolerant species along with a relative measure of species diversity. This metric requires specific sampling equipment, knowledge of sampling methodologies, and the ability to identify aquatic macroinvertebrates to their taxonomic order and family level. While knowledge of existing macroinvertebrates is important, their presence or absence is somewhat predictable based on *Stream Channel* scores. However, the possible presence of an unseen toxic contaminant may be identified by using this metric.

Following each category is a discussion of the metric scores. These discussions indicate how scores are related to the aquatic environment and include suggestions that effectively increase water quality protection. In many instances the response necessary to improve the aquatic environment is made obvious by the metric score itself. Persons involved in the evaluation process <u>must remember</u> that many of the characteristics observed in the channel area are the result of practices that currently, or recently, exist(ed) upstream from the assessment site. Land Use and Riparian Zone scores may be very good yet accompanied by low Stream Channel scores at any given sampling station. Metric scores often reflect only the potential impact a parcel of land may have on the stream environment. Poor channel habitat may result from land use upstream or a combination of upstream and adjacent watershed activities. However, impaired stream function increases the potential for further dysfunction from any condition that continues to degrade water quality. Streams that have been heavily impacted by poor management in upstream portions of the watershed still require protection from land use effects to maintain or improve water quality downstream from the sampling site.

Metric scores are given in two forms, a numeric value and a level of vulnerability (1-4). The vulnerability codes are as follows.

- *Level one* for optimal conditions. The stream environment is insignificantly impacted by local conditions.
- *Level two* signifies somewhat less than optimal conditions exist without serious impacts to the stream environment.
- *Level three* denotes marginal or significant potential for impact to the stream environment.
- *Level four* describes poor conditions with the greatest level of vulnerability or impact.

The numeric score provides a more accurate description for each respective metric and a means to evaluate the effects of changing farm management strategies. Anticipated management changes can be re-scored against existing conditions to predict future outcomes to the stream environment. Total scores for each of the three categories should be placed in the appropriate box at the base of the individual score charts that follow each category.

The potential to impact water quality is not always clear and requires interpreting many variables. Several additional land use characteristics such as animal management and tiling to enhance sub-surface drainage require special attention and are addressed at the end of the metric section.

Selecting A Sampling Location

Site selection is an important consideration when performing an environmental assessment. The evaluated area must represent average or typical land use, riparian zone, and channel conditions for the land in question. The following guidelines should be followed to achieve an accurate assessment.

1. While land use tends to be somewhat constant, slope may increase slightly as you approach the riparian zone. The AWQI allows for this potential change in slope by providing two metrics, one for the first 200 yards and a second metric for an additional 300 yards adjacent to the riparian zone. Use an average of the two scores when analyzing results. If slope is relatively constant use metric 1a <u>or</u> 1b (not both) to evaluate the soils and slope 500 yards adjacent to the riparian zone. Examine the soil surface at several locations adjacent to the riparian zone. Soil structure can be identified at any time; however, soil surface sealing will not be evident if the land has been recently tilled. Examine the soil surface following at least one significant rain event or on an undisturbed edge of the tilled field.

2. The riparian zone may be somewhat inconsistent in width. It is important to examine a minimum length of 100 yards to accurately assess this area for vegetation types and possible breaks or interruptions in the vegetation. Note the length examined on the inventory sheet.

3. Road/stream crossings can have a dramatic effect on channel characteristics. Whenever possible, begin sampling approximately 50 yards upstream from culverts or road/stream crossings. When sampling downstream from a culvert or crossing is necessary, allow at least 150 yards below the crossing before beginning the assessment. Examine at least 100 yards of channel length, including a minimum of two pool/riffle sequences where possible. Pool/riffle sequences may not occur in highly disturbed systems.

4. Macroinvertebrate sampling (optional) requires a field technician with a basic knowledge of aquatic macroinvertebrate taxonomy and familiarity with accepted sampling methods. Site selection should follow the same criteria as listed above with respect to road/stream crossings. The stream should be sampled in proportion to the substrate materials represented using a standard D-frame or aquatic kick net. As an example, if substrate materials are 80% sand and 20% gravel, 80% of the sampling effort should be made on sand and 20% in gravel areas. A sample data sheet is provided in Appendix C.

5. If the land to be assessed occupies both sides of the stream, score the side with the lowest scoring potential. Lower scores reflect a stronger potential for water quality impact and, therefore, communicate a more realistic potential to the stream.

Land Use And Soil Characteristics

Metric 1 Soils And Landforms

Soils and landforms, including slope, can be extremely variable within a given catchment basin. These variables help determine where water may collect on soil surfaces and become part of shallow wetland areas (swamps and marshes), lakes, or streams or if water quickly infiltrates the soil to areas of shallow and/or deep groundwater storage. These pathways are generally utilized in proportions that are determined by the soil types and local geomorphic characteristics (refer to Figure 1). The degree to which each pathway is followed (surface or subsurface flow) will have a demonstrable effect on stream characteristics including physical appearance, nutrient concentrations, and biotic composition.

Soils are grouped into four *hydrologic soil* groups that describe a soil's permeability and, therefore, its susceptibility to runoff. The hydrologic soil classifications are (USDA 1992):

- Group A soils which have low runoff potential and high infiltration rates even when wet. They consist chiefly of sand and gravel and are well to excessively drained.

- Group B soils have moderate infiltration rates when wet and consist chiefly of soils that are moderately deep to deep, moderately to well drained, and moderately to moderately course textures.

- Group C soils have low infiltration rates when wet and consist chiefly of soils having a layer that impedes downward movement of water with moderately fine to fine texture.

- Group D soils have high runoff potential, very low infiltration rates, and consist chiefly of clay soils.

The following metrics are intended to identify the dominant soil types in two areas or zones adjacent to the riparian zone. The first zone begins at the riparian edge and extends approximately 200 yards into the land use area. The second zone is an additional 300 yards that is both adjacent to and parallel to the first zone. Metric scores do not reflect soil productivity. These scores do, however, reflect a potential or vulnerability to surface runoff.

Selected References: Richards et al. 1996, Omernik 1976, Correll et al. 1994.

Habitat Parameter	Condition Category			
	Level 1	Level 2	Level 3	Level 4
Metric 1a. Hydrologic Soil Group and Landform 1 to 200 yards outside of the immediate riparian zone.	0-5% slope and in hydrologic soil group A	0-5% slope and in hydrologic soil group B or >5% up to 10% slope in hydrologic soil group A	0-5% slope and in hydrologic soil group C or >5% up to 10% slope and in hydrologic soil group B or >10% and up to 15% slope and in hydrologic soil group A	Hydrologic soil group D or >5% up to 10% slope and in hydrologic soil group C or >10% and up to 15% slope and in hydrologic soil group B or > 15% slope and in hydrologic soil group A
SCORE	30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0

Note: Question 1b may not be necessary if the average slope for the given survey site is consistent from the edge of the riparian zone out to approximately 500 yards. If both metrics are necessary, average the two scores into one and record in the Soil Group and Landform portion of the Land Use And Soil Characteristics Summary following Metric 3.

Habitat Parameter	Condition Category			
	Level 1	Level 2	Level 3	Level 4
Metric 1b. Hydrologic Soil Group and Landform 200 to 500 yards outside of the immediate Riparian zone.	0-5% slope and in hydrologic soil group A	0-5% slope and in hydrologic soil group B or >5% up to 10% slope in hydrologic soil group A	0-5% slope and in hydrologic soil group C or >5% up to 10% slope and in hydrologic soil group B or >10% and up to 15% slope and in hydrologic soil group A	Hydrologic soil group D or >5% up to 10% slope and in hydrologic soil group C or >10% and up to 15% slope and in hydrologic soil group B or > 15% slope and in hydrologic soil group A
SCORE	30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0

Metric 2 Land Use

Land use information may exist in digital formats for use with GIS (geographic information system) technology. In addition, some local units of government involved with land use planning may have detailed maps that describe area land use. The investigating technician may wish to consult with these local sources of information or with the nearest Soil Conservation Service or U.S. Forest Service.

Land use within a catchment basin will have dramatic effects on how water moves through the watershed. Changes in vegetation and the degree of land disturbance (e.g. lumbering and plowing) affect the volume and quality of water entering the stream channel. Nutrient availability and transport can be influenced by deep rooted versus shallow rooted plants and exposed soils from frequent tilling that allows nutrients to quickly migrate toward the stream channel.

Scores for the following questions are based on land use modifications with the greatest potential to impact water quality. High scores pose little modification (impact) while low scores represent large-scale modifications that are known to place the quality of the stream at risk.

Selected References: Petersen 1992, Leopold et al. 1964, Chesters and Schierow 1985, Duda and Johnson 1985, Richards et al. 1997, Likens 1984, Schlosser 1991, Roth et al. 1996, Patrick 1994, Menge and Olson 1990, Ricklefs and Schluter 1993, Omernick 1976, Lenat 1984, Miller et al. 1997, Cooper et al. 1998.

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 2. Land use approximately one to 500 yards beyond the immediate riparian zone (modified from Petersen 1992)	Generally undisturbed consisting of forest and/or wetland. Interruptions or modifications to the natural setting from residential dwellings or agriculture are rare. Vegetative cover is complete with no unnatural breaks or bare spots	Permanent pasture/hay mixed with woodlots, and/or swamps with few mixed row and small grain crops. Vegetative cover may have a few breaks or bare spots. Occasional modifications for residential dwellings or agricultural dwellings.	Consisting of a mixture of row crops, small grains, and pasture/hay or an increase in suburban characteristics (multiple housing units in close proximity). Vegetative cover may contain many weed and/or brush species. May have some bare areas.	Land use is dominated by row crops or is largely urban or suburban in nature. Vegetative cover may have many breaks or bare areas. The lowest end score would be a paved area or compacted bare soil.
SCORE	30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0

Metric 3 Soil And Surface Conditions

The natural permeability and infiltration rate of a soil can be altered by changes in soil characteristics that result from agricultural activities or the development of urban and/or suburban environments. These changes affect the hydrologic responses to precipitation events, threats from excessive runoff, volume of water in the stream channel, annual temperature budgets, nutrient concentrations, and the biotic composition. Collectively these factors have a major effect on water quality.

Certain types of land use are known to alter soil structure, which changes its response to precipitation events. For example, frequent soil tilling and cultivation, as in row cropping, substantially and negatively affects the physical properties of the soil. Continuous row cropping (little or no crop rotation) will significantly alter soil structure, reduce infiltration rates, and increase runoff potential (Brady and Weil 1996).

Natural permeability and infiltration rates are influenced by the physical properties of soil, such as soil structure. A partial list of factors affecting those physical properties that alter infiltration rates include the organic matter content and the activity of soil organisms such as earthworms.

The following metric is designed to estimate the impact of current soil characteristics on infiltration and thus upon runoff in the area outside the riparian zone. This measurement requires the use of a shovel to expose and examine the upper six to ten inches of soil in several areas that represent current land use.

Selected References: Brady and Weil 1996, Cooper et al. 1998.

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 3. Soil and Surface Conditions outside of the riparian zone	Surface open or loose, even when wetted. Large strong granules, crumbs, or sand particles. Many root channels and earthworm burrows and other voids in the soil. No gleying or mottling.	Surface open or loose, small or weak granules or crumbs, or sand particles. Some root channels and earthworm burrows. May have orange or bright mottles	Surface crusted; however, easy to break or Structure very fine and very weak or is sub-angular blocky to blocky. May have mottles or gleying.	Surface crusted and hard to break or Bulk soil massive or puddled. No evidence of granules or crumbs. No root channels or earthworm burrows. Contains mottling and/or gleying. The most undesirable extreme is a paved area or a compacted bare crusted area.
SCORE	30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0

Land Use And Soil Characteristics Summary

Place land use scores in the appropriate box below each respective category. Consult the *Recommendations* section for the highest of the three scores listed to determine possible farm management changes that will minimize potential impacts to the stream environment.

Metric 1 Soil Group And Land Form	**Metric 2 Land Use**	**Metric 3 Soil Surface Condition**	**Recommendations**
Level 4	Level 4	Level 4	Land cannot tolerate a continuous crop. Set to forest, permanent pasture, or long rotations. Minimize continuous row crops. Use minimum or no-till with additions of organic matter/crop residue. Badly eroded land may require complete renovation. In addition, follow recommendations for Level 2 and 3 categories.
Level 3	Level 3	Level 3	Be alert as some precaution is needed. If in continuous row crop, rotate grain and hay/grasses. Use minimum or no till where tillage is required. In addition, follow recommendations for Level 2.
Level 2	Level 2	Level 2	Have soils tested to determine if lime or fertilizer additions are needed. Examine vegetative cover. If cover is sparse, interseeding is needed.
Level 1	Level 1	Level 1	No special precautions or new management schemes are needed based on this assessment.

Total Land Use And Soil Characteristics Score (Sum metrics 1+2+3) ________

Soil Management Adjustment Factor

While land use has a dramatic effect on water movement through a landscape, natural geomorphic features such as soil types and slope are not options that are normally changed by human activities. These features, help define hydrologic processes and strongly influence the land use management. Poor scores for soil types do not indicate a poor quality soil. They do, however, suggest a greater vulnerability to surface runoff than higher scores. This vulnerability increases with an increase in slope and/or land use that involves frequent soil disruption (Figure 1). Soil types that are susceptible to surface runoff may exaggerate the effects to a stream due to increases in slope or patterns of land use that reduce soil structure.

There are a number of farm management options that work to offset the risk imposed by soil groups that characteristically contain a high potential for surface runoff. These methods include such practices as no till and regular or frequent crop rotation. Frequent tillage tends to destroy soil structure and drastically reduce infiltration rates. Therefore, soils that are normally characterized as highly permeable may demonstrate characteristics of heavier, more impermeable soils such as clay.

The following metric is a Soil Management Adjustment Factor, intended to appropriately modify the Land Use And Soil Characteristics score in the chart above. Add the adjustment score to the Total Land Use Score listed above and re-examine possible recommendations for potential impacts to the stream environment.

Farm Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Crop And Tillage Practices (Adjustment Factor)	Long term rotation with minimal row cropping and maximal hay and/or pasture. Mixed farm uses including crop production and pasture. Minimum or no-till where applicable.	Short term crop rotation with conservation or no till practices.	Some crop rotation with standard tillage practiced.	Intensive row crop monoculture with intensive tillage.
SCORE	5	0	-5	-10

Total Land Use And Soil Characteristics Score (Adjusted**)___________**
(Total Land Use And Soil Characteristics Score + Crop And Tillage Adjustment Factor)

The Riparian Zone

<u>Metric 4</u> **<u>Riparian Zone Width</u>**

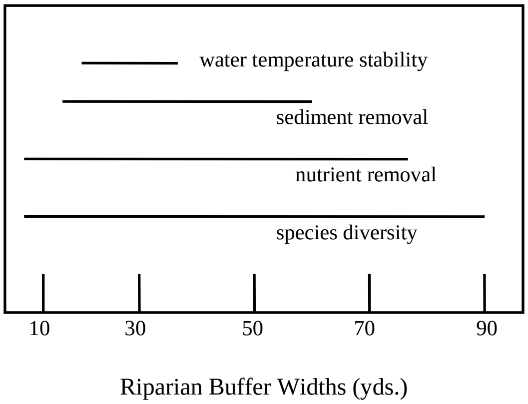


Figure 2. Range of riparian buffer widths needed to maintain specific stream buffer functions (from Castelle et al. 1994).

Riparian zones (sometimes called riparian buffers) are those areas of natural vegetation and/or low wet swamp/marsh areas adjacent to the stream channel that act to minimize the effects from runoff.

The condition of the riparian zone greatly affects a stream's ability to process the flow of energy input by the watershed. The width of the riparian zone must provide enough area for a sufficient quantity and diversity of vegetation to act as a sediment and nutrient filter (Figure 2). Vegetation plays an active role in water quality by providing a continuous source of materials that act to stabilize both the physical and biological aspects of the stream environment.

Adequate riparian buffer widths are determined by the intensity of adjacent land use, buffer characteristics, and specific buffer functions required. Due to possible variations in soil types, slope, and land use, the following metrics rely on averages derived from literature review.

Selected References: Castelle et al. 1994, Castelle et al. 1992, Petersen 1992, Wong and McCuen 1982, Johnson and Ryba 1992, Gilliam 1994, Barton et al. 1985, Roth et al. 1994, Richards et al. 1996, Budd et al. 1987, Lenat 1984, Hynes 1975, Cooper et al. 1998.

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 4. Riparian Zone width from stream to edge of field.	Marshy or woody riparian zone 100 to 150 feet or more.	Marshy or woody riparian zone varying from 50 to 99 feet.	Marshy or woody riparian zone from 20 to 49 feet.	Marshy or woody riparian zone essentially absent or less than 20 feet.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Metric 5 Completeness Of The Riparian Zone

Along with width, the presence or absence of breaks or gaps in riparian vegetation describes potential weaknesses in the riparian zone. These breaks in the buffer zone are frequently due to animal crossings, game trails, areas of intense erosion, or areas of general access to the stream. High scores are given to riparian areas that maintain their maximum thickness. Low scores describe frequent breaks in the vegetation that may allow for sediment and nutrient enriched runoff to penetrate the vegetation buffer and enter the stream or describe various degrees of bank failures that exist.

Selected References: Petersen 1992, Richards et al. 1996

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 5. Riparian Zone Completeness (Petersen 1992).	Riparian zone intact to nearly intact with infrequent breaks occurring at intervals greater than 165 feet.	Incidental breaks in the riparian zone at approximately 100-164 foot intervals.	Breaks in the riparian zone frequent with some gullies and scars occurring every 100 feet.	Riparian zone has frequent breaks in the vegetation with deeply scarred gullies along its length.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Metric 6 Riparian Vegetation Types

The type of riparian vegetation (e.g. trees versus shrubs versus grass) as well as the diversity of vegetation (plant specie) play an important role in the structure and function of river systems. Trees and large shrubs provide a shade canopy over small channels that protect the stream from direct sunlight, thereby maintaining water temperature stability during day long and seasonal extremes. In addition to temperature protection, streambank vegetation provides the stream with a critically important source of organic carbon, mostly in the form of leaf litter. This organic carbon is the food base that strongly influences the well being of a stream's biological community.

The riparian zone also supplies woody debris necessary in retaining organic material for biological processing and maintaining habitat diversity. Trees growing along the stream bank and active channel area deposit dead limbs and branches or enter the stream as an entire unit. Once in the channel, these materials acts to retain or hold leaf litter and other organic inputs for processing, provides flow diversity, acts as solid substrates for fish and macroinvertebrates to live on and around, and functions as bank stabilization devices.

Riparian zones that have undergone extensive vegetation reduction or removal will result in stream quality degradation. This degradation is associated with increases in sedimentation, flow fluctuations, and/or temperature extremes. In addition, the loss of interaction between the Riparian Zone and stream channel will impair the biological functions necessary to maintain water quality.

Selected References: Petersen 1992, Richards et al. 1996, Jones and Smock 1991.

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 6. Riparian Zone Vegetation.	Riparian vegetation consists of trees, shrubs, herbaceous species, and grasses. Maximum canopy potential is achieved with native plant species.	Riparian vegetation has sustained some degree of alteration. Some degree of canopy cover less than the maximum potential exists. At least one of the four categories of plants is missing or very limited.	Riparian vegetation has been altered with at least two of the four vegetation types missing. Obvious gaps in the canopy exist, and the potential to supply organic material and woody debris to the stream channel has been significantly reduced.	Riparian vegetation has been severely altered with an abundance of only one or none of the four plant categories present. Organic material and woody debris is not realistically available to the stream channel or has been replaced with agricultural commodities or used as pasture.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Riparian Zone Summary

Soil types and land uses that maximize the potential for stormwater runoff, erosion, and nutrient loading to the stream environment may place additional stress on the riparian zone. The AWQI scoring method for riparian zone width, completeness, and vegetation characteristics (Metrics 4-6) compensate for this additional stress. The scoring recommendations are increased to a higher vulnerability level when soil characteristics and/or land use requires an increase in riparian buffer function.

Place the Riparian Zone Width score (metric 4) in the appropriate box within its respective category. If the Land Use was a Level 3 or 4, shift your riparian zone score to the next higher level of vulnerability and refer to the *Recommendations* listed in the same row of the chart. As an example, if the Riparian Zone score is 17 (Level 1) and the Land Use score is 14 (Level 3), refer to the Level 2 *Recommendations*. No adjustments are necessary if the Riparian Zone Width score falls into a Level 4 category or if Land Use scores fall into a Level 1 or 2 category. All recommendations assume that the condition and completeness of the riparian zone is of high quality. In all cases, changes in land use may require an increase in riparian zone width.

Metric #4 Riparian Zone Width	**Recommendations**
Level 4	Riparian zone widths need to be increased to a minimum of 100 feet in areas containing hydrologic soil groups A or B with slopes <10% and up to 150 feet for hydrologic soil groups C or D. Where slopes exceed 10% an additional 50 feet may be necessary, especially if land use involves frequent tilling and/or occasional row crops or if slope exceeds 10%.
Level 3	Riparian zone widths need to be doubled or tripled in areas containing hydrologic soil groups A or B with slopes <10% with an additional 50 feet for areas containing hydrologic soil groups C or D. An additional 50 feet may be necessary where slopes exceed 10%, especially if land use involves frequent tilling and/or occasional row crops.
Level 2	Riparian widths may be adequate if located within hydrologic soil group A with less than a 10% slope or hydrologic soil group B with less than a 5% slope. An additional 50 feet is necessary for areas containing hydrologic soil groups C or D or where slopes exceed 10% or where land use involves frequent tilling and/or occasional row crops.
Level 1	No special recommendations are needed based on this assessment. However, changes in current land use may require increases in existing riparian zone widths.

Place the Riparian Zone Completeness score (Level 5) in the appropriate box below, following the same pattern of scoring instructions as previously given with respect to the Land Use score. All recommendations assume that the riparian zone width is adequate. If the riparian zone width is not adequate, the recommendations described in this section must be performed in conjunction with the Riparian Zone Width recommendations previously described in the text and in Metric #4.

Metric #5 Riparian Zone Completeness	**Recommendations**
Level 4	Identify and eliminate sources of erosion. Restore eroded banks with appropriate vegetation. Refer to Level 3 and 4 recommendations under Riparian Buffer Widths.
Level 3	Modify and/or eliminate non-essential breaks in the riparian vegetation. Essential breaks in the vegetation need to be modified so that surface runoff flows away from the area of the break. Continue to observe riparian zone standards as described in the previous section.
Level 2	Modify essential breaks in the riparian vegetation so that surface runoff flows away from the area of the break. Continue to observe riparian zone standards as described in the previous section.
Level 1	No special recommendations are needed based on this assessment. Continue to observe riparian zone standards as described in the previous section.

Place the Riparian Zone Vegetation score (metric 6) in the appropriate box below, following the same pattern of scoring instructions as previously given with respect to Land Use. All recommendations assume that the riparian zone width is adequate. If not adequate, these recommendations must be performed in conjunction with the Riparian Zone Width recommendations previously described in the text and in Metric #4.

Metric #6 Riparian Zone Vegetation	**Recommendations**
Level 4	Riparian vegetation needs to be re-established. One third of the riparian zone area nearest the stream should be planted with several large tree species at approximately 6-10 foot intervals. The middle third of the riparian zone should be planted with woody shrubs at 3-6 foot intervals while the remaining portion of the riparian zone should remain as undisturbed grasses with intermittent woody shrubs. Refer to the section on Riparian Zone Widths for the correct dimensions for existing soil types, land use, and land features.
Level 3	Riparian vegetation needs to be expanded to include the various forms listed above. Select species that will provide some degree of shade and stability to the stream channel.
Level 2	Areas where riparian vegetation has been altered should be selectively restored. Select species that will provide some degree of shade and stability to the stream channel.
Level 1	No special recommendations are needed based on this assessment. However, changes in current land use may require increases in current riparian zone widths. Continue to monitor vegetation quality for changes due to high water or frequent flooding that may eliminate some forms of grasses, trees, or shrubs.

Total Riparian Zone Score_______ (Sum metric numbers 4+5+6)

Riparian zones are interactive areas between the terrestrial and aquatic environments that provide essential biotic and abiotic elements to the stream while protecting water quality from excessive nutrient and stormwater inputs. Numerous studies (previously cited) as well as research results derived specifically for this project (Cooper et al. 1998) found strong links to the width of the riparian zone, the types of vegetation that exist within this area, and the quality of the stream channel itself.

There is little substitute for adequate buffer width; however, wetland areas adjacent to the stream channel provide very effective sediment and nutrient barriers. In addition, these wetland areas can hold large amounts of stormwater, which diffuses the damage potential to streambanks and in-stream habitats from frequent surges in discharge and bank erosion.

Low scores in riparian vegetation can be offset by increasing the riparian buffer width, while weak points (breaks) along the riparian corridor will require specific management methodologies including vegetation restoration, berm construction, and/or wood and rock riprap to ensure water quality protection. Information concerning programs and potential funding assistance for resource protection may be available through a local or state agency such as the National Resource and Conservation Services (NRCS), a county extension service, or your local Farm Bureau organization.

Stream Channel

Metric 7 Channel Flow Status

Damage to the stream system will result from the interruption of normal groundwater recharge sources or excessive water withdrawals that significantly decrease flow volume. These reductions in flow volume can be caused by excessive irrigation removal directly from the stream channel or groundwater supplies, excessive evapotransporation losses from large monocultures of coniferous trees or evaporation losses resulting from solar exposure following canopy removal. However, regardless of the removal pathway, excessive water loss from the active channel results in substrate exposure that inhibits microbial and macroinvertebrate colonization. In addition, the reduced volume of water is much more susceptible to temperature fluctuations resulting from greater air temperature and solar influence. Temperature extremes cause additional stress to stream biota, decreasing the streams sediment carrying capacity and limiting population diversity and richness, further reducing organic processing rates.

High scores are given for streams that give evidence of very stable base flow conditions while poor scores are given where excessive water losses impair stream function. This metric does not apply to intermittent streams where water is commonly absent from the channel area during dry weather cycles.

Selected references: Colby 1964, Dunne and Leopold 1978, Rosgen 1985, Hopp and Simon 1986, Hicks et al. 1991, Lenat 1984, Allan 1995.

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 7. Channel Flow Status (from Barbour et al. 1997).	Water reaches the base of both banks with minimal or no channel substrates exposed.	Water reaches >75% of the active channel substrates or <25% of active channel substrate is exposed.	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in the channel and mostly present as standing pools.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Metric 8 Flow Stability

Good habitat diversity and optimum fish and macroinvertebrate populations are typically correlated with flow stability. Flow stability allows for accumulation and retention of woody debris that in turn acts to retain organic materials for biological processing, provide solid substrates, and create flow diversity that optimizes microbial, macroinvertebrate, and fish populations. Rapidly fluctuating discharge provides an excessive amount of stream energy that flushes woody debris from the stream channel, thus removing habitat and nutrient storage capabilities. In addition, streambank vegetation is commonly scoured away by such flows resulting in severe bank erosion, bank slumping, and stream bed aggradation with widespread loss to the fish and macroinvertebrate community.

Indications of significant flow instability are relatively easy to see in a stream. High water is accompanied by increases in flow velocity, which scours away bank vegetation leaving bare, unstable soil and exposed root systems along and above the active stream channel. Excessive erosion of these bare soils generally follows, resulting in increased suspended and bed-load stream sediments, streambed aggradement, and habitat loss.

High scores are given for streams with little or no vegetation removal or exposed soil above the water from frequent increases in high water. Retention devices (when present) should be oriented somewhat perpendicular to the stream bank. Low scores should reflect stream banks with large areas of exposed soil above the surface of the water. Woody debris may exist along the stream channel; however, it has been deposited above the water level by the force of high water events.

Selected References: Lenat 1984, Richards et al. 1996, Omernick 1976, Liemi et al. 1990, Cooper et al. 1998.

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 8. Flow Stability (at or near base flow).	Vegetation along the stream banks is complete nearly to the water's edge. Little or no evidence of frequent changes in discharge and/or stream velocity that scours stream bank vegetation. Channel retention devices (if present) stable and extending laterally across the stream channel.	Some evidence of bank scouring approximately 4-8 inches above the water surface. Channel retention devices (if present) mostly stable and extending partially into the stream channel.	Bank scour evident 9-18 inches above the water surface. Channel retention devices (if present) tend to lay more against the stream bank rather than extending out into the active channel.	Bank scour severe (>20 inches) into the stream channel. Channel retention devices are generally absent from the active channel and/or may exist as woody debris jams along the stream bank above the active channel.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Metric 9 Channel Sinuosity

Stream channel sinuosity refers to the meandering pattern that streams acquire as they flow through the landscape. These back and forth patterns are determined by water velocity (as determined by the volume of water and stream gradient) and erodability of the parent soils that contain the stream channel. As the water flows through the bends created at the point of the meanders, stream power or the energy needed to erode the stream banks, is dissipated. The lateral distance that the meanders create will, therefore, increase until enough energy is lost to establish a balance between the erosive potential of the water and the stream bank's susceptibility to erosion.

Stream meandering creates a pattern of riffles and pools that provide high quality habitat diversity for macroinvertebrates and areas of refugia, as well as spawning areas and cover for fish. The degree of meandering may be limited in streams located in erosion resistant parent soils. However, channels with a moderate to low degree of meandering will still have a definable pool/riffle sequence that repeats at normal intervals of approximately five to seven stream widths.

Meanders create an effective method of handling the destructive force of normal stormwater inputs by diffusing its erosive energy. This energy absorption maintains habitat stability within the stream. Stream channels that have been altered (generally straightened) to facilitate drainage are typically erosive due to a re-acquisition of stream power that was once dissipated in the bends in the stream. Channelized streams frequently lose their riparian buffer as a result of a dredging operation which, combined with an increase in stormwater flow volume, increases stream bank erosion, in-stream sedimentation, and streambed aggradement. The habitat lost from these degrading forces sharply reduces stream processes and overall stream quality that supports the desirable biological community of which it is capable.

High scores are given for channels that have maintained their natural sinuosity. Moderate scores are intended for streams that, although once channelized, have incurred a certain degree of recovery. Low scores are reserved for recently channelized streams with streambeds that are mostly or completely uniform in substrate materials, depth, and flow diversity.

Selected References: Keller 1979, Kondolf 1996, Brooks 1988, Petersen 1992, Niemi et al. 1990, Platts et al. 1983, Hawkens et al. 1982, Cooper et al. 1998.

Habitat Parameter	Condition Category			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 9. Channel Sinuosity (from Barbour et al. 1997).	The bends in the stream increase the stream length 3 to 4 times longer than if it was a straight line.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel is essentially straight; waterway has been channelized for a long distance.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Metric 10 Channel Structure (Retention Devices)

Channel structure, in the form of rock, cobble, and/or woody debris, provides necessary substrate for a variety of benthic macroinvertebrates, habitat and refugia for macroinvertebrates and fishes, and creates relatively stable flow diversity within the active channel. Unstable flow extremes are responsible for flushing and removing woody debris from the active channel. This material protects stream banks from erosion and retains organic particles for physical and biological processing that ensures more desirable water quality. Woody debris is often the only stable substrate for benthic invertebrates and fishes in low gradient streams. Significant increases in sand or silt sediment in the active channel may embed (bury) rock and woody material, reducing or eliminating fish and insect populations.

High scores are given for stream channels that contain large amounts of stable woody debris, debris jams, rocks, and assorted gravel. Low scores represent those streams where little structure and; therefore, little retention is available due to excessive and/or frequent stormwater flows, recent channelization, sedimentation, or woody debris removal by man.

Selected References: Wesche et al. 1985, Angermeier and Karr 1984, Roth et al. 1994, Schlosser 1991, Beckman and Rabeni 1987, Liemi et al. 1990, Jones and Smock 1991, Bilby and Likens 1980, Cooper et al. 1998.

Habitat Parameter	Condition Category			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 10. Channel Structure (Retention Devices).	Channel structure comprised of rocks and/or logs firmly set in place in both the active channel as well as along the interface of the bank and channel area.	Channel structure comprised of rocks and/or logs however largely backfilled with sediment.	Channel structure loose; moving with floods.	Channel with few or no retention structures. Substrate materials dominated by sand and silt.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Stream Channel Summary

Add the scores for the entire Stream Channel section (metrics 7-10) and place in the appropriate box below. Refer to the *Recommendations* section, immediately to the right of the Stream Channel score for direction with future management strategies.

Total Stream Channel Scores	**Recommendations**
Level 4 (Scores 0-15)	Poor habitat that has resulted from riparian zone impairment, poor land use management, and/or somewhat recent stream channelization. Re-establish adequate riparian widths and land use management strategies as described in previous sections. If the disturbance is not caused on site, maintain adequate riparian zone widths and appropriate land use management strategies to minimize additional sediment and nutrient inputs.
Level 3 (Scores 16-30)	Marginal habitat. Re-examine Land Use and Riparian Zone scores to identify possible causes of habitat loss. Identify possible weak areas from individual Stream Channel metric scores and adjust. If Land Use and Riparian Zone scores are in Level 1 or 2, determine the extent of impacts resulting from upstream land use. Increase protective measures where possible.
Level 2 (Scores 31-45)	Good habitat. Identify possible weak areas from individual Stream Channel metric scores and adjust where possible. If Land Use and Riparian Zone scores are in Level 1 or 2, determine the extent of impacts resulting from upstream land use.
Level 1 (Scores 46-60)	Optimal habitat. Continue to maintain adequate riparian zone widths and farm management practices that minimize impacts to the stream environment.

Stream Channel Scores ________ (Sum metrics 7+8+9+10)

Flow stability is heavily dependent on land use and the size and characteristics of the riparian zone. As such, these metrics show the actual effect of land use on the stream channel. Discernible short-term decreases in discharge may occur from excessive water withdrawals to facilitate irrigation. Long-term changes can result from deforestation or the maturation of significantly sized forest monocultures that increase or decrease (respectively) the amount of groundwater recharge to a stream.

Changes in sinuosity can result from excessive and frequent high water events that will extend the lateral movement of the meanders. While this lateral movement increases in response to high water, channel substrate materials are usually buried by sand and silt as base flow velocities decrease to the point where sufficient stream power no longer exists to flush in-stream sediment. Activities that seek to remedy these situations are complicated and require permits from state natural resource management agencies. Attempts to facilitate this type of work without proper instruction frequently cause more damage than good. In general, every effort should be made to eliminate excessive stormwater inputs or large water withdrawals. Land use management that minimizes stream impact remains far less costly than stream rehabilitation and restoration.

In-stream retention structures and channel structure are strongly related to discharge patterns and local parent materials. Most Midwestern streams that are stable and with minimal modifications have meandering patterns through forested areas and contain woody material in varied sizes and lengths. Although once viewed as a nuisance to navigation and drainage, woody debris is now known to be very important if not critical for natural processes and stream function to proceed at desirable rates. Streams without woody debris, or with wood that has been dislodged from the channel frequently, suffer from excessive periodic runoff events as previously described.

Cumulative Metric Score Results

Step 1. Add the Total Riparian Zone Score with the Total Land Use And Soil Characteristics Score (metrics 1-6) to form a *Total Land Use And Riparian Score* (1 to 150). Place this score in the appropriate space indicated in Figure 3. Place an *X* in the position along the horizontal scale labeled "Land Use And Riparian Score" that represents your *Total Land Use And Riparian Score*. From the *X*, draw a vertical line to the top of the colored chart.

Step 2. Place the Total Stream Channel Score (metrics 7-10) in the appropriate space indicated in Figure 3. Place an *X* in the position along the vertical scale labeled "Channel Score" that represents your score results. From the *X*, draw a horizontal line to the right side of the colored chart.

Step 3. Circle the point where the two lines intersect.

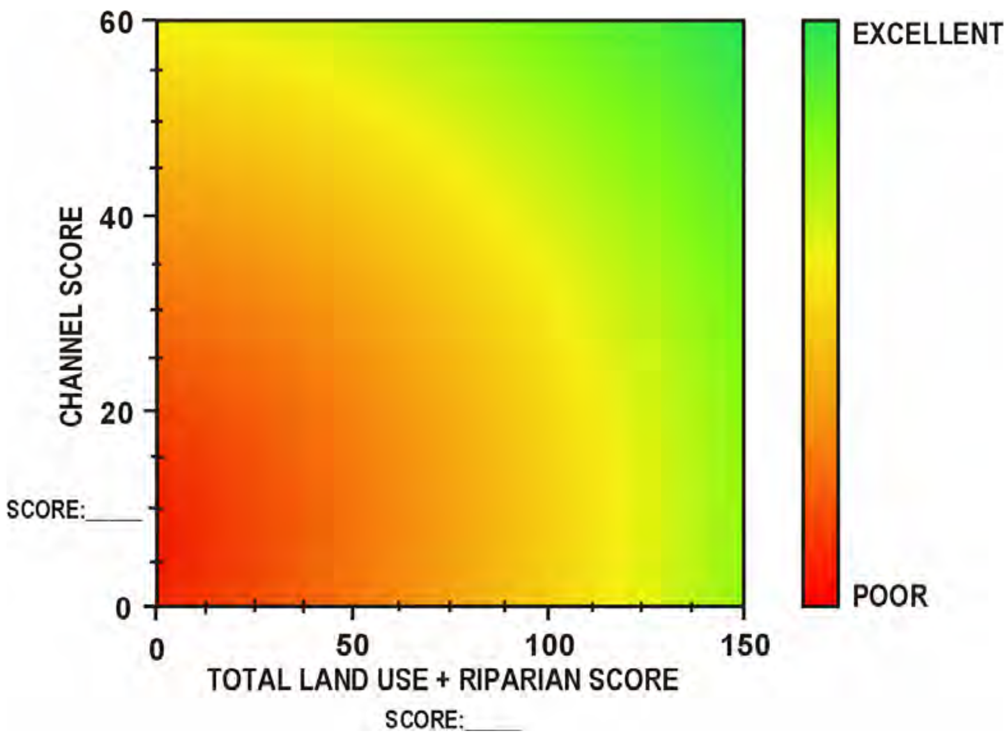


Figure 3. Cumulative score chart for the AWQI. Record the Total Land Use and Riparian Score in the appropriate blank and place an X where this score occurs on the horizontal axis. In similar fashion, record the Channel Score in the appropriate blank and place an X where this score occurs on the vertical axis. Draw a straight (vertical and horizontal) line from each X to the opposite side of the chart and circle the intersection of the two lines.

Both aquatic and terrestrial environments are multi-dimensional, highly dynamic systems that remain approximately, yet not exactly the same with temporal and spatial changes. Because of this variability, total scores need to be somewhat approximate when describing real environmental conditions in order to communicate the constant yet subtle changes that occur in nature. The AWQI utilizes a color gradient to represent final assessment results. An exact numerical score implies a precise condition that rarely if ever exists in environmental assessments, whereas the color gradient more accurately reflects environmental complexity. The color gradient in Figure 3 represents a continuum between very good conditions (green shades) to very poor conditions (orange to red shades) for Channel Scores. For Land Use And Riparian Scores, the color continuum represents a relative degree of shared responsibility for existing channel conditions and the intensity of the potential to impact the stream environment.

The intersection of the two lines provides an estimation of the degree that the existing stream environment is due to upstream watershed conditions (line intersection is on the far right side of the figure). A degree of shared impact potential is described when the line intersection is between the extreme right and left margins of the figure. When the intersection is on the far left side of the chart, adjacent conditions could be largely responsible or impose a high potential for impairment to the stream environment. In general, the relative amount of potential impact to the stream from adjacent land use, soils, and riparian conditions is greater if the intersection is to the left and less if the intersection is to the right.

The color fields transected by the vertical line illustrate the intensity of a potential stream impact. Only a minimal potential to impact the stream exists if the line passes through green and/or yellow shades while a more serious potential exists if the vertical line crosses red or orange fields.

As an example, if the Channel Score is 55 and the Total Land Use And Riparian Score is 145, the intersection will occur in the green, upper right portion of the figure (Figure 4, Example A). The interpretation would be that stream conditions are good as a result of upstream conditions and adjacent characteristics offer little potential to impact the stream. However, if the Channel Score remains the same and the Total Land Use And Riparian Score is 40, the intersection would communicate that stream conditions are good; however, a strong potential for impact from adjacent land use, soil, and/or riparian conditions exists (Figure 4, Example B).

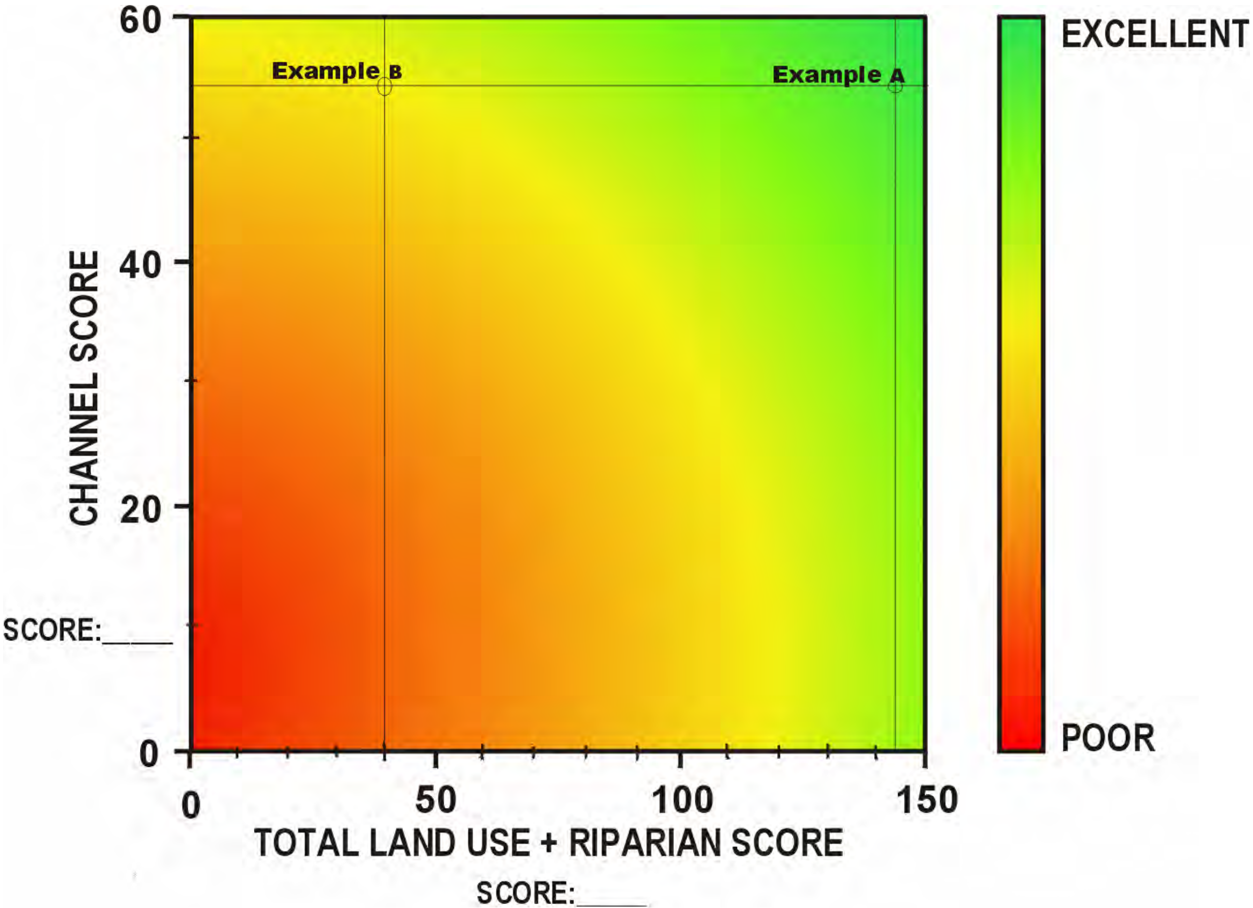


Figure 4. An example of a high Stream Channel Score with a high Land Use And Riparian Score (Example A) and a high Stream Channel Score with a poor Land Use And Riparian Score (Example B).

An investigator will probably encounter conditions where both sets of scores are less than excellent. As an example, if the Channel Score is 35 and the Total Land Use And Riparian Score is 100, the interpretation would conclude that stream conditions are marginal (Figure 5, Example C). While the upstream portion of the watershed contributes a substantial percent to current channel conditions, adjacent characteristics also offer a potential (yellow bordering on orange) to impact water quality. Again, if the Channel Score remains at 35 and the Total Land Use And Riparian Score is 60, the interpretation would conclude that stream conditions are marginal and adjacent conditions have a strong potential to contribute to overall water quality along with upstream portions of the watershed (Figure 5, Example D). This latter conclusion is drawn by the position of the transect (degree of share responsibility) and by the colors transected by the vertical line (red/orange).

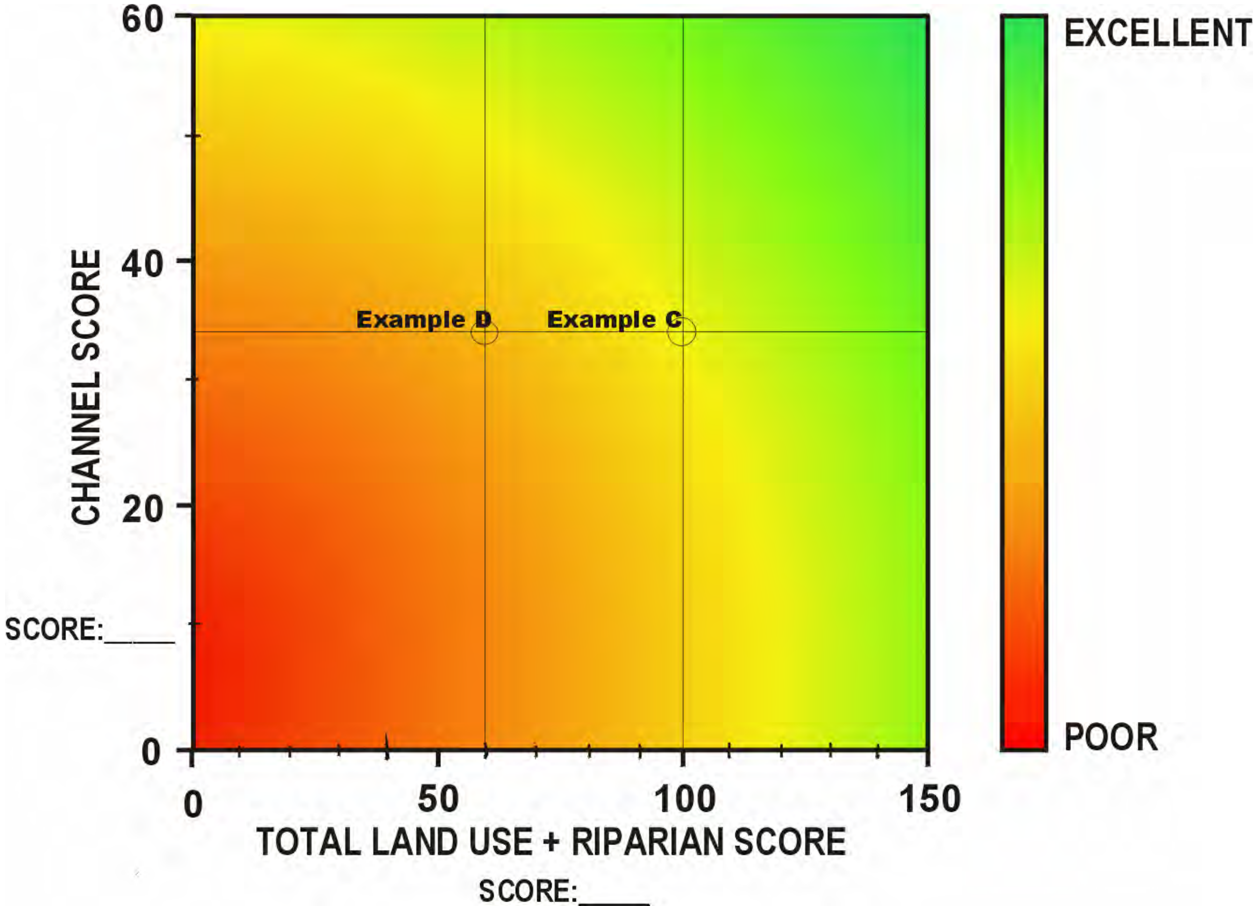


Figure 5. An example of a marginal Stream Channel Score with a fair Land Use And Riparian Score (Example C) and a marginal Stream Channel Score with a poor Land Use And Riparian Score (Example D).

Score Modifications

Once existing conditions have been scored and the results interpreted, potential modifications to current farm management strategies or changes to the riparian zone can be made within the index to project potential outcomes. This will allow the producer/land owner to make theoretical changes using the AWQI index itself and extrapolate outcomes expressed as the potential to impact stream quality and, therefore, water quality. Add the adjustment score to the Total Land Use And Soil Characteristics Score and repeat Steps 1 and 3 under Score Results. Plot additional vertical lines in Figure 3 and compare with existing conditions as shown by the initial line plotted.

Special Land Use Features Affecting Water Quality

Several features common to agriculturally dominated watersheds are not listed in the index itself yet warrant special comment because of their potential to affect water quality. These features include animal waste management and artificial subsurface drainage to rapidly remove shallow groundwater.

The effects of various animal management practices, or the lack of, are difficult to assess because of the variables associated with the problem. One must consider the number of animals, rate of nutrient excretion/specie of pastured animal, pasture size (acres per animal), pasture condition (vegetation density and plant size), and animal proximity to water. In addition, slope, soil types, and riparian zone conditions persist in modifying the influence of animal management practices on water quality. The role of the riparian zone, however, is no different with animals as it is with row crops or hay fields. The animal density must not exceed the vegetation's ability to filter and moderate the amount of sediment and nutrients from the pasture area that enters the stream. Excessive animal densities compact soils and eliminate some if not all pasture vegetation, thereby maximizing surface runoff. Pastured areas that include a stream almost always result in serious bank failure, in-stream sediment accumulation, habitat loss, and a general loss of stream processes that result in serious water quality impairment.

It has been suggested by some researchers (e.g. Richards et al. 1997) that protecting habitat diversity by protecting and enhancing the buffering capabilities of the riparian zone and increasing the availability of hard substrate materials in the stream channel will do more to enhance and restore a stream's natural water purifying capabilities than focusing on animal waste management. The exception to this philosophy may fall with the poultry and swine industry. According to well published agricultural sources, poultry produces proportionately greater amounts of phosphorous than any other domestic farm animal. Phosphorous inputs are particularly troubling because, unlike nitrogen and carbon, phosphorus is not easily removed from an aquatic system and can cause measurable impairment to our lakes and stream. In addition, both poultry and swine waste contain large quantities of ammonia which, under certain temperature and pH conditions, becomes extremely toxic to aquatic organisms. Great care must be taken to maximize buffer areas between poultry and/or swine production and our water resources.

Application rates that optimize nutrient utilization from manure application are now available to producers through various agriculture resource groups. These rates, known as *agronomic application rates,* have been identified through careful consideration of soil groups, vegetation, land use, and animal types to produce efficient animal waste management options that seek to minimize environmental impact.

Farm management plans should include operational strategies that cover the proper animal waste containment. Programs that provide for animal feeding and watering should not be detrimental to the stream environment. As with the calculation of agronomic rates, the engineering designs required for a farm management plan cannot be readily determined by the visual indicator approach used in the AWQI. Methods to determine agronomic rates and develop a farm management plan for a particular agricultural operation can be obtained from the Farm Bureau, Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA), or the local agricultural extension office.

Agriculture frequently uses various methods to influence surface water or shallow groundwater drainage. As a general rule, any interruption to natural hydrologic cycles by artificial drainage influences the quantity and quality of runoff, usually by increasing the nutrient and sediment content that reaches the stream. However, it is not difficult to argue that rapidly removing shallow groundwater or standing surface water may decrease soil loss potential and therefore minimize erosion.

The data collected during this project suggest that any land use practice that increases the amount of water or the rate of delivery to the stream was closely associated with poor stream habitat and diminished water quality. In addition, some tiled lands appeared to have been wetland areas that, in other watersheds, demonstrated the greatest ability to buffer effects caused by land use change. The tile materials used to facilitate drainage effectively prohibit contact between nutrients in the water and the natural biota in the soil that is capable of removing and utilizing these nutrients. This separation allows for seasonal increases in nutrient loadings to the receiving stream and downstream reaches. Because drain tiles cannot be quickly removed and/or installed, the differences in erosion, sediment, and nutrient export rates in tiled versus untiled fields remain difficult to measure.

Benthic Macroinvertebrates in Rapid Bioassessment Protocols (Optional)

Macroinvertebrate community assemblages are important indicators of localized conditions and are frequently used as biological end-points for stream rehabilitation projects and to describe environmental conditions. Because many benthic macroinvertebrates have limited migration patterns or an attached mode of life, they are particularly well suited for assessing site-specific impacts (upstream-downstream studies).

Macroinvertebrate diversity is both closely related to and inversely proportionate to substrate particle size. While the total number of individuals in the stream may increase with a decrease in substrate particle size, overall diversity, including intolerant species, will decrease when confronted with particle size reduction.

Macroinvertebrates integrate the effects of short-term environmental variations. Most species have a complex life cycle of approximately one-year (univoltine) and therefore require relatively stable habitats. Less sensitive species, or tolerant species, generally produce multiple generations (multivoltine) in a given year and are, therefore, more capable of adapting to areas that are frequently disturbed. Sensitive life stages of aquatic organisms, macroinvertebrate and fish, will respond quickly to stress while the overall aquatic community will respond more slowly.

Increases in disturbance generally result in an increase in the percent of sand or silt deposition within the stream. An increases in small particle size substrate materials will:

- result in a decrease in diversity and species richness including the loss of more intolerant species,
- result in a gradual shift from univoltine to multivoltine species, and

- lead to a loss of secondary production (conversion of organic carbon into animal biomass) which will contribute to a loss of water quality due to a reduction in the streams ability to process organic material and re-cycle nutrients.

Degraded stream conditions can often be detected by an experienced biologist with only a cursory examination of the benthic assemblage. Aquatic macroinvertebrates are relatively easy to identify to family; many "intolerant" taxa can be identified to lower taxonomic levels with ease. In addition, benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances and adjust quickly to relatively slowly adjusting physical conditions (Niemi 1990) thus providing valuable information for interpreting cumulative effects.

Macroinvertebrates are typically abundant in most streams. Sampling is fairly easy yet requires careful procedures to prevent biased results. Sampling equipment is relatively inexpensive and the process has no significant effect on resident biota. Many small, unmodified streams, which often support only a limited fish fauna, naturally support a diverse macroinvertebrate population.

Most state water quality agencies that routinely collect biosurvey data focus on macroinvertebrates (Southerland and Stribling 1995) and as such may already have background macroinvertebrate data. Such background information may be valuable to field technicians that are not well versed with species that are common to a given area or when interpreting sampling results. In addition, sampling is generally performed between May 15th and September 30th to provide data that is comparable on a yearly basis.

Metric 11. Aquatic Macroinvertebrates

Aquatic macroinvertebrates are found in all areas of the active stream channel. Streams that provide stable habitat, stable flow rates and hard substrate materials, typically contain higher species diversity than streams that are less stable. The possibility of some form of toxic pollutant must be considered when aquatic macroinvertebrate populations are sparse or absent, even in the presence of good substrate materials.

Most assessment methods utilize one or a combination of key indicator organisms to describe in-stream habitats. Variations in macroinvertebrate life histories and sampling dates, however, may result in errors when interrupting results. In general, good quality streams will have populations of mayflies, stoneflies, caddis flies (Ephemeropterans, Plecopterans, and Trichopterans [EPT]), as well as assorted Dipterans (flies) and other common benthic fauna. Poor quality substrates result in disproportionately large populations of midge flies (Diptera: Chironomidae) with poor EPT representation.

High scores are associated with good diversity that include mayflies, stoneflies, and caddis while poor scores are associated with few species or streams that are dominated by only a very few species with one or two species being disproportionately dominant.

Selected References: Allan 1975, Minshall 1984, Richards and Host 1993, Richards and Minshall 1992, Rosenberg et al. 1986, Ward 1975, Cordone and Kelly 1961, Richards et al. 1997, Lenat 1984, Niemi et al. 1990

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 11. Aquatic Macroinvertebrate.	Macroinvertebrate populations are very diverse. Several different orders including mayflies, stoneflies, and caddis are present with no specie being overly dominant in number. Stoneflies may not be normally found in warmwater streams or during warm summer months.	Macroinvertebrate populations are somewhat diverse; however, not all groups of high water quality indicator species are present. Stoneflies may not be normally found in warmwater streams or during warm summer months. 1-3 species dominate the sample population.	Only one group of high water quality indicators (EPT) are present while midge flies, amphipods, and/or isopods are dominant and may occur in large numbers	EPT are absent with variable to few other macroinvertebrates found. The entire number of species found may not exceed 5 with 1 or 2 being obviously dominant in number.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Macroinvertebrate populations are an indirect description of land use, seasonal flow rates, annual temperatures, and diversity of substrate materials present. An experienced aquatic biologist can extrapolate a wealth of information concerning the watershed through careful macroinvertebrate sampling. In general, there is an increase in macroinvertebrate diversity associated with good habitat diversity, and good habitat diversity is associated with stable flow rates and a well vegetated, stable riparian zone that minimizes the effects of land use change. Changing watershed features that effect in-stream habitat can make changes in macroinvertebrate populations. However, an absence of macroinvertebrates in streams with good habitat is a strong indication of toxic chemical pollution and requires further chemical analysis of both water and sediments.

Macroinvertebrate scores should roughly agree (same score level) with Stream Channel Scores with some variance possible due to life histories (may be present in an adult or egg stage and therefore not seen in the samples). A total or near total absence of macroinvertebrates should be followed by careful water testing for the presence of toxic substances. Consult with your local or state natural resource agency for more information.

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GLOSSARY OF TERMS

Active Stream Channel - (see Stream Channel)

Aggradement - Aggradement is a process whereby the bottom of the stream channel increases in elevation. This increase is caused by a greater amount of sediment being deposited than removed (more sediment import than export).

Agroecosystem - A complex environmental system that involves interactions between the components and processes of natural ecosystems and activities associated with agricultural production

Benthos (as in Benthic Organism) - An inclusive term that refers to all living organisms on the bottom of an aquatic system.

Biota - A term that collectively refers to all living organisms in a defined area (e.g. stream biota).

Buffer Zone - The buffer zone (or buffer) is a term often substituted for riparian zone or the undisturbed vegetative area between the stream channel and existing land use. The term buffer zone describes this area's ability to trap and hold sediment and utilize nutrients from runoff. In addition, the buffer zone protects the stream from temperature extremes (shading) and supplies woody debris and leaf litter to the stream channel for food and necessary substrates.

Catchment or Catchment Basin (see Watershed)

Cobble (see Substrate)

Diversity - Diversity is a general description of the animal and/or plant community that considers both richness and relative abundance of different types of organisms. **Habitat diversity** is the same as plant and animal diversity only the reference is to the degree of variance in area characteristics that promotes or limits some or all plant and animal types.

Fauna - A term to collectively refer to all animal life in a given area.

Flora - A term to collectively refer to all plant life in a given area.

Geomorphology - The geologic composition of the land, the soil types, glacial deposits, mineral composition, etc. is referred to as an areas geomorphology.

Gravel (see Substrate)

Habitat - All of the physical, biological, and chemical aspects of an environment.

Hydrology - The characteristics, distribution, and movement of water both on and through the soil.

Inorganic Sediment - A small particle that was not once part of a living thing (e.g. sand or clay).

Macroinvertebrate - Organisms that are large enough to be seen by the unaided eye and without a spine or backbone are called Macroinvertebrates. These include insects, mollusks, and annelids to name a few.

Meandering - A meandering stream is one that flows in a side to side or, in a sinuous pattern, creating numerous bends.

Nutrient - Nutrients are elements that are required by living organisms in small amounts to facilitate necessary functions for respiration and growth. A partial list of common nutrients includes nitrogen, phosphorous, and carbon.

Organic - Any substance that is or was once living is considered to be organic.

Organic Substrate - Organic materials that make up the lake or stream bottom. These materials may include woody debris, leaf litter, and/or fine organic sediment from decomposed plant and animal tissues.

Pool - A pool is an area of the stream with greater than average depth and slower than average flow. Pools typically occur where the river bends or meanders.

Pool/Riffle Sequence - In their natural state, rivers, and streams have a pattern of flow that contains alternating pool and riffle areas. Each sequence should occur at approximately five to seven times the width of the stream.

Processing - Processing refers to the sum total of all physical and biological processes in the environment that assimilate and recycle nutrients and break down organic carbon into carbon dioxide and simple minerals.

Refugia (plural for refugium) A small, isolated area that has escaped the extreme changes undergone by the surrounding area allowing for the survival of plants and animals.

Relief (see Slope)

Retention - Retention is a characteristic of the stream environment whereby organic materials are temporally held in stable areas (quiet eddies or structural devices like logs, branches, or rocks) to allow for processing to occur.

Retention Device - Any instrument that is able to facilitate retention is considered to be a retention device (see Retention).

Richness - The relative abundance of an organism when compared to the total population of its environmental community is a measure of species richness. Typically, as diversity decreases specie(s) richness increases due to the lack of competition between different organisms for a limited resource (see Diversity).

Riffles - A riffle is a raised area of the active channel that results in an increase in flow velocity. Riffle areas are typically preceded by pools and represent the fastest current in a given river or stream.

Riparian Zone - The riparian zone is an undisturbed portion of land that interacts between the stream channel and the active land use. Riparian zones are frequently referred to as buffer zones to describe the protective nature of its vegetation to the stream environment.

Row Crop - Any crop or agricultural commodity that is grown in distinct rows with little or no vegetation between the rows. Common row crops include commodities such as corn and beans.

Scour - Erosion that occurs along the banks of the stream channel is called bank scour and is caused by frequent high water events that erodes bank vegetation away leaving exposed soil.

Sealing - (i.e. Soil Sealing) (see Soil Characteristics)

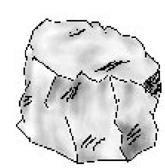
Sedimentation - The process of accumulating sediment is called sedimentation.

Slope - Sometimes called relief, the slope of the land is defined as the angle created by the rise over the run or the degree to which an elevation changes over a given distance.

Soil Characteristics - Soil traits are the physical properties of soil (below).

- **Blocky (angular)** - A soil aggregate (usually in the B-horizon) that has been reduced to irregular blocks with the three dimensions more or less equal. Size Range is from 0.5-4 inches. The edges of the cubes are sharp and distinct.

- **Blocky (sub-angular)** - Same as above only cube edges are less sharp or with somewhat rounded corners.



- **Crumbs** - Rounded aggregates that easily separate from each other when soil is pulled apart. Aggregates are distinctly porous and are found in grassland soils and soils worked by earthworms.

- **Gleying** - A process whereby soil particles become gray to bluish in color as a result of prolonged wet or anaerobic (no oxygen) conditions.

- **Granules** - Same as Crumbs only aggregates are relatively non-porous.

- **Massive –** Massive soil acts as single grains that are cohesive yet do not aggregated into structures such as crumbs or blocks.

- **Mottles** - Individual blotch or spot that distinctly differs in color from surrounding soil (see Mottling below).

- **Mottling** - Soil is interspersed with different colored blotches or spots.

- **Puddled** - Dense, massive soil that is artificially compacted when wet and has no aggregated structure. The condition commonly results from tillage of a clayey soil when it is wet.

- **Sealing** - Soil surface condition whereby the porous nature of the soil's surface becomes blocked with fine sediment or organic particles that prevent water infiltration. Sealed soils frequently have a hard or crusted surface and are subject to significant runoff and erosion potentials.

Stream Channel - The stream channel is the area containing the wetted portion of the stream (called the active stream channel) and the banks that contain the active channel.

Substrate - The materials that make up the surface of the stream bottom. Examples include (in order of size in millimeters) silt (<0.063), sand (0.062-1.0), gravel (2-64), cobble (65-256), and rock (>256). Stream substrates also include wood from branches and logs that have entered the stream channel from the terrestrial environment.

Taxa - (taxon = *singular*) A group of organisms organized or categorized by similar features are referred to collectively as taxa.

Topography - Topography refers to the physical structure of an environment.

Trophic - The relative position of an organism in the food chain is a description of its trophic level. The trophic level is often determined by food requirements or foraging base required by an organism.

Watershed - A watershed is a geographical basin. All water collected or captured within this basin will migrate towards a central collection area.

Woody Debris - Woody material (tree limbs and branches) that falls from the forested environment.

APPENDIX A

Physical Inventory Form

Physical Characterization/Water Quality Field Data Sheet

Stream Name		Location	
Station #	River Mile	Stream Class	
Lat	Long	River Basin	
Storet #		Agency	
Investigators			
Form Completed By	Date	AM PM	Reason For Survey

Site Location/Map	**Draw a map of the site and indicate the areas sampled. Identify dominant natural features and land use.**

Stream Characterization	**Subsystem Classification** **Stream Type** ☐ Perennial ☐ Intermittent ☐ Tidal ☐ Coldwater ☐ Warmwater
Weather Conditions	**Now** **Past 24 Hours** **Has there been a heavy rain in the last 7 days?** ☐ ☐ storm (heavy rain) ☐ Yes ☐ No ☐ ☐ rain (steady rain) **Air Temperature** °C ☐ ☐ showers (intermittent) **Other** ☐ ☐ % cloud cover ☐ ☐ clear/sunny

Riparian Zone/In-stream Features	**Predominant Surrounding Land Use** ☐ Forest ☐ Commercial ☐ Field/Pasture ☐ Industrial ☐ Agricultural ☐ Other ☐ Residential **Local Watershed NPS Pollution** ☐ No Evidence ☐ Some Potential Sources ☐ Obvious Sources **Canopy Cover** ☐ Partly Open ☐ Partly Shaded ☐ Shaded **High Water Mark** **Local Water Erosion** ☐ None ☐ Moderate ☐ Heavy **Estimated Stream Width** **Estimated Stream Depth** ☐ Riffle ☐ Run ☐ Pool Velocity **Estimated Reach Length** **Channelized** ☐ Yes ☐ No **Dam Present** ☐ Yes ☐ No
Riparian Vegetation (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☐ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous **Dominant species present**
Aquatic Vegetation	**Indicate the dominant type and record the dominant species present** ☐ Rooted Emergent ☐ Rooted Submergent ☐ Rooted Floating ☐ Free Floating ☐ Floating Algae ☐ Attached Algae **Dominant species present** **Portion of the reach with vegetative cover %**
Sediment/Substrate	**Odors** ☐ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other **Oil** ☐ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper Fiber ☐ Sand ☐ Relict Shells ☐ Other **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No
Water Quality	**Temperature** °C **Specific Conductance** **Dissolved Oxygen** **pH** **Turbidity** **WQ Instrument Used** **Water Odors** ☐ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ None ☐ Other **Turbidity (if not measured)** ☐ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Water color ☐ Other

Inorganic Substrate Components (should add to 100%)			**Organic Substrate Components (does not necessarily add up to 100%)**		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	>256 mm (10”)				
Cobble	64-256 mm(2.5”-10”)		Muck-Mud	black, very fire organic (FPOM)	
Gravel	2-64mm (0.1”-2.5”)				
Sand	0.06-2mm (gritty)		Marl		
Silt	0.004--0.06 mm				
Clay	<0.004 mm (slick)				

APPENDIX B

The Agricultural Water Quality Index

Introduction

The Agricultural Water Quality Index (AWQI) is an assessment tool designed for use in agroecosystems. Most existing environmental indices and assessment tools focus on the stream channel and/or riparian zone (the area between the channel and active land use). In contrast, the AWQI places an emphasis on land use and soil types that play a significant role in hydrologic cycles and water quality characteristics within the watershed.

The AWQI is designed to be used by agricultural technicians with limited experience in aquatic ecology; however, it does assume a reasonable background in soil characteristics. This index is intended for use during the active growing season (approximately mid-May through September). The purpose of the index is two-fold; to describe the level of vulnerability or potential environmental impact a particular farming operation may have to the stream environment, and to provide direction in developing farm management strategies that work to stabilize or improve water quality.

The following are condensed instructions that are designed to assist the farmer, field technician, or agricultural consultant that may be performing the assessment. A more technical version of the AWQI is available to individuals seeking additional background information or more detail involving individual metrics within the index.

The AWQI is divided into two major sections. Part I is a physical inventory of the site to be assessed. This information is standard to many aquatic studies and allows for some comparison among sites. Additionally, conditions that may significantly affect aquatic biota are documented. Seasonal variations (current temperature and recent weather events) as well as observations that relate to local conditions are helpful to fully understand the relationship between land use and water quality. Although the first section is not scored, it does provide important information that supports the second portion of the index.

Part II of the AWQI is composed of three general categories plus an optional fourth category. Each of the first three categories is subsequently broken down into three to five *metrics* or statements that describe an existing habitat condition. The first category, *Land Use And Soil Characteristics*, involves features outside of the immediate riparian zone that impact water movement through the watershed. These features include soils and land forms, current land use, and the soil and surface condition, which will collectively influence the pathway water follows as it migrates toward the stream.

The second category, *The Riparian Zone*, is intended to evaluate the ability of the riparian area (or zone) to filter sediment, nutrients, and stormwater as well as provide sufficient shade, woody debris, and organic carbon to the stream channel.

The third category involves the *Stream Channel* itself. These metrics describe the amount of water in the channel during base flow conditions as well as the streams response to rain and runoff events. Channel sinuosity and structure are metrics that describes both the type of streambed materials available (such as rock, cobble, sand, or woody debris) as well as the stream's ability to capture and retain materials for processing by stream biota.

An additional and optional category consists of one metric, which is a qualitative measure of existing *Aquatic Macroinvertebrates*. The goal of this final metric is to identify the presence or absence of tolerant versus intolerant species along with a relative measure of species diversity. This metric requires specific sampling equipment, knowledge of sampling methodologies, and a basic knowledge of aquatic macroinvertebrate taxonomy.

Following each category is a discussion of the metric scores. These discussions indicate how scores are related to the watershed and include suggestions that efficiently increase water quality protection. In many instances the necessary corrective action to improve the aquatic environment is made obvious by the metric score itself.

Metric scores from the second section of the index are given in two forms, a numeric value and a level of potential impact or vulnerability to impact (1-4). The vulnerability levels are as follows.

- *Level one* for optimal conditions. The stream environment is insignificantly impacted by local conditions.
- *Level two* for somewhat less than optimal conditions that exist without serious impacts to the stream environment.
- *Level three* denotes marginal or significant potential for impact to the stream environment.
- *Level four* describes poor conditions with the greatest level of vulnerability or impact.

The numeric score provides a more accurate description for each respective metric and a means to evaluate the effects of changing farm management strategies. Anticipated management changes can be re-scored against existing conditions to predict future outcomes to the stream environment. Total scores for each of the three categories should be placed in the appropriate box at the base of the individual score charts that follow each category.

PART I. Physical Inventory Of The Sampling Location

The physical inventory data sheet is generally self-explanatory. However, several areas that may require additional explanation are listed in more detail below.

Station Identifier

The station information is identical on all data sheets and requires sufficient information to describe the station and location where the assessment was conducted, date and time of assessment, and the investigators responsible for the quality and integrity of the data. The intent of good location information is to help identify access to the station for repeat visits.

Site Location/Map

To complete this phase of the bioassessment, a photograph may be helpful in identifying station location and documenting habitat conditions. A hand-drawn map is useful to illustrate major landmarks or features of the channel morphology (orientation, vegetative zones, buildings, to name a few) that might be used to aid in data interpretation.

Stream Characterization

Stream Subsystem: Note if the stream is perennial or intermittent, or where tidal influences on the stream will alter the structure and function of stream communities. Perennial streams flow all year long while intermittent streams typically flow only during wet seasons.

Stream Origin: Note the origin of the stream under study, if it is known. As the size of the stream or river increases, include the origin of additional tributaries as they occur.

Watershed Features

Subsequent assessments within the same watershed will require verification of possible changes in land use; however, features such as soil types and slope will remain constant and need not be re-described.

Predominant Surrounding Land Use Type: Document the prevalent land-use type in the watershed of the station, noting any other land uses in the area which, although not predominant, may potentially affect water quality. This documentation may be accomplished by a careful visual inspection of the area or by using current land use information that has been compiled by local agriculture and/or natural resource agencies.

Local Watershed Nonpoint-Source Pollution: Describe potential nonpoint-source pollution problems in the watershed or any other compromising factors that may affect water quality. You should include feedlots, constructed wetlands, septic systems, dams and impoundments, mine seepage, etc.

Local Watershed Erosion: The existing or potential detachment of soil within the local watershed (the portion of the watershed or catchment that directly affects the stream reach or station under study) and its movement into the stream is noted. Erosion can be rated through visual observation of watershed and stream characteristics. Note any point sources of pollution that are present in the area and any turbidity observed during water quality assessment below.

Riparian Vegetation

The riparian zone serves to protect the stream from excessive runoff that adds sediment and nutrients to the active channel. Accepted buffer widths are variable and based on land use, soil types, and slope. The vegetation within the riparian zone is documented here as the dominant type and species, if known.

In-stream Features

Proportion of reach represented by stream form types: The proportion represented by riffles, runs, and pools should be noted to describe the channel and flow diversity of the reach.

Estimated length of stream surveyed: This information is important if variable length reaches are surveyed and assessed. Indicate the length of the stream that was surveyed.

High water mark (feet): Estimate the vertical distance from the wetted channel to the peak overflow level, as indicated by debris hanging in riparian or floodplain vegetation, and deposition of silt or soil. In instances where bank overflow is rare, a high water mark may not be evident.

Inorganic substrate compounds: The difference between silt and fine sand may be difficult to identify in the field. As a general rule, sand will have a somewhat course or gritty texture when rubbed between your fingers while silt will be smoother.

Physical Characterization/Water Quality Field Data Sheet

Stream Name		Location	
Station # River Mile		Stream Class	
Lat Long		River Basin	
Storet #		Agency	
Investigators			
Form Completed By	Date AM PM		Reason For Survey
Site Location/Map	**Draw a map of the site and indicate the areas sampled. Identify natural features, structures and land use**		

Stream Characterization	**Subsystem Classification** ☐ Perennial ☐ Intermittent ☐ Tidal	**Stream Type** ☐ Coldwater ☐ Warmwater
Weather Conditions	**Now** **Past 24 Hours** ☐ ☐ storm (heavy rain) ☐ ☐ rain (steady rain) ☐ ☐ showers (intermittent) ☐ ☐ % cloud cover ☐ ☐ clear/sunny	**Has there been a heavy rain in the last 7 days?** ☐ Yes ☐ No **Air Temperature** °C **Other**

Riparian Zone/In-stream Features	**Predominant Surrounding Land Use** ☐ Forest ☐ Commercial ☐ Field/Pasture ☐ Industrial ☐ Agricultural ☐ Other ☐ Residential **Local Watershed NPS Pollution** ☐ No Evidence ☐ Some Potential Sources ☐ Obvious Sources **Canopy Cover** ☐ Partly Open ☐ Partly Shaded ☐ Shaded **High Water Mark**	**Local Water Erosion** ☐ None ☐ Moderate ☐ Heavy **Estimated Stream Width** **Estimated Stream Depth** ☐ Riffle ☐ Run ☐ Pool Velocity **Estimated Reach Length** **Channelized** ☐ Yes ☐ No **Dam Present** ☐ Yes ☐ No
Riparian Vegetation (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☐ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous **Dominant species present**	
Aquatic Vegetation	**Indicate the dominant type and record the dominant species present** ☐ Rooted Emergent ☐ Rooted Submergent ☐ Rooted Floating ☐ Free Floating ☐ Floating Algae ☐ Attached Algae **Dominant species present** **Portion of the reach with vegetative cover %**	
Sediment/Substrate	**Odors** ☐ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other **Oil** ☐ Absent ☐ Slight ☐ Moderate ☐ Profuse	**Deposits** ☐ Sludge ☐ Sawdust ☐ Paper Fiber ☐ Sand ☐ Relict Shells ☐ Other **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No
Water Quality	**Temperature** °C **Specific Conductance** **Dissolved Oxygen** **pH** **Turbidity** **WQ Instrument Used**	**Water Odors** ☐ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ None ☐ Other **Turbidity (if not measured)** ☐ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Water color ☐ Other

Inorganic Substrate Components (should add to 100%)			**Organic Substrate Components (does not necessarily add up to 100%)**		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	>256 mm (10”)				
Cobble	64-256 mm(2.5”-10”)		Muck-Mud	black, very fire organic (FPOM)	
Gravel	2-64mm (0.1”-2.5”)				
Sand	0.06-2mm (gritty)		Marl		
Silt	0.004--0.06 mm				
Clay	<0.004 mm (slick)				

PART 2. The Agricultural Water Quality Index

Metric #1. Hydrologic Soil Group And Landform (1a and 1b) requires a description of the dominant or average hydrologic soil classification and slope for approximately 500 yards adjacent to the riparian zone. The hydrologic soil classifications are as follows (USDA 92).

- Group A soils which have low runoff potential and high infiltration rates even when wet. They consist chiefly of sands and gravel's and are well to excessively drained.
- Group B soils have moderate infiltration rates when wet and consist chiefly of soils that are moderately deep to deep, moderately to well drained, and moderately to moderately course textures.
- Group C soils have low infiltration rates when wet and consist chiefly of soils having a layer that impedes downward movement of water with moderately fine to fine texture.
- Group D soils have high runoff potential, very low infiltration rates, and consist chiefly of clay soils.

Soil groups are defined in county soil survey maps, by physical examination, a description may exist with state or local agencies in a digital format for Geographic Information System (GIS) application. Slope can be measured in the field or using United States Geological Survey (USGS) topographical maps.

Use Metrics 1a and 1b if there is a change in slope from approximately 200 to 500 yards outside of the riparian zone and average the results into one score. If slope is constant for the entire 500 yards, only the latter (question 1b) is necessary and should be used to describe the slope for the full 500 yards.

Metric #2. Land Use – One To 500 Yards Adjacent To The Riparian Zone records a description of dominant or shared land uses that exist along the riparian zone.

Metric #3. Soil And Surface Conditions describes the soil structure and the condition of the soil surface. Use a shovel to examine the top 10-14 inches of soil for the given characteristics that determine soil structure. In addition, examine the surface of the soil for evidence of crusting or soil sealing that occurs in the presence of frequently disturbed soil. A soil manual may provide some initial assistance with soil descriptions.

Metric #4. Riparian Zone Width is the distance between the edge of the stream bank and the beginning of existing land use.

Metric #5. Riparian Zone Completeness describes breaks or potential weak points along the riparian continuum that may negate the buffering characteristics of the riparian vegetation. These breaks may appear as cattle paths, game trails, drives, or gullies formed by significant erosion. Any sudden change in the riparian vegetation that results in an area where the riparian width is significantly less should be scored as a break.

Metric #6. Riparian Zone Vegetation describes existing plant diversity within the riparian zone. A good mix of trees, shrubs, herbaceous, and grassy vegetation will maximize sediment filtering and nutrient assimilation capabilities within the riparian zone and provide woody debris and organic carbon leaf and plant litter to the stream channel.

Metric #7. Channel Flow Status characterizes hydrologic stability during base flow conditions. High scores should be given to streams that retain enough water at base flow to cover substrate materials in the active channel. Poor scores result when channel substrates are mostly or completely exposed. Look for evidence of dried algae or macroinvertebrate stone cases on exposed rocks and logs. Note if the stream is known to be perennial or intermittent.

Metric #8. Flow Stability differs from Channel Flow Status in that it describes flow stability as it relates to hydrologic responses from precipitation events. Stream systems with poor flow stability (sometimes called "flashy") react suddenly and sometimes violently to rain events. These streams typically have stream banks with a band of exposed soil beginning at the surface of the water. High scores describe streams with thick vegetation to the water's edge while flashy streams have bare soil as previously described.

Metric #9. Channel Sinuosity describes the extent of channel meandering through the riparian zone. Meandering streams typically have greater flow diversity in pools and riffles and are more efficient in diffusing stream power during high water events than straight channels. Straight channels tend to have more laminar flows, uniform substrate materials, and low aquatic plant and animal diversity.

Metric #10. Channel Structure describes both the presence and absence of hard substrate materials and the ability of these materials to trap and retain course and fine organic materials. Hard substrates and good retention capabilities are critical for facilitating nutrient cycling and carbon transformation processes that maintain good water quality.

Metric #11. (Optional) Aquatic Macroinvertebrates serve as excellent indicators of overall stream conditions. The stream channel should be sampled in proportion to the substrate materials represented with a standard D-frame or aquatic kick net. As an example, if substrate materials are 80% sand and 20% gravel, 80% of the sampling effort should be made in sandy areas and 20% in gravel areas. Macroinvertebrates need to be identified to a minimum of the taxonomic level order or family. Scores place an emphasis on diversity stoneflies, mayflies, and caddis flies representing high water quality indicators. Systems dominated by midge flies (Chironomidae) usually indicate poor stream environments.

Metrics And Scoring

The following metrics are to be applied against the average conditions that exist at each survey site. Circle an appropriate numerical score within each category that best fits local conditions.

Land Use And Soil Characteristics

Habitat Parameter	Condition Category			
	Level 1	Level 2	Level 3	Level 4
Metric 1a. Hydrologic Soil Group and Landform 1-200 yards outside of the immediate riparian zone.	0-5% slope and in hydrologic soil group A	0-5% slope and in hydrologic soil group B or >5-10% slope in hydrologic soil group A	0-5% slope and in hydrologic soil group C or >5-10% slope and in hydrologic soil group B or >10-15% slope and in hydrologic soil group A	Hydrologic soil group D or >5% up to 10% slope and in hydrologic soil group C or >10% and up to 15% slope and in hydrologic soil group B or > 15% slope and in hydrologic soil group A
SCORE	30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0

Note: Question 1b may not be necessary if the average slope for the given survey site is consistent from the edge of the riparian zone out to approximately 500 yards. If both metrics are necessary, average the two scores into one and record in the Soil Group and Landform portion of the Land Use And Soil Characteristics Summary following Metric 3.

Habitat Parameter	Condition Category			
	Level 1	Level 2	Level 3	Level 4
Metric 1b. Hydrologic Soil Group and Landform 200-500 yards outside of the immediate riparian zone.	0-5% slope and in hydrologic soil group A	0-5% slope and in hydrologic soil group B or >5-10% slope in hydrologic soil group A	0-5% slope and in hydrologic soil group C or >5-10% slope and in hydrologic soil group B or >10-15% slope and in hydrologic soil group A	Hydrologic soil group D or >5% up to 10% slope and in hydrologic soil group C or >10% and up to 15% slope and in hydrologic soil group B or > 15% slope and in hydrologic soil group A
SCORE	30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0

Habitat Parameter	Condition Category			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 2. Land use approximately one to 500 yards beyond the immediate riparian zone (modified from Petersen 1992)	Generally undisturbed, consisting of forest and/or wetland . Interruptions or modifications to the natural setting from residential dwellings or agriculture are rare. Vegetative cover is complete with no unnatural breaks or bare spots	Permanent pasture/hay mixed with woodlots and/or swamps with few mixed row and small grain crops. Vegetative cover may have a few breaks or bare spots. Occasional modifications for residential dwellings or agricultural dwellings.	Consisting of a mixture of row crops, small grains, and pasture/hay or an increase in suburban characteristics (multiple housing units in close proximity). Vegetative cover may contain many weed and/or brush species. May have some bare areas.	Land use is dominated by row crops or is largely urban or suburban in nature. Vegetative cover may have many breaks or bare areas. The lowest end score would be a paved area or compacted bare soil.
SCORE	30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0

Habitat Parameter	Condition Category			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 3. Soil and Surface Conditions (outside of the riparian zone)	Surface open or loose, even when wetted. Large strong granules, crumbs or sand particles. Many root channels and earthworm burrows and other voids in the soil. No gleying or mottling.	Surface open or loose, small or weak granules or crumbs or sand particles. Some root channels and earthworm burrows. May have orange or bright mottles	Surface crusted however easy to break Or Structure very fine and very weak or is sub-angular blocky to blocky. May have mottles or gleying	Surface crusted and hard to break Or Bulk soil massive or puddled. No evidence of granules or crumbs. No root channels or earthworm burrows. Contains mottling and/or gleying. The most undesirable extreme is a paved area or a compacted bare crusted area.
SCORE	30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0

Land Use And Soil Characteristics Summary

While land use has a dramatic effect on water movement through a landscape, natural geomorphic features such as soil types and slope are not options that can be changed by man. However, these features are essential forces that define hydrologic processes and are strongly influenced by land use management. Poor scores for soil types do not indicate a poor quality soil. These scores do, however, suggest a greater vulnerability to surface runoff than higher scores. This vulnerability increases with an increase in slope and/or land use that involves frequent soil disruption. Soil types that are susceptible to surface runoff may exaggerate the effects to a stream due to increases in slope or patterns of land use that reduce soil structure.

Place land use scores in the appropriate box below each respective category. Consult the *Recommendations* section for the highest of the three scores listed to determine possible farm management changes that will minimize potential impacts to the stream environment.

Metric #1 Soil Group And Landform	Metric #2 Land Use	Metric #3 Soil Surface Condition	Recommendations
Level 4			Land cannot tolerate a continuous crop. Set to forest, permanent pasture, or long rotations. Avoid or minimize row crops. Use minimum or no-till with additions of organic matter/crop residue. Badly eroded land may require complete renovation. In addition, follow recommendations for Level 2 and 3 categories.
Level 3			Be alert as some precaution is needed. If in continuous row crop, rotate to a non-row crop. Use minimum or no till where tillage is required. In addition, follow recommendations for Level 2
Level 2			Have soils tested to determine if lime or fertilizer additions are needed. Examine vegetative cover. If cover is sparse, interseeding is needed.
Level 1			No special precautions or new management schemes are needed based on this assessment.

Total Land Use And Soil Characteristics Score________(Metrics 1+2+3)

Land Use And Soil Characteristics Adjustment Factor

Agricultural lands that have been exposed to recent increases or decreases in conservation tillage practices will reflect changes to the soils hydrologic characteristics over time. While the total land use score (above) reflects current conditions, the following metric is an adjustment factor that reflects the potential change to soil hydrologic conditions and potential impact to the stream environment. The Crop and Tillage Practice metric below provides a potential adjustment to the Land Use and Soil Characteristics score in the chart above and, therefore, a method of evaluating the effects of various farm management practices. Add the *adjustment factor* score to the Land Use and Soil Characteristics Score listed above for a Land Use and Soil Characteristics Score (adjusted).

Farm Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Crop And Tillage Practices (Adjustment Factor).	Long term rotation with minimal row cropping and maximal hay and/or pasture. Mixed farm uses including crop production and pasture. Minimum or no-till where applicable.	Short term crop rotation with conservation or no till practices.	Some crop rotation with standard tillage practiced.	Intensive row crop monoculture with intensive tillage.
SCORE	5	0	-5	-10

Total Land Use And Soil Characteristics Score (Adjusted**)**__________
(Metrics 1+2+3 plus the Adjustment Factor)

The Riparian Zone

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 4. Riparian Zone Width (from stream to edge of field).	Marshy or woody riparian zone 100 to 150 feet or more.	Marshy or woody riparian zone varying from 50 to 99 feet.	Marshy or woody riparian zone from 20 to 49 feet .	Marshy or woody riparian zone essentially absent or less than 20 feet.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 5. Riparian Zone Completeness (Petersen 1992).	Riparian zone intact to nearly intact with infrequent breaks occurring at intervals greater than 165 feet.	Incidental breaks in the riparian zone at approximately 100-164 foot intervals.	Breaks in the riparian zone frequent with some gullies and scars occurring every 100 feet.	Riparian zone has frequent breaks in the vegetation with deeply scarred gullies along its length.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 6. Riparian Zone Vegetation.	Riparian vegetation consists of trees, shrubs, herbaceous species, and grasses. Maximum canopy potential is achieved with native plant species.	Riparian vegetation has sustained some degree of alteration. Some degree of canopy cover less than the maximum potential exists. At least one of the four categories of plants is missing or very limited.	Riparian vegetation has been altered with at least two of the four categories missing. Obvious gaps in the canopy exist, and the potential to supply organic material and woody debris to the stream channel has been significantly reduced.	Riparian vegetation has been severely altered with an abundance of only one or none of the four plant categories present. Organic material and woody debris is not realistically available to the stream channel or has been replaced with agricultural commodities or used as pasture.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Riparian Zone Scores

Place the Riparian Zone Width score in the appropriately box within its respective category below. If the Land Use score (from the previous section) was a level 3 or 4, shift to the next higher level of vulnerability and refer to the *Recommendations* listed to the right in the same row. As an example, if the Riparian Zone score is 17 (level 1) and the Land Use score was 14 (level 3), refer to the level 2 Riparian Zone Width *Recommendations*. No adjustments are necessary if Riparian Zone Width score falls into a level 4 category or if Land Use scores fall into a level 1 or 2 category. All recommendations assume that the condition and completeness of the riparian zone is of high quality. In all cases, changes in land use may require increases in riparian zone width.

Metric #4 Riparian Zone Width	**Recommendations**
Level 4	Riparian zone widths need to be increased to a minimum of 100 feet in areas containing hydrologic soil groups A or B and slopes <10% and up to 165 feet for hydrologic soil groups C or D. Where slopes exceed 10% an additional 50 feet may be necessary, especially if land use involves frequent tilling and/or occasional row crops or if slope exceeds 10%. Refer to level 1 riparian characteristics (metric #6) as a guide to riparian zone reconstruction.
Level 3	Riparian zone widths need to be doubled or tripled in areas containing hydrologic soil groups A or B with slopes <10% with an additional 50 feet for areas containing hydrologic soil groups C or D. An additional 50 feet may be necessary where slopes exceed 10%, especially if land use involves frequent tilling and/or occasional row crops. Refer to level 1 riparian characteristics as a guide to riparian zone reconstruction.
Level 2	Riparian widths may be adequate if located within hydrologic soil group A with less than a 10% slope or hydrologic soil group B with less than a 5% slope. An additional 50 feet is necessary for areas containing hydrologic soil groups C or D or where slopes exceed 10% or where land use involves frequent tilling and/or occasional row crops.
Level 1	No special recommendations are needed based on this assessment. However, changes in existing land use may require increases in current riparian zone widths.

Place the Riparian Zone Completeness score in the appropriately box below, following the same pattern of scoring instructions as previously given with respect to the Land Use score. All recommendations assume an adequate Riparian Zone Width. If not adequate, these recommendations must be performed in conjunction with the Level 1 Riparian Zone Width description from Metric #4.

Metric #5 Riparian Zone Completeness	Recommendations
Level 4	Identify and eliminate sources of erosion. Restore eroded banks with appropriate vegetation. Refer to Level 3 and 4 recommendations under Riparian Buffer Widths.
Level 3	Modify and/or eliminate non-essential breaks in the riparian vegetation. Essential breaks in the vegetation need to be modified so that surface runoff flows away from the area of the break. Continue to observe riparian zone standards as described in the previous section.
Level 2	Modify essential breaks in the riparian vegetation so that surface runoff flows away from the area of the break. Continue to observe riparian zone standards as described in the previous section.
Level 1	No special recommendations are needed based on this assessment. Continue to observe riparian zone standards as described in the previous section.

Place the Riparian Zone Vegetation score in the appropriately box below, following the same pattern of scoring instructions as previously given with respect to the Land Use score. All recommendations assume an adequate Riparian Zone Width. If not adequate, these recommendations must be performed in conjunction with the Level 1 riparian zone width description in Metric #4.

Metric #6 Riparian Zone Vegetation	Recommendations
Level 4	Riparian vegetation needs to be re-established. One third of the riparian zone area nearest the stream should be planted with several large tree species at approximately 6-10 foot intervals. The middle third of the riparian zone should be planted with woody shrubs at 3-6 foot intervals while the remaining portion of the riparian zone should remain as undisturbed grasses with intermittent woody shrubs. Refer to the section on Riparian Zone Widths for the correct dimensions for existing soil types, land use, and land features.
Level 3	Riparian vegetation needs to be expanded to include the various forms listed above. Select species that will provide some degree of shade and stability to the stream channel.
Level 2	Areas where riparian vegetation has been altered should be selectively restored. Select species that will provide some degree of shade and stability to the stream channel.
Level 1	No special recommendations are needed based on this assessment. However, changes in current land use may require increases in riparian zone widths. Continue to monitor vegetation quality for changes due to high water or frequent flooding that may eliminate some forms of grasses, trees, or shrubs.

Total Riparian Zone Score__________ (metric numbers 4+5+6)

The Stream Channel

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 7. Channel Flow Status (from Barbour et al. 1997).	Water reaches the base of both banks with minimal or no channel substrates exposed.	Water reaches >75% of the active channel substrates or <25% of active channel substrate is exposed.	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in the channel and mostly present as standing pools.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 8. Flow Stability (at or near base flow).	Vegetation along the stream banks is complete nearly to the water's edge. Little or no evidence of frequent changes in discharge and/or stream velocity that scours stream bank vegetation. Channel retention devices (if present) mostly stable and extending laterally across the stream channel.	Some evidence of bank scour approximately eight to 4-8 inches above the water surface. Channel retention devices (if present) mostly stable and extending partially into the stream channel.	Bank scour evident 9-18 inches above the water surface. Channel retention devices (if present) tend to lay more against the stream bank rather than extending out into the active channel.	Bank scour severe (>20 inches) into the stream channel. Channel retention devices are generally absent from the active channel and/or may exist as woody debris jams along the stream bank above the active channel.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 9. Channel Sinuosity (from Barbour et al. 1997).	The bends in the stream increase the stream length 3 to 4 times longer than if it was a straight line.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel is essentially straight; waterway has been channelized for a long distance.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 10. Channel Structure (Retention Devices).	Channel structure comprised of rocks and/or logs firmly set in place in both the active channel as well as along the interface of the bank and channel area.	Channel structure comprised of rocks and/or logs however largely backfilled with sediment.	Channel structure loose; moving with floods.	Channel with few or no retention structures. Substrate materials dominated by sand and silt.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

Stream Channel Scores

Add total scores for the entire Stream Channel section (metrics 7-10) and place in the appropriate box below. Refer to the *Recommendations* section immediately to the right of the Stream Channel score for direction with future management strategies.

Stream Channel Scores	**Recommendations**
Level 4 (Scores 0-15)	Poor habitat that has resulted from riparian zone impairment, poor land use management and/or somewhat recent stream channelization. Re-establish adequate riparian widths and land use management strategies as described in previous sections. If the disturbance is not caused on site, maintain adequate riparian zone widths and appropriate land use management strategies to minimize additional sediment and nutrient inputs.
Level 3 (Scores 16-30)	Marginal habitat. Re-examine Land Use and Riparian Zone scores to identify possible causes of habitat loss. Identify possible weak areas from individual Stream Channel metric scores and adjust. If Land Use and Riparian Zone scores are in Level 1 or 2, determine the extent of impacts resulting from upstream land use. Increase protective measures where possible.
Level 2 (Scores 31-45)	Suboptimal habitat. Identify possible weak areas from individual Stream Channel metric scores and adjust where possible. If Land Use and Riparian Zone scores are in Level 1 or 2, determine the extent of impacts resulting from upstream land use.
Level 1 (Scores 46-60)	Optimal habitat. Continue to maintain adequate riparian zone widths and farm management practices that minimize impacts to the stream environment.

Total Channel Score_________(metrics 7+8+9+10)

Cumulative Metric Score Results

Step 1. Add the Total Riparian Zone Score with the Total Land Use And Soil Characteristics Score (metrics 1-6) to form a *Total Land Use And Riparian Score* (0 to 150). Place this score in the appropriate space indicated in Figure 1. Place an *X* in the position along the horizontal scale labeled "Land Use And Riparian Score" that represents your *Total Land Use And Riparian Score.* From the *X*, draw a vertical line to the top of the colored chart.

Step 2. Place the Total Stream Channel Score (0-60 for metrics 7-10) in the appropriate space indicated in Figure 1. Place an *X* in the position along the vertical scale labeled "Channel Score" that represents your score results. From the *X*, draw a horizontal line to the right side of the colored chart.

Step 3. Circle the point where the two lines intersect.

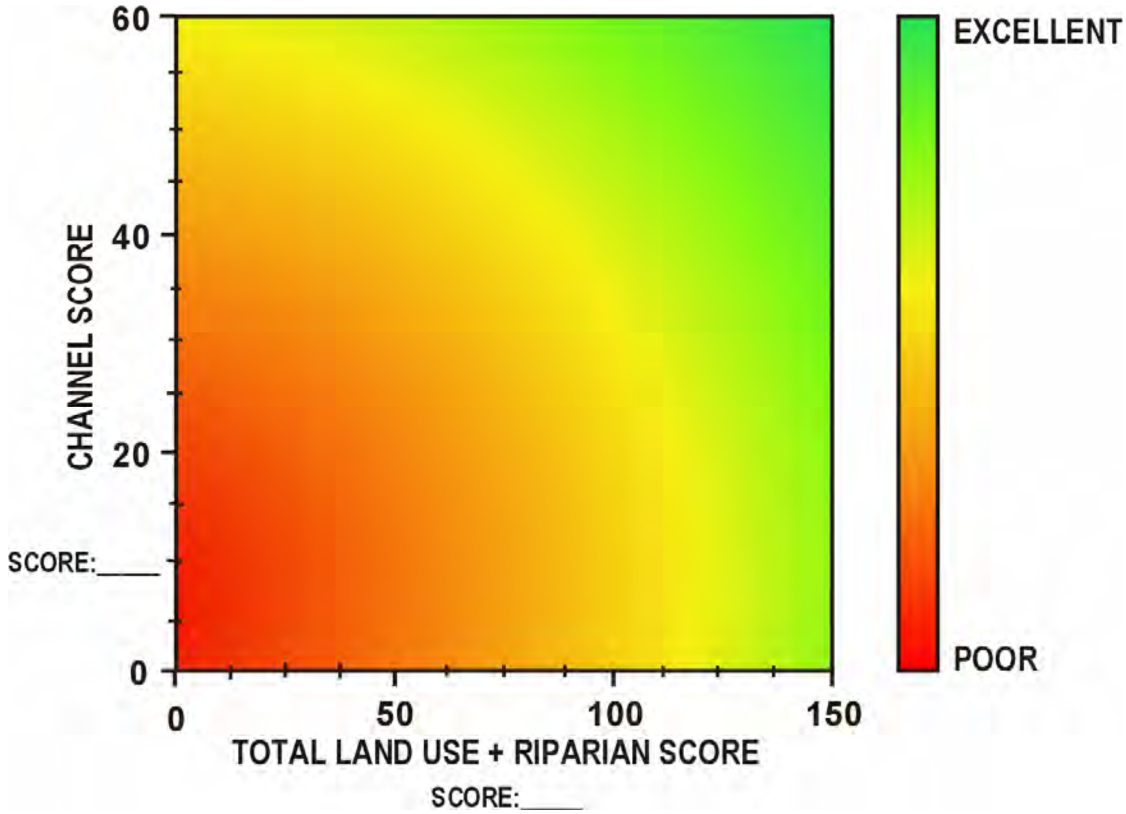


Figure 1. Cumulative score chart for the AWQI. Record the Total Land Use and Riparian Score in the appropriate blank and place an X where this score occurs on the horizontal axis. In similar fashion, record the Channel Score in the appropriate blank and place an X where this score occurs on the vertical axis. Draw a straight (vertical and horizontal) line from each X to the opposite side of the chart and circle the intersect of the two lines.

Both aquatic and terrestrial environments are multi-dimensional, highly dynamic systems that remain in a constant state of flux with temporal and spatial changes. Because of this variability, total scores need to be somewhat approximate when describing real environmental conditions to accurately communicate the constant yet subtle changes in nature. The AWQI utilizes a color gradient to represent final assessment results. An exact numerical score implies a precise condition that rarely if ever exists in environmental assessments, whereas the color gradient more accurately reflects environmental complexity. The color gradient in Figure 1 represents a continuum between very good conditions (green shades) to very poor conditions (orange to red shades) for Channel Scores. For Land Use And Riparian Scores, the color continuum represents a shared impact from upstream and adjacent conditions that are responsible for existing channel characteristics and the intensity of the potential to impact the stream environment.

The intersection of the two lines provides an estimation of the degree that the existing stream environment is due to upstream watershed conditions (line intersection is on the far right side of the figure). A degree of shared impact potential is described when the line intersection is between the extreme right and left margins of the figure. When the intersection is on the far left side of the chart, adjacent conditions could be largely responsible or impose a high potential for impairment to the stream environment. In general, the relative amount of potential impact to the stream from adjacent land use, soils, and riparian conditions is greater if the intersection is to the left and less if the intersection is to the right.

The color fields transected by the vertical line illustrate the intensity of a potential stream impact. Only a minimal potential to impact the stream exists if the line passes through green and/or yellow shades while a more serious potential exists if the vertical line crosses red or orange field.

As an example, if the Channel Score is 55 and the Land Use And Riparian Score is 145 (Figure 2, Example A), the intersection will occur in the green, upper right portion of the figure. The interpretation would be that stream conditions are good, as a result of upstream conditions, and adjacent characteristics offer little potential to impact the stream. If the Channel Score remains the same and the Land Use And Riparian Score is 40 (Figure 2, Example B), the intersection would communicate that stream conditions are good; however, there is a strong potential for impact from adjacent land use, soil, and/or riparian conditions.

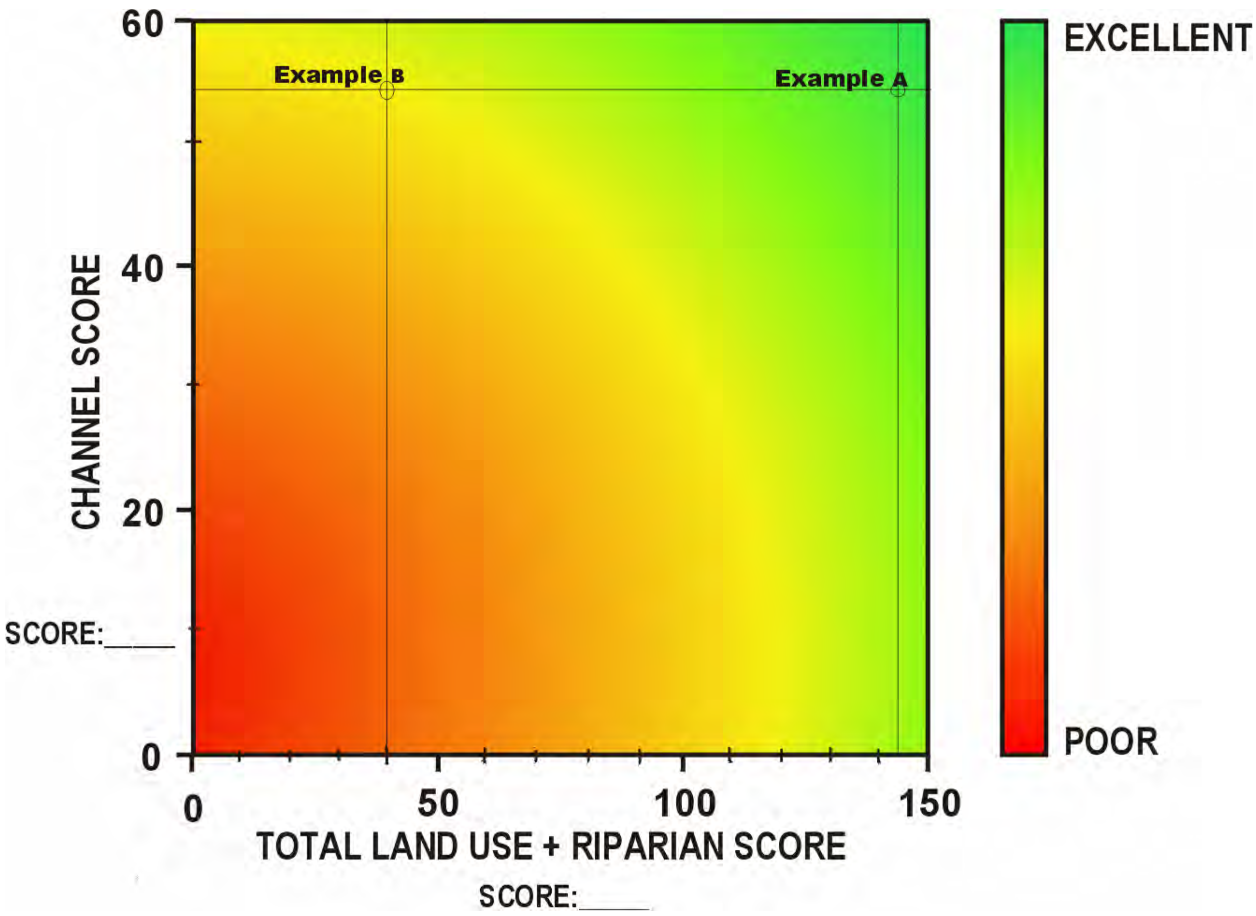


Figure 2. An example of a high Stream Channel Score with a high Land Use And Riparian Score (Example A) and a high Stream Channel Score with a poor Land Use And Riparian Score (Example B).

In reality an investigator will probably encounter conditions where both sets of scores are less than excellent. As an example, if the Channel Score is 35 and the Land Use And Riparian Score is 100 (Figure 3, Example C), the interpretation would conclude that stream conditions are marginal. While the upstream portion of the watershed contributes a substantial percent to current channel conditions, adjacent conditions also offer the potential (yellow bordering on orange) to contribute to existing channel conditions. Again, if the Channel Score remains 35 and the Land Use And Riparian Score is 60 (Figure 3, Example D), the interpretation would conclude that stream conditions are marginal and adjacent conditions have a strong potential to contribute along with upstream portions of the watershed. This latter conclusion is drawn by the position of the transect (degree of share responsibility) and by the colors transected by the vertical line (orange/red).

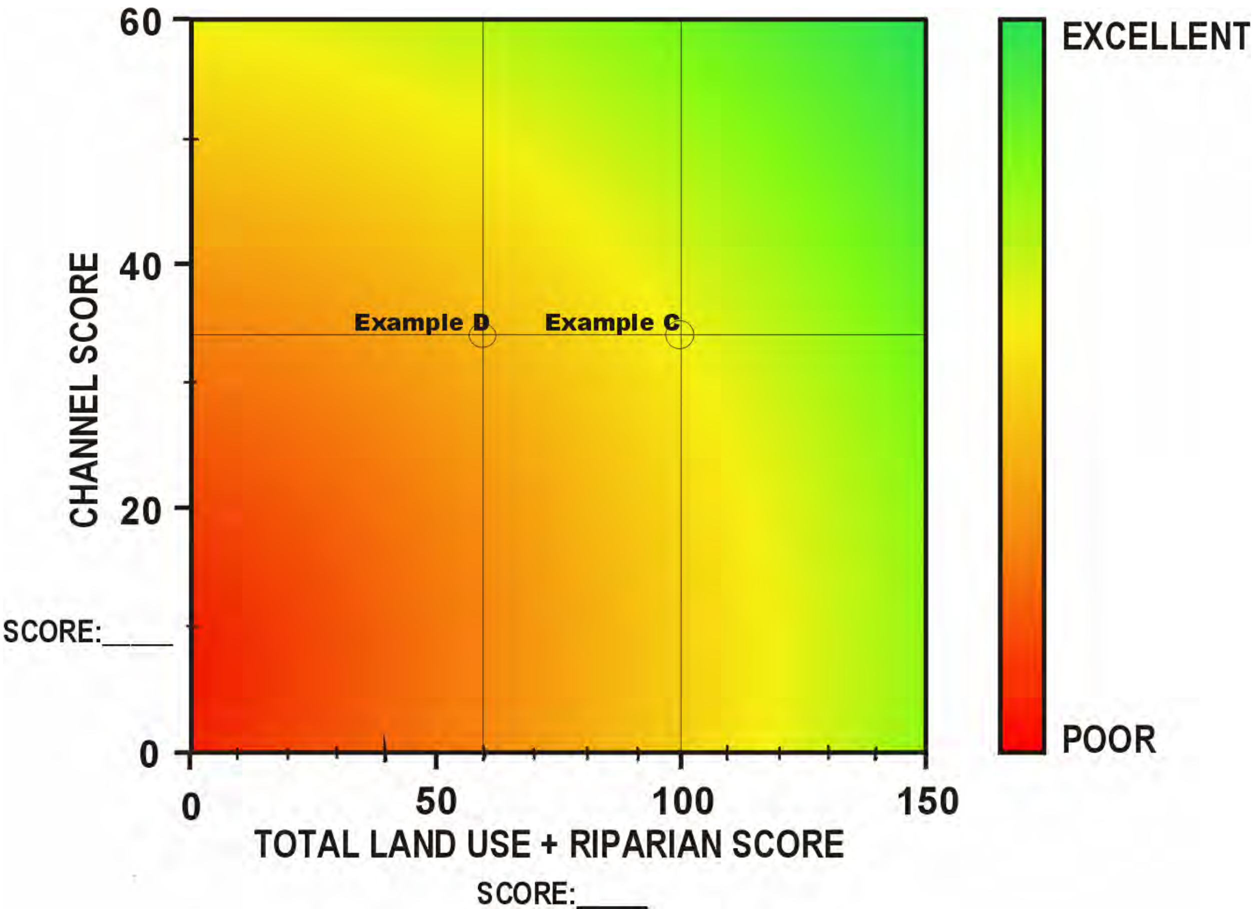


Figure 3. An example of a marginal Stream Channel Score with a fair Land Use And Riparian Score (Example C) and a marginal Stream Channel Score with a poor Land Use And Riparian Score (Example D).

Score Modifications

Once existing conditions have been scored and the results interpreted, potential modifications to current farm management strategies or changes to the riparian zone can be made within the index to project potential outcomes. This will allow the producer/land owner to make theoretical changes using the AWQI index itself and extrapolate outcomes expressed as the potential to impact stream quality and, therefore, water quality. Add the adjustment score to the Total Land Use And Soil Characteristics Score and repeat Steps 1 and 3 under Score Results. Plot additional vertical lines in Figure 3 and compare with existing conditions as shown by the initial line plotted.

Aquatic Macroinvertebrates

The following metric is an optional check or method of validating the AWQI assessment process. An additional and optional category consists of one metric, which is a qualitative measure of existing *Aquatic Macroinvertebrates*. The goal of this final metric is to identify the presence or absence of tolerant versus intolerant species along with a relative measure of species diversity. This metric requires specific sampling equipment, knowledge of sampling methodologies, and a basic knowledge of aquatic macroinvertebrate taxonomy. If used, scores should be at approximately the same level as the Channel Scores listed above, specifically Metric #10. Strong discrepancies may indicate a need to re-examine some or all of the Stream Channel metrics or consider chemical contamination as a possible explanation.

Habitat Parameter	**Condition Category**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Metric 11. Aquatic Macroinvertebrate.	Macroinvertebrate populations are very diverse. Several different orders including mayflies, stoneflies, and caddis are present with no specie being overly dominant in number. Stoneflies may not be normally found in warmwater streams or during warm summer months. 1-3 species dominate the sample population.	Macroinvertebrate populations are somewhat diverse; however, not all groups of high water quality indicator species are present. Stoneflies may not be normally found in warmwater streams or during warm summer months. 1-3 species dominate the sample population.	Only one group of high water quality indicators (EPT) are present while midge flies, amphipods, and/or isopods are dominant and may occur in large numbers	EPT are absent with variable to few other macroinvertebrates found. The entire number of species found may not exceed 5 with 1 or 2 being obviously dominant in number.
SCORE	15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0

APPENDIX C

Macroinvertebrate Sampling Results

River/Stream________________________Site ID________________Date___/___/____ Time__________AM PM

Individuals Present (initials)______________,______________,______________,______________

	Riffle/ Cobble	Coarse Dep.	Fine Dep.	Bank	Woody	Plant
ANNELIDA						
Oligochaeta						
ARTHROPODA						
ISOPODA (sow bugs)						
AMPHIPODA (scuds)						
DECAPODA						
INSECTA						
Ephemeroptera						
Baetidae						
Ephemerellidae						
Isonychiidae						
Heptageniidae						
Leptophlebiidae						
Tricorythidae						
Ephemeridae						
Plecoptera						
Perlidae						
Pteranarcidae						
Taenyopterigidae						
Nemouridae						
Perlodidae						
Odonata						
Zygoptera (damselflies)						
Anisoptera (dragonflies)						
Hemiptera (true bugs)						
Belostomatidae						
Belastoma						
Corixidae						
Notonectida						
Gerridae						
Megaloptera						
Sialidae						
Corydlidae						
Nigronia						
Corydalis						
Trichoptera						
Glossosomatidae						
Limnephilidae						
Helicopsychidae						
Brachycentridae						
Molanidae						
Rhyacophilidae						
Hydropsychidae						
Percent (of total available substrate) represented in sample reach.	%	%	%	%	%	%

	Riffle/ Cobble	Coarse Dep.	Fine Dep.	Bank	Woody	Plant
Coleoptera						
Psephenidae						
Elmidae						
Hydrophilidae						
Dytiscidae						
Staphylinidae						
Diptera (flies)						
Tipulidae						
Simuliidae						
Chironomidae						
Tabanidae						
Empididae						
Ceratopogonidae						
Athericidae						
Culicidae						
MOLLUSCA						
Gastropoda (snails)						
Pelecypoda (clams)						
Other (specify)						

Total Number of Taxa
Number of Mayfly Taxa
Number of Stonefly Taxa
Number of Caddisfly Taxa
Percent Mayfly Comp.
Percent Caddis Comp.
Percent Contr. Dom. Taxon
Percent Isopod, Snail, Leech
Percent Surface Air Breathers
Ratio EPT:Chiron

# of samples/habitat ____ ____ ____ ____ ____ ____