United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

National Biology Handbook

Subpart B—Conservation Planning

Part 614

Stream Visual Assessment Protocol Version 2

Issued draft December 2009

For additional information contact:

Fisheries Biologist
West National Technology Support Center
1201 NE Lloyd Blvd., Suite 1000
Portland, OR 97232
(503) 273–2400

Preface

This document presents a revised and updated NRCS Stream Visual Assessment Protocol Version 2 (SVAP2) for use by conservation planners, field office personnel, and private landowners. Like its predecessor, it is a relatively easy-to-use tool for qualitatively evaluating the condition of aquatic ecosystems associated with wadeable streams, that is, those shallow enough to be sampled without use of a boat. Such wadeable streams include those modified to improve drainage on agricultural lands, especially if these systems are part of an ecologically functional stream and/or river network. While the protocol does not require users to be experts in aquatic ecology, it does require they read the protocol's user guidance thoroughly before beginning an assessment. The SVAP and SVAP2 are tools that work best when users first identify local stream reference conditions that can effectively provide a standard for comparison. State offices are encouraged to refine the protocol based on the physical settings, stream conditions, and life history requirements of aquatic fauna found in their specific locales. Additional guidance on how to make State modifications is provided in appendix C.

Both versions of the SVAP provide a relatively basic level of ecological assessment based on qualitative descriptions. Each is designed to give a snapshot of wadeable stream ecosystem conditions that allows planners and conservationists to assist landowners with determining the quality of stream habitats located on their property. SVAP2 was developed to provide more comprehensive descriptions of several scoring elements, namely, channel condition, hydrological alteration, riparian area conditions, and fish habitat complexity. Field conservationists are encouraged to use SVAP2 in those situations where more detail is needed to critically score these elements and their relative contribution to the condition of the stream. This version lends itself to tracking trends in stream conditions over time, as well as identifying resource concerns and their potential causes. The original SVAP is designed to be conducted with the landowner. SVAP2 can be completed with a landowner or conservation planning team. Background information relevant to ecological processes and functions of stream/riparian ecosystems is incorporated into both versions of the SVAP.

Acknowledgments

This version of the Stream Visual Assessment Protocol (SVAP) was developed by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) under the leadership of **Kathryn Boyer**, fish biologist, West National Technology Support Center, Portland, OR. The SVAP Revision Workgroup members provided substantial assistance in revision of the overall protocol and specific scoring elements.

Jenny Adkins, water quality specialist, NRCS, Nashville, TN

Kale Gullett, fisheries biologist, East National Technology Support Center, Greensboro, NC

Edward Neilson, resource conservationist, NRCS, Grand Junction, CO

Barry Southerland, fluvial geomorphologist, West National Technology Support Center, Portland, OR

Billy Teels (retired), Central National Technology Support Center, Fort Worth, TX

Deborah Virgovic, fisheries biologist, NRCS, Mount Vernon, WA

Kip Yasumiishi, civil engineer, West National Technology Support Center, Portland, OR

Formal technical reviews of an earlier draft of the protocol were completed by the following people whose assistance is much appreciated.

Greg Kidd, biologist, NRCS, Madison, WI

Julie Hawkins, biologist, NRCS, Richmond, VA

Robert Weihrouch, biologist, NRCS, Madison, WI

Mitch Cummings, fisheries biologist, NRCS, Tillamook, OR

Todd Bobowick, soil conservationist (fisheries), NRCS, Torrington, CT

Erin Myers, biologist, NRCS, Gainesville, FL

Romy Myszka, biologist, NRCS, Fort Worth, TX

Jennifer Anderson-Cruz, biologist, NRCS, Des Moines, IA

Stephen Brady, wildlife biologist, NRCS, Fort Worth, TX

Chet Hadley, biological science technician, NRCS, Heppner, OR

Andrew Lipsky, biologist, NRCS, Warwick, RI

Daniel Thompson, wildlife biologist, NRCS, Grand Junction, CO

National Riparian Service Team, Bureau of Land Management, Prineville, OR

Part 614

Stream Visual Assessment Protocol Version 2

Contents:

614.00 Introduction 614–1

614.01 What is a healthy stream? 614–2

614.02 Stream classification 614–5

614.03 Reference sites 614–5

614.04 Using this protocol 614–6

(a) Preliminary assessment of the stream's watershed 614–6
(b) Delineating the assessment reach 614–6
(c) Scoring the elements of the Stream Visual Assessment Protocol 614–8

614.05 Stream assessment elements 614–9

(a) Element 1—Channel condition 614–9
(b) Element 2—Hydrologic alteration 614–17
(c) Element 3—Bank condition.. 614–19
(d) Elements 4 and 5—Riparian area quantity and quality 614–21
(e) Element 6—Canopy cover 614–24
(f) Element 7—Water appearance 614–26
(g) Element 8—Nutrient enrichment.. 614–27
(h) Element 9—Manure or human waste presence 614–28
(i) Element 10—Pools.. 614–29
(j) Element 11—Barriers to aquatic species movement............................ 614–31
(k) Element 12—Fish habitat complexity 614–32
(l) Element 13—Aquatic invertebrate habitat.. 614–34
(m) Element 14—Aquatic invertebrate community 614–36
(n) Element 15—Riffle embeddedness 614–40
(o) Element 16—Salinity (if applicable) 614–41

614.06 References 614–42

Appendices

Appendix A Additional References for Further Reading A–1
Appendix B Glossary B–1
Appendix C Technical Information to Support Implementation of the Stream Visual Assessment Protocol Version 2 C–1

Tables

Table 1	Guide to figure ratings and CEM stage	614–14
Table C–1	Correlations between qualitative SVAP metrics and quantitative EMAP metrics	C–3

Figures

Figure 1	Factors that influence the quality or condition of streams (modified from Karr et al. (1986))	614–3
Figure 2	Baseflow, bankfull, and flood plain locations	614–7
Figure 3	Channel Evolution Model	614–9
Figure 4	CEM stage I. Typically excellent channel condition with natural bank protection	614–9
Figure 5	CEM stage II. Poor channel condition, headcuts common	614–10
Figure 6	CEM stage III, with bars adjacent to vertical banks	614–10
Figure 7	CEM stage V channel, with developing flood plain and abandoned flood plain, now a terrace	614–10
Figure 8	CEM stage I. Score: 10	614–12
Figure 9	CEM stage V. Score: 9	614–12
Figure 10	CEM stage I. Point bars below bank. Score: 8	614–12
Figure 11	CEM stage V. Slight flood plain detachment. Score: 8	614–12
Figure 12	CEM stage V. Score: 7	614–13
Figure 13	CEM stage IV. Score: 6	614–13
Figure 14	CEM stage IV. Score: 5	614–13
Figure 15	CEM stage III. Score: 4	614–13
Figure 16	CEM, stage II. Score: 3	614–14
Figure 17	CEM stage III, with active point bars forming. Score: 2 or 1	614–14
Figure 18	CEM stage II. Score: 1 or 0	614–14

Figure 19	Aggrading channel with point bar separated from flood plain. Score: 8	614–15
Figure 20	Aggrading channel with shallow areas in reach. Score: 6–7	614-15
Figure 21	Aggrading channel, downward trend with lateral migration evident. Score: 5	614–15
Figure 22	Multiple aggraded wide and shallow channels, with actively eroding streambanks. Score: 4	614–16
Figure 23	Aggraded channel. Score: 2	614–16
Figure 24	Aggraded channel. Score: 1–0	614–16
Figure 25	Percent canopy cover	614–25
Figure 26	Stream invertebrates	614–38

Subpart B Conservation Planning

Part 614 Stream Visual Assessment Protocol Version 2

614.00 Introduction

The Stream Visual Assessment Protocol (SVAP) is a national protocol that provides an initial evaluation of the overall condition of wadeable streams, their riparian zones, and their instream habitats. The majority of the Nation's streams and rivers are small, often with intermittent flows and, yet, they constitute a close multidimensional linkage between land and water management. These smaller streams and rivers are increasingly a focus of Natural Resources Conservation Service (NRCS) assistance to landowners. This protocol is developed for relatively small streams, be they perennial or intermittent. If the stream can be sampled during low flow or seasonally wet periods of the year without a boat, it can be assessed using the SVAP. Although this protocol has been developed for use nationwide, its authors recognize the importance of regional differences in influencing stream conditions. The NRCS thus encourages modification and calibration of the national protocol's scoring elements, if needed, to achieve greater sensitivity to resource conditions at State and regional levels. Thus, version 2 (SVAP2) can be viewed as a national framework for States to revise or amend, if necessary, to better assess local stream and riparian conditions. Guidance for such modifications is provided in appendix C.

The SVAP2 protocol can be successfully applied by conservationists with limited training in biology, geomorphology, or hydrology. Since publication of the initial version of the SVAP, the protocol has taken on broader applications as a tool to evaluate quality criteria for conservation planning, establish eligibility for Farm Bill programs, identify potential resource concerns, and assess trends in stream and riparian conditions over time. Consequently, NRCS State Offices have played a large role in modifying the protocol, updating training materials, and transferring SVAP2 technology to the field. States should continue with such efforts and also pay close attention to achieving consistency in how the protocol is applied within their States and in adjacent States. It is less critical that a particular assessment discern between a score of 5 or 6 with subtle subjective differences than it is that the protocol be interpreted and applied consistently, year-to-year by multiple users. Consistency, efficiency, and effectiveness can be gained by collaborating closely with local users and those in other States within the region. NRCS State Offices are encouraged to contact appropriate National Technology Support Center (NTSC) specialists regarding refinement of this SVAP2's scoring criteria to more accurately reflect local conditions. NTSC specialists can also assist with coordinating regional training to improve understanding of the methodology and consistency in use of the SVAP2.

The SVAP2 is a preliminary qualitative assessment tool to evaluate features that affect overall stream conditions at the property level. The tool assesses visually apparent physical, chemical, and biological features within a specified reach of a stream corridor. Because of its qualitative nature, the protocol may not detect all causes of resource concerns, especially if such causes are a result of land use actions in other parts of the watershed. It does provide a means to assess site conditions in the context of the larger watershed. A synthesis of information gathered during the preliminary assessment and field assessment portions of the protocol can be used to provide general guidance to landowners on how watershed features and practices they employ are reflected in the quality of their stream ecosystems.

614.01 What is a healthy stream?

A stream's watershed captures precipitation, filters and stores water, and regulates its release through the stream channel network and eventually into a lake, another watershed, or an estuary and the ocean. Watersheds are characterized by different climates, geomorphic features, soil types, vegetation, and land uses. Their upland features control the quantity and timing of water and materials that make their way overland and into a stream system. The environmental conditions of a stream or river corridor (such as water quantity and quality, riparian and flood plain function, and habitat quality) are thus linked to the entire watershed. These linkages affect stream processes that act vertically, laterally, longitudinally, and over time. Land managers may have little control of watershed management beyond their property lines or jurisdictional boundaries. Nevertheless, activities that occur in many individual farm fields, rangelands, or pastures can have cumulative impacts on the condition of an individual landowner's stream and those downstream. Sound watershed and stream corridor management are important for maintaining stream conditions that allow the stream to be resilient and resistant to natural disturbance and human-caused perturbations. The natural resilience of a stream to recover from floods, fire, and drought is an indicator that it is healthy (Meyer 1997).

Streams, their flood plains, and adjacent riparian areas are complex ecosystems where numerous biological, physical, and chemical processes interact (Cushing and Allen 2001). Changes in any one feature or process in a stream ecosystem have cascading effects throughout the stream as it flows downstream and as its flows change with seasonal shifts in precipitation. Stream processes are interconnected, and these connections maintain a balance of materials that are transported and deposited by the stream, including sediment, water, wood, and nutrients. If conditions change, these processes must readjust to keep the stream resilient and functional for energy and material transport and aquatic fauna and flora. The conditions of a stream reflect current and past land uses and management actions. As such, they can also help predict future trends of watershed land use and conditions.

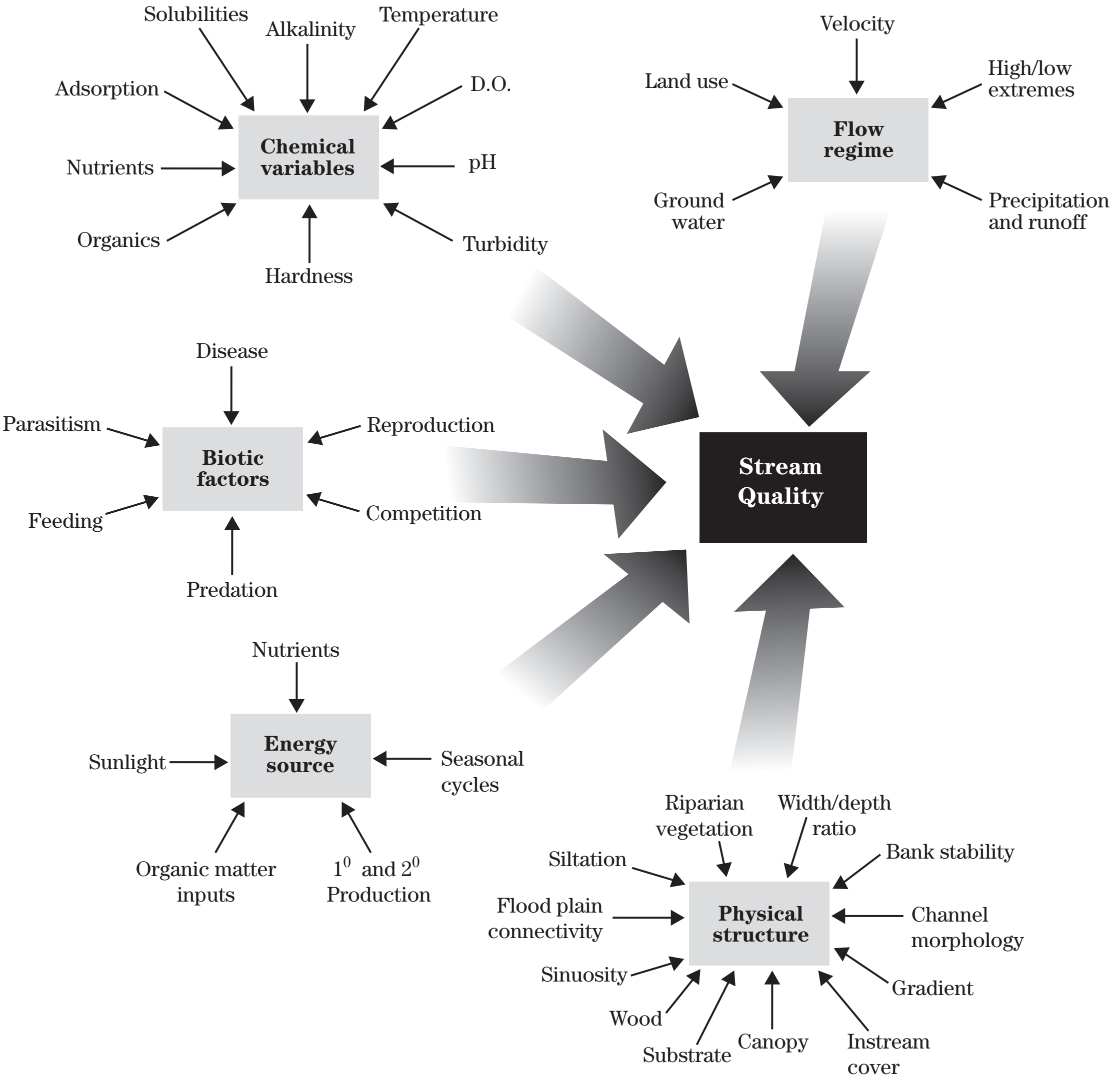
Multiple factors affect stream conditions and, therefore, stream quality (fig. 1). For example, increased nutrient loads alone may not cause a visual change to a forested stream, but when combined with tree removal and channel widening, the result may shift the energy dynamics from a community based on leaf litter inputs to one based on algae and aquatic plants. The resulting chemical changes caused by photosynthesis and respiration of aquatic plants coupled with temperature increases due to loss of canopy cover will alter the aquatic community.

Many stream processes are in delicate balance. For example, the force of the streamflow, amount of sediment, and stream features that slow or hasten flow must be in relative balance to prevent channel incision or bank erosion. Increases in sediment loads beyond the capacity of the stream to transport them downstream can lead to extensive deposition of sediments and channel widening.

Lastly, the biological community of a stream also affects its overall condition. As indicators of biological integrity fish, aquatic invertebrates, and all other members of a stream's community portray a pattern of stream condition that further enhances our ability to detect concerns. For example, the prevalence of exotic species in a fish assemblage of a particular stream often indicates deterioration in stream function or quality. While beyond the scope of the SVAP2, such indices of biological integrity provide an even more comprehensive picture of a stream ecosystem's condition (Giller and Malmqvist 1998; Matthews 1998).

Stream corridors benefit from complex and diverse physical structure. Such complexity increases channel roughness that dissipates the energy of water and reduces its erosive power. Structural complexity is provided by channel form (meanders, pools, riffles, backwaters, wetlands), profile (stream gradient, width, and depth), materials that have fallen into the channel (trees and bank material), overhanging vegetation, roots extending into the flow, and streambed materials (sand, gravel, rocks, and boulders). The movement of these materials and the path of flow form pools, riffles, backwaters, side channels, flood plain wetlands, and many other types of habitats. Thus, streams with complex flood plains and a diversity of structural features generally support a higher diversity of aquatic species

Figure 1 Factors that influence the quality or condition of streams (modified from Karr et al. (1986))



(Schlosser 1982; Pearsons et al. 1992; Gurnell et al. 1995).

Chemical pollution of streams and rivers diminishes stream health and harms aquatic species. The major categories of chemical pollutants are oxygen-depleting sources such as manure, ammonia, and organic wastes; nutrients such as nitrogen and phosphorus from both fertilizers and animal wastes; acids from mining or industrial effluents; and contaminants such as pesticides, salts, metals, and pharmaceuticals. It is important to note that the effects of many chemicals depend on multiple factors. For example, an increase in the pH caused by excessive algal plant growth may cause an otherwise safe concentration of ammonia to become toxic.

Finally, it is important to recognize that healthy, resilient streams, riparian areas, and flood plains operate as a connected stream corridor system. Lateral exchange of water and materials between a stream and its flood plain is the driving force for nutrient dynamics in the stream corridor community. Primary productivity of flood plain habitats is closely tied to hydroperiod, or the length of time the flood plain is inundated or saturated with water. Productivity is greatest in wetlands with pulsed flooding (periodic inundation and drying) and high nutrient input and lower in drained or permanently flooded conditions. Flood plains and their associated wetlands play a critical role in the health of the stream itself. An example would be the removal of nitrogen (denitrification) in floodwaters by flood plain wetlands (Forshay and Stanley 2005).

Riparian wetlands may also influence stream channel morphology and flows, buffering the stream channel against the physical effects of high flows by dissipating energy as waters spread out onto the flood plain. In many instances, these flood plains provide refuge habitat for aquatic species, especially during flood events. As streamflows recede, riparian wetlands provide water storage, slowly releasing water and aquatic organisms back to the stream through surface and subsurface transport, thereby influencing stream baseflows during drier times of the year.

In summary, physical, chemical, and biological elements that influence stream conditions also provide indicators of how well a stream is functioning and responding to natural disturbances (floods) or human actions (land clearing). A stream corridor that maintains key ecological and physical functions over time is a healthy, resilient ecosystem that can support diverse communities of aquatic species.

614.02 Stream classification

A healthy stream will look and function differently depending on its location or ecological setting. A mountain stream that flows through a narrow valley over a shale bedrock bottom is very different from a stream that flows through a wide valley over alluvial deposits. Similarly, coastal streams are different from piedmont streams and desert canyon streams. Accurately classifying the type of stream in an area of interest is important to assessing the current condition, or health, of that particular stream. Stream classification is a way to account for the effects of natural variation in streams and helps avoid comparing the conditions of streams of different classes. A stream's classification provides a point of reference for subsequent assessments that may occur at the site. Ideally, a separate SVAP modification should be developed for each stream class, but realistically, this is not possible. At best, States should identify only as many stream classes as are necessary to account for natural variation in streams caused by the prevailing environmental influences of their region. Some important factors to consider are major land resource areas (MLRA) or ecoregion, drainage area, and gradient. Ecoregions are geographic areas in which ecosystems are expected to be similar. Drainage area is the size of the area of a watershed (catchment or basin). Gradient is the slope of a stream. For example, an SVAP2 modification may be warranted for low gradient, wadeable streams of the northern Piedmont of North Carolina. References regarding stream classification can be found in appendix A.

NRCS State Offices are responsible for SVAP2 modifications. Because there are many stream classification systems, States should select the one most suitable to their ecoregion and decide the scale at which their SVAP2 will be modified or refined (for all stream classes within the State, for all stream classes within an ecoregion of the State, or for several stream classes within an ecoregion). Enough up-front work should be done by State Offices in tailoring the protocol to permit field offices to use it without further modification. This includes refining and evaluating the protocol, modifying the element criteria and scoring to reflect local conditions, and delineating the geographic boundaries for its intended use.

614.03 Reference sites

One of the most difficult challenges associated with evaluating a stream's quality or existing condition is the determination of historic and potential conditions. An accurate assessment of the stream requires a benchmark of, or reference to, what a healthy stream in the targeted ecoregions should look like. It is often assumed that historic conditions of streams were healthy or resilient after disturbances. However, it is unrealistic to expect that all stream systems can potentially be as resilient as they were prior to extensive land use activity. In such cases, land managers often identify a benchmark condition that reflects the least impaired conditions of the ecoregion. Under this scenario, the SVAP2 would be adapted to reflect the stream corridor conditions to which managers are aspiring to.

Reference sites represent the range of conditions that potentially exist for a particular class of stream. Least impaired reference sites represent the best conditions attainable, and most impaired reference sites the worst. One challenge in selecting least impaired reference sites is that there are few streams left, especially in agricultural landscapes, that have not been influenced by human actions. Accessible, least impaired reference sites are important not only because they define a benchmark for attainable conditions, but they also serve as demonstration areas for field staff to observe the characteristics of the region's best streams that would result in the highest possible SVAP2 scores. A common pitfall in reference site selection is the failure to survey a wide enough area to find sites that are truly least impaired and are representative of an entire class of stream. Another common problem, particularly in highly altered landscapes, is the failure to identify sites that are most impaired. In addition to setting the lower bar of the stream health gradient, most impaired sites provide a clear illustration of how streams are not supposed to look and serve as models for improvement actions. Remember, reference sites should represent an entire stream class and thus may be located in another county or State. Therefore, it helps if they can be identified at a State or higher level and with the help of State agencies that may have already established reference sites that represent a full range of human perturbations for a given class of stream.

614.04 Using this protocol

This protocol is intended for use in the field with the landowner. Conducting the assessment with the landowner provides an opportunity to discuss natural resource concerns and conservation opportunities. Before leaving the office to assess a stream, a preliminary assessment of watershed features should be conducted in the field office. The Stream Visual Assessment Summary Sheet (exhibit 1) provides a standardized form for recording information and data collected during both the preliminary and field portions of the assessment.

(a) Preliminary assessment of the stream's watershed

- *Become familiar with watershed conditions* before going to the assessment site. Stream conditions are influenced by the entire watershed including uplands that surround the assessment site. Changes in upland conditions can change the discharge, timing, or duration of streamflow events that affect stream conditions. Aerial photographs, topographic maps, stream gages, and any other source of data available can be used to obtain information about watershed conditions before conducting the SVAP2 on a stream. State agencies, watershed groups, local landowners, and Federal land managers are likely to already have documented relevant information about watershed conditions. Ecoregion descriptions, size of the watershed (drainage area) and upland practices often explain conditions at the assessment site and are helpful for addressing some of the elements in SVAP2.
- *Gather land use information about the watershed* to provide a context for the stream to be assessed and a better understanding of the conditions at the site. For example, road crossings and water control structures may prevent movement of aquatic species. Mining, agriculture, and urbanization all influence water quality and quantity, as well as stream corridor condition.
- *Review available water resource information* for the watershed and stream reach. Water control structures and/or activities outside of the assessment reach may be affecting streamflow. Ask the landowner if he or she is aware of upstream withdrawals (surface diversions or pump stations), drains, or any features that affect the amount of instream flow during the year. The U.S. Environmental Protection Agency's (EPA) Surf Your Watershed Web site (http://www.epa.gov/surf) is also a good source of information.
- *Consult the State fish and wildlife agency* regarding stream and riparian species likely to be present in the reach and whether fish passage to or from the area is limited.
- *Become familiar with potential riparian plant species* and community types appropriate to the area to be assessed.

(b) Delineating the assessment reach

Assess one or more representative reaches, evaluate conditions on both sides of the stream, and indicate left and right bank conditions looking downstream. A reach is a length of stream with relatively consistent gradient and channel form. *An assessment reach for this protocol is, at a minimum, a length of stream equal to 12 times the bankfull channel width.* Longer reaches may be appropriate, depending on the objectives of the assessment.

Bankfull channel width is the stream width at the bankfull discharge, or flow rate that forms and controls the shape and size of the active channel. Bankfull discharge or bankfull flow is the flow rate at which the stream begins to move onto its active flood plain, if one is present. On average, the bankfull discharge occurs every 1.5 to 2 years, depending on local stream channel and weather conditions. Figure 2 illustrates the relationship between baseflow (low flow), bankfull flow, and the flood plain.

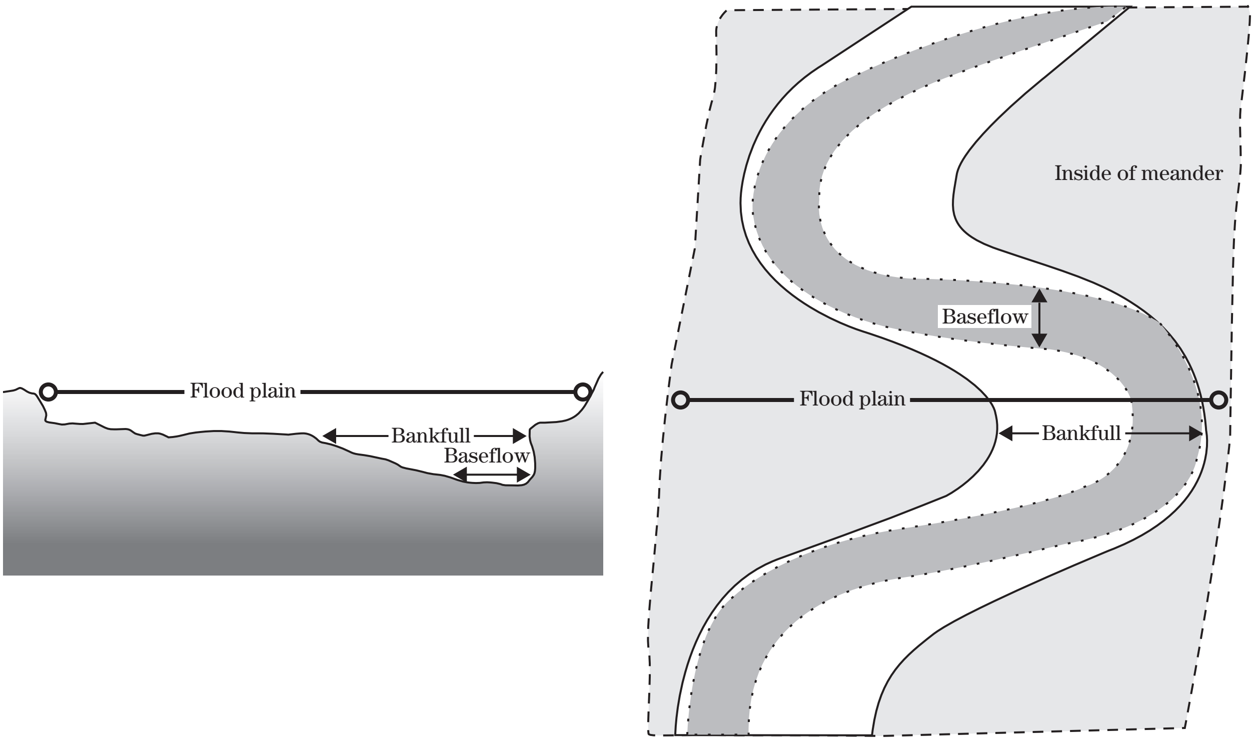
Bankfull width is determined by locating the first flat depositional surface occurring above the bed of the stream. The lowest elevation at which the bankfull surface could occur is at the top of the point bars or other sediment deposits in the channel bed. These generally occur on the inside of the meanders (white part of the figure 2). Other indicators of bankfull elevation include a break in slope on the bank, vegetation changes or exposed roots, a change in the particle size of bank material, and wood or small debris left from high waters. In temperate areas of the country, vegetation can grow into depositional bars below some bankfull indicators. Therefore, look for signs of well-established vegetation at the elevation level with the top of point bars to help identify bankfull stage.

The following videos and documents are resources to assist field personnel in identifying bankfull discharge indicators across the coterminous United States. They can be downloaded from: http://www.stream.fs.fed.us. Click on "Publications and Products."

- A Guide to Field Identification of Bankfull Stage in the Western United States, principally narrated by Luna B. Leopold.
- Identifying Bankfull Stage in Forested Streams of the Eastern United States, principally narrated by M. Gordon Wolman.
- Guide to Identification of Bankfull Stage in the Northeastern United States. USDA General Technical Report (RMRS–GTR–133–CD). Fort Collins, CO.
- Harrelson, C., L. Rawlins, and J.P. Potyondy (1994). Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA General Technical Report (RM–245): 61.

Often the stream length within the landowner's property boundaries is shorter than the minimum length needed to adequately determine conditions using the SVAP2. If permission is received to cross property boundaries, it is appropriate to do so to evaluate an adequate length of the stream. If crossing property boundaries is not an option, the assessment reach length will be the length that is within the property boundaries. When large sections of stream are to be assessed and there are constraints that prohibit assessing the entire stream length, representative reaches of the stream on the property should be subsampled. Using aerial photographs, topographic maps, and various stream classification methods, streams can be stratified into smaller units (stream reaches) that share common physical characteristics such as stream gradient and average bankfull width. The degree of

Figure 2 Baseflow, bankfull, and flood plain locations (Rosgen 1996)



stratification will depend on the reason for assessing the stream. If simply providing an opportunity for the landowner to learn about the general conditions of the stream, perhaps only one reach is assessed. If the SVAP2 is being conducted to identify potential improvement actions, the entire stream within the property should be assessed. SVAP2 scores can then be used as a preliminary and qualitative evaluation of conditions. Low scores likely indicate more quantitative assessments of geomorphic, hydrological, and biological features of the stream corridor are needed to determine what stressors are causing the problems identified. Quantitative assessments should only be completed by trained specialists (stream ecologists, hydrologists, geomorphologists, hydraulic engineers) to assure the complex features influencing stream conditions are being evaluated as accurately as possible. If there are several stream types (reaches) within the property, multiple stream visual assessments should be completed, one for each reach. Regardless of the situation, the SVAP2 requires field personnel to score four elements based upon the entire length of the stream that is within a single landowner's property. These are: riparian area quantity, riparian area quality, canopy cover, and barriers to aquatic species movement.

(c) Scoring the elements of the Stream Visual Assessment Protocol

The SVAP2 ideally should be completed during baseflows when habitat feature limitations are likely to be most visible. Each assessment element is scored with a value of zero to 10. Some of the 16 elements, for example, salinity, may not be relevant to the stream being assessed. Score only those elements appropriate to the ecological setting of the stream. Livestock or human waste should be scored in all reach assessments.

Background information is provided for each assessment element, as well as a description of what to look for. Using Part 2B of the Stream Visual Assessment Protocol Summary Sheet, record the score that best fits the observations made in the assessment reach. Base observations on the descriptions in the matrix provided for each element assessed. Assign a score that applies to the conditions observed in the assessment reach. If the conditions of the stream fit descriptions that occur in more than one column of the matrix, score the element based on the lower valued descriptions. For example, when scoring the element hydrological alteration, if bankfull flows occur according to the natural flow regime (score 10–9 column), but there is a water control structure present (score 8–7 column), assign the score based on the lowest scoring indicator present within the reach, which in this case would be an 8 or 7. Again, evaluate conditions on both sides of the stream, and note left bank and right bank conditions while looking downstream.

The complete assessment is recorded on the summary sheet, which consists of two principal sections: Preliminary Watershed Assessment and Field Assessment.

Section 1 records basic information about the watershed and reach such as drainage area, location, and land uses. Space is provided for a description of the reach, which may be useful to locate the reach or illustrate problem areas. On the worksheet, indicate tributaries, presence of drainage ditches, and irrigation ditches; note springs and ponds that drain to the stream; include road crossings, and note whether they are fords, culverts, or bridges.

Section 2 is used to record the scores for up to 16 assessment elements. Score an element by comparing the observations to the descriptions provided. If matching descriptions is difficult, try to compare what is being observed to the conditions at reference sites for the area. Again, some of the elements may not be applicable to the site and, therefore, should not be included in the assessment. The overall assessment score is determined by adding the values for each element and dividing by the number of elements assessed. For example, if the scores add up to 76 and 12 assessment elements were used, the overall assessment value would be 6.3, which is classified as FAIR. This value provides a numerical score of the environmental condition of the stream reach. This value can be used as a general statement about the state of the environment of the stream or (over time) as an indicator of trends in condition.

614.05 Stream assessment elements

(a) Element 1—Channel condition

Description and rationale for assessing channel condition

The shape of a stream channel changes constantly, imperceptibly, or dramatically, depending on the condition of the stream corridor (channel, riparian area, and flood plain) and how it transports water and materials. Channel condition is a description of the geomorphic stage of the channel as it adjusts its shape relative to its flood plain. Channel adjustments resulting in a dramatic drop in streambed elevation (incision or degradation) or excessive deposition of bedload that raises the bed elevation (aggradation) affect the degree of bank shear and often decrease stream channel stability. Such channel adjustments can have substantial effects on the condition of streams, adjacent riparian areas, associated habitats, and their biota. For example, the greater the incision in a channel, the more it is separated from its flood plain, both physically and ecologically. Conversely, the greater the aggradation, the wider and shallower a stream becomes, which can affect riparian vegetation, surface water temperatures, and stream and riparian habitat features.

Conceptual models of how a channel evolves or adjusts over time illustrate the sequence of geomorphic changes in a stream that result from disturbances in the watershed. Such sequences are useful for evaluating trends in channel condition. The stages of the Schumm Channel Evolution Model (CEM), as shown in figure 3, provide a visual orientation of the pattern of streambed adjustment in an incising stream, its gradual detachment from the existing flood plain, and eventual formation of a new flood plain at a lower elevation. A similar model by Simon (1989) is also described in the Stream Corridor Restoration Handbook (FISRWG 1998) available in most NRCS field offices.

Stage I channels are generally stable and have frequent interaction with their flood plains. The relative stability of the streambed and banks is due to the fact that the stream and its flood plain are connected, and flooding occurs at regular intervals (Q_2). Consequently, the stream's banks and flood plain are well vegetated. Depositional areas (bars), if present, form a gradual transition into the active flood plain, as shown by the arrow in figure 4.

Figure 3 Channel Evolution Model, after Schumm, Harvey and Watson (1984). Q_2 indicates a flood interval of 2 years; Q_{10} indicates an interval of 10 years

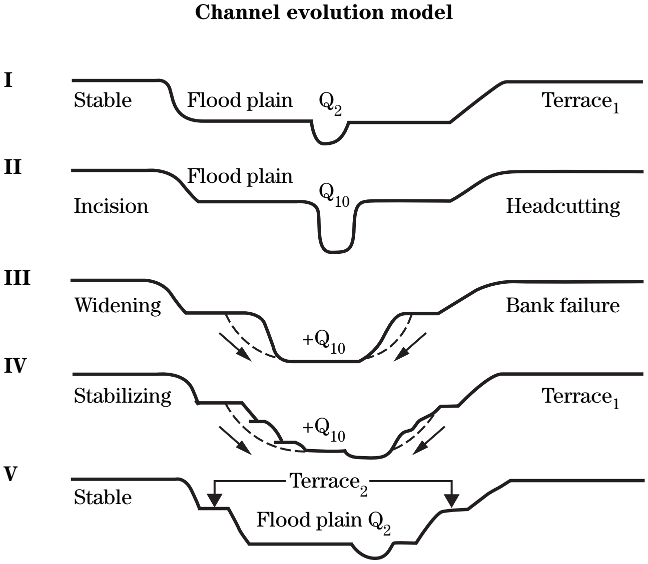


Figure 4 CEM stage I. Typically excellent channel condition with natural bank protection

Land use activities that increase runoff, such as land-clearing, paving, or channel straightening, often result in channel incision processes characteristic of stage II in channel evolution. The height of the banks increases due to downcutting of the channel, and the stream and flood plain have less frequent interaction. Bank vegetation becomes stressed, and banks are prone to failure. Once failures begin, the channel widening of stage III begins. A stage II channel is typically narrower at the bed relative to the depth (often referred to as low width-to-depth ratio) than a stage III channel. A stage II channel is in an active downward trend in condition and active headcuts are often present (fig. 5).

During stage III, bank failures increase the formation of bars located next to the now relatively vertical banks. In stage III, alternating point bars are typically forming on opposite banks adjacent to vertical banks (fig. 6). Channel widening continues until the stream bed is wide enough to disperse streamflows and slow the water, beginning stage IV in channel evolution. Bank vegetation loss continues.

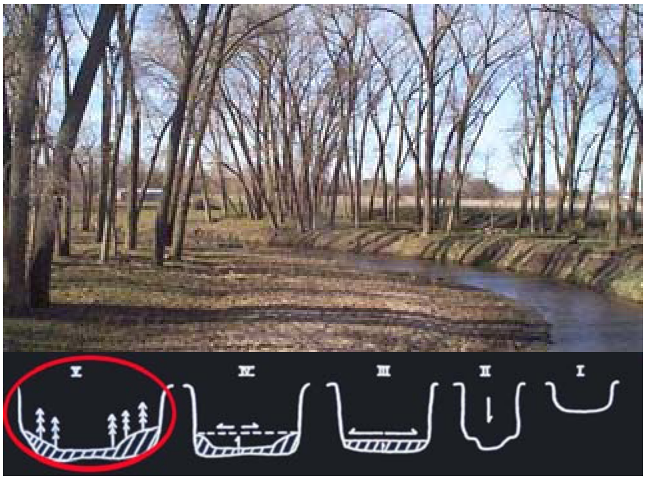
During stage IV, sediments begin to build up in the channel instead of moving downstream, aggrading the bed. Eventually, vegetation begins to establish in the sediment deposited along the edge of the stream, creating channel roughness and further slowing the flow. An early stage IV channel indicates relatively poor conditions, while a late stage IV channel indicates an improving trend in channel condition. At this stage, the stream has become more sinuous. Alternating bar features are apparent.

Stage V begins when a new flood plain begins to form. Early in stage V, bank vegetation may not be fully established, and some bank erosion is likely. In a late stage V, the original active flood plain from stage I is now a high terrace, and the evolution of a stage I channel begins, with a new flood plain developing at a lower elevation than the terrace (fig. 7).

Figure 5 CEM stage II. Poor channel condition, head-cuts common

Figure 6 CEM stage III, with bars adjacent to vertical banks

Figure 7 CEM Stage V channel, with developing flood plain (left) and abandoned flood plain, now a terrace, behind trees on right side of stream



The reader should keep this conceptual channel evolution model in mind as he or she visually assesses the characteristics of the stream. In areas where heavy vegetation occurs naturally due to higher annual precipitation, eroded banks and slightly incised channels may be masked and consequently harder to observe. In these areas, try to observe bank features from a location near the channel bed. In using the scoring matrix, note that a channel that is either incising or aggrading cannot score higher than an 8. Use the upper right portion of the matrix to score incising or incised channel reaches. Use the lower right portion of the matrix to score aggrading channel reaches.

Element 1 Channel condition

Natural, stable channel with established bank vegetation	**If channel is incising (appears to be downcutting or degrading), score this element based on the descriptions in the upper section of the matrix**		
No discernible signs of incision (such as vertical banks) or aggradation (such as very shallow multiple channels)	Evidence of past incision and some recovery; some bank erosion possible	Active incision evident; plants are stressed, dying or falling in channel	Headcuts or surface cracks on banks; active incision; vegetation very sparse
Active channel and flood plain are connected throughout reach, and flooded at natural intervals	Active channel and flood plain are connected in most areas, inundated seasonally	Active channel appears to be disconnected from the flood plain, with infrequent or no inundation	Little or no connection between flood plain and stream channel and no inundation
Streambanks low with few or no bank failures	Streambanks may be low or appear to be steepening	Steep banks, bank failures evident or imminent	Steep streambanks and failures prominent
	Top of point bars are below active flood plain	Point bars located adjacent to steep banks	Point bars, if present, located adjacent to steep banks
Stage I : Score 10 Stage V: Score 9 (if terrace is visible)	Stage I: Score 8 Stage V: Score 7–8 Stage IV: Score 6	Stage IV: Score 5 Stage III: Score 4 Stage II: Score 3	Stage II or III, scores ranging from 2 to 0, depending on severity
	8 7 6	**5 4 3**	**2 1 0**
	If channel is aggrading (appears to be filling in and is relatively wide and shallow), score this element based on the descriptions in the lower section of the matrix		
	Minimal lateral migration and bank erosion	Moderate lateral migration and bank erosion	Severe lateral channel migration, and bank erosion
	A few shallow places in reach, due to sediment deposits	Deposition of sediments causing channel to be very shallow in places	Deposition of sediments causing channel to be very shallow in reach
No more than 1 bar forming in channel	Minimal bar formation (less than 3)	3–4 bars in channel	Braided channels (5 or more bars in channel)
10 9	**8 7 6**	**5 4 3**	**2 1 0**

What to look for

State Offices are encouraged to develop photo series appropriate to their particular area. Figures shown are from all regions of the United States.

- **Channel is not incising or aggrading**. A score of 10 is appropriate for a stage I channel (fig. 8) with a frequently inundated flood plain that often covers the width of the valley. A late stage V channel with a lower active (frequently flooded) flood plain, well-established vegetation on the banks, and a higher terrace (abandoned flood plain) from previous channel evolutions would score 9 (fig. 9).
- **Channel appears to be incising.** Scores of 8, 7, or 6 indicate degrees of observable detachment between the active bankfull channel and the flood plain. The top of the point bars are below the elevation of the flood plain. A stage I or V channel that has an active, but less frequent, out-of-bank flow into the flood plain would score an 8 (figs. 10 and 11).

Figure 8 CEM stage I. Score: 10

Figure 9 CEM stage V. Score: 9

Figure 10 CEM stage I. Point bars below bank. Score: 8

Figure 11 CEM stage V. Slight flood plain detachment. Score: 8

- **Channel is incising.** If active channel erosion is apparent on the outside of meanders of a stage V and it is forming a new flood plain and out-of-bank flows still occur, lower the score to a 7 (fig. 12).
- **Channel is incising**. Active bank erosion is causing sediment build up in channel, forming depositional features of a stage IV channel. The channel is still adjusting its width. If top of bars are below active flood plain, score a 6 (fig. 13). Lower score to 5 if top of bars of the stage IV channel are adjacent to steep banks as shown by the arrow in figure 14.
- **Channel is incising**. There is disconnect between the flood plain and the bankfull channel (fig. 15), with riparian vegetation compromised by lack of seasonal flooding and lowered water table. Channel appears to be widening in areas of sediment build-up, typical of stage III channels (score 4).

Figure 12 CEM stage V. Score: 7

Figure 13 CEM stage IV, Score: 6

Figure 14 CEM stage IV. Score: 5

Figure 15 CEM stage III. Score: 4. Note point bar adjacent to steep bank (where person is standing)

- **Channel is incising** with no connection between the active flood plain and the vegetation. Tensile cracks or headcuts often present in a Stage II channel; score would be a 3 (fig. 16).

- **Channel is deeply incised** and completely disconnected from flood plain, usually characteristic of a stage II or III, depending on whether channel widening has begun. Scores range from 2 to 0 (table 1) depending on observed conditions (figs. 17 and 18).

Figure 16 CEM stage II. Score: 3


5/20/2000

Figure 17 CEM stage III, with active point bars forming. Score: 2 or 1

Figure 18 CEM stage II. Score: 1 or 0

Table 1 Guide to figure ratings and CEM stage

Figure no.	CEM stage	SVAP score
4	I	10
5	II	0–1
6	III	4
7	V	9
8	I	10
9	V	9
10	I	8
11	V	8
12	V	7
13	IV	6
14	IV	5
15	III	4
16	II	3
17	III	1–2
18	II	0–1

What to look for (aggrading channels)

The removal of willows and other kinds of riparian vegetation will decrease bank stability and contribute to streambank failure. Excessive streambank failure and lateral migration (the process of a stream shifting from side to side within a valley or other confinement) often result in wider and shallower channels unable to transport sediments downstream. Excessive channel filling occurs when a stream channel can no longer transport both the size and load of sediments associated with the watershed runoff conditions. Streams with no pools that previously had pools and riffles are most likely aggraded. Stream segments that are excessively wide and shallow with multiple center bars are often aggraded. Streams that once maintained single- or dual-threaded channel patterns, but have converted to a braided system (three or more channels at bankfull discharge), are typically aggraded. Excessively aggraded systems are unstable and channel adjustments from side to side can be rapid.

- **Channel is aggrading.** The streambed appears to be filling with sediment faster than it can be transported downstream. Deposits appear oversteepened and unstable, as in figure 21. Channel appears to be wider and shallower than in other reaches of stream. Some bank erosion is evident. Some mid-channel bars may be forming or present. Bed features such as pools and riffles appear to be less discernible or segregated. Lateral migration of channel is apparent. Point bar(s) may be separated from their flood plain. Scores range from 8 to 6 depending on degree of impairment from stable reference conditions (figs. 19, 20, and 21).

Figure 19 Aggrading channel with point bar separated from flood plain. Score: 8

Figure 20 Aggrading channel with shallow areas in reach. Score: 6–7

Figure 21 Aggrading channel, downward trend with lateral migration evident. Score: 5

- **Channel is aggrading.** Channel is wide and shallow, and the banks are actively eroding. Extensive deposition such as center bars and side bars are present. The streambed appears to have less pool-riffle features with a more consistent riffle-plane bed. Bank vegetation is sparse. Pools that would have typically formed in the meander bend portion are shallow and featureless. Scores range from 5 to 3 (fig. 22).
- **Channel is aggrading.** Channel is extremely wide and shallow with interconnected channels (figs. 23 and 24). Streambanks are typically unstable and highly eroded with sparse vegetation. Excessive deposition is common throughout the active channel. Multiple bars, both center and side bars, are located throughout the active channel. Lateral migration is common.

Figure 22 Multiple aggraded wide and shallow channels, with actively eroding streambanks. Score: 4

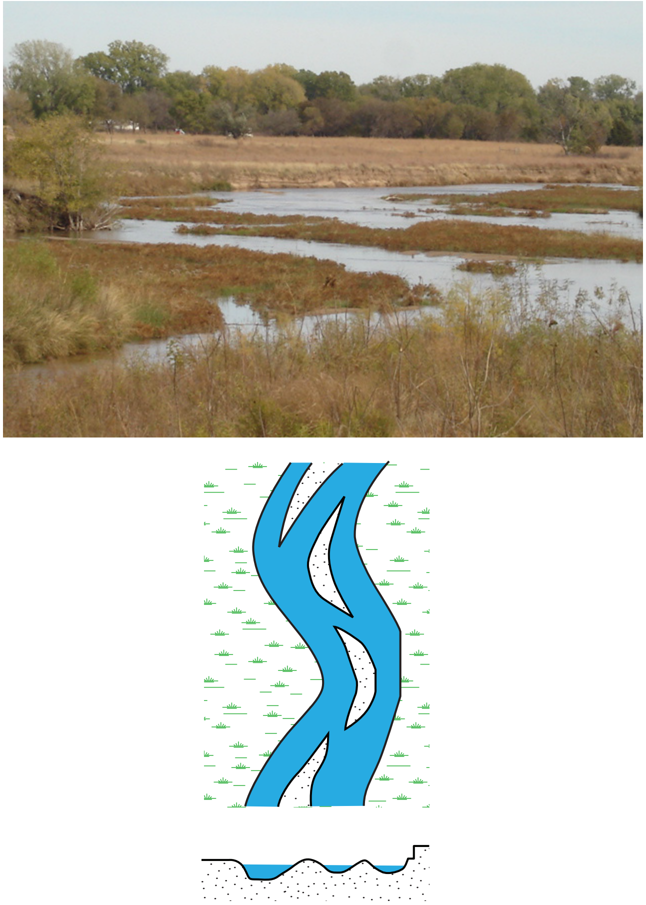


Figure 23 Aggraded channel. Score: 2

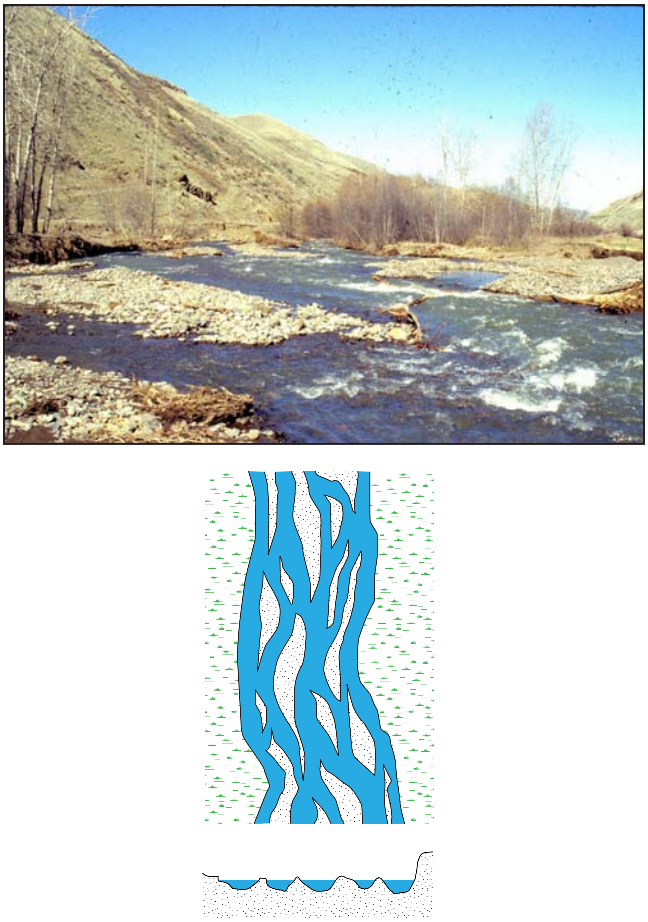


Figure 24 Aggraded channel. Score: 1–0

In concluding the assessment of this element of SVAP, remember that **channel condition** is of critical importance to overall stream health, yet difficult to visually assess accurately. Scores of less than 5 for channel condition may indicate substantial channel adjustments are occurring and a quantitative assessment by well-trained specialists is warranted.

(b) Element 2—Hydrologic alteration

Description and rationale for assessing hydrologic alteration

Hydrologic alteration is the degree to which hydrology and streamflow conditions differ from natural, unregulated flow patterns. Streamflow regime affects the distribution and abundance of stream species and influences the health of streams through several physical and chemical processes (Allan 1995; Poff et al. 1997). Naturally occurring daily and annual flow variations provide ecological benefits to flood plain ecosystems and the aquatic and terrestrial organisms that depend upon them (Poff and Ward 1989). With respect to fish, natural streamflow variations provide cues for spawning, egg hatching, rearing, and swimming to off-channel flood plain habitats for feeding or reproduction and upstream or downstream migration (Junk et al. 1989).

The full range of streamflow at any point in a given watershed is essential in maintaining the complex physical and biological structures and functions of a stream corridor. The geometry, composition, and appearance of a stream channel and its adjacent flood plain are largely the result of fluvial processes that govern a dynamic equilibrium between streamflow, the materials it carries, and riparian vegetation (Lane 1955; Leopold et al. 1964). Bankfull and higher flows are important factors that control stream channel shape and function and maintain physical habitat for animals and plants (Wolman and Miller 1960). Generally, bankfull flow occurs every 1 to 2 years in unregulated alluvial rivers (Wolman and Leopold 1957) and lasts for only a few days each year. However, numerous researchers have recorded bankfull flow return intervals greater than 2 years (Williams 1978), especially in arid and semiarid settings such as in the southwestern United States (Wolman and Gerson 1978). Conversely, in regions dominated by frequent, prolonged rainfall, bankfull flow can occur once or twice yearly. Consequently, the 2-year event should be considered as only a coarse estimate of bankfull flow. The reader is encouraged to seek additional assistance when working in streams where streamflow is generated by monsoonal precipitation or other extreme climatic events or affected by significant flow regulation because of upstream reservoirs, pump plants, or diversions.

Water and land management practices that alter the timing, duration, magnitude, frequency, or rate of change of streamflow patterns can substantially alter riparian and instream habitat along regulated stream reaches (Calow and Petts 1994). Water withdrawals, watershed and flood plain development, agricultural or wastewater effluents, and practices that change surface runoff (dikes and levees) or subsurface drainage (tile drainage systems) affect the amount and quality of water in a stream channel across the water year. The effects of water withdrawals on aquatic resources and stream condition can usually be readily observed (especially during low-flow periods). However, augmenting streamflow with irrigation runoff or stormwater from municipal areas also often results in adverse physical and biological impacts. For example, the total runoff volume from a 1-acre parking lot is about 16 times that produced by an undeveloped acre of meadow (Schueler 1994). Additionally, peak discharge, velocity, and time of concentration also increase significantly when natural landscapes are replaced by impervious surfaces (Booth 1990). Further, runoff introduces pollutants to waterways and often results in rapid physical deterioration and aquatic community changes (Booth and Jackson 1997). Finally, heavy grazing and clearcutting often have similar, although typically less severe, effects (Platts 1991; Jones and Grant 1996).

Element 2 Hydrologic alteration

Bankfull or higher flows occur according to the flow regime that is characteristic of the site, generally every 1 to 2 years **and** No dams, dikes, or development in the flood plain[1/], or water control structures are present **and** natural flow regime[2/] prevails	Bankfull or higher flows occur only once every 3 to 5 years or less often than the local natural flow regime Developments in the flood plain, stream water withdrawals, flow augmentation, or water control structures may be present, but do not significantly alter the natural flow regime[2/]	Bankfull or higher flows occur only once every 6 to 10 years, or less often than the local natural flow regime Developments in the flood plain, stream water withdrawals, flow augmentation, or water control structures alter the natural flow regime[2/]	Bankfull or higher flows rarely occur Stream water withdrawals completely dewater channel; and/or flow augmentation, stormwater, or urban runoff discharges directly into stream and severely alters the natural flow regime[2/]
10 9	**8 7 6**	**5 4 3**	**2 1 0**

1/ Development in the flood plain refers to transportation infrastructure (roads, railways), commercial or residential development, land conversion for agriculture or other uses, and similar activities that alter the timing, concentration, and delivery of precipitation as surface runoff or subsurface drainage.

2/ As used here, "natural flow regime" refers to streamflow patterns unaffected by water withdrawals, flood plain development, agricultural or wastewater effluents, and practices that change surface runoff (dikes and levees) or subsurface drainage (tile drainage systems).

What to look for

- Ask the landowner about the frequency of bankfull, overbank, and low flows, referring to figure 2 as needed. Be cautious—water in an adjacent field does not necessarily indicate natural flooding. The water may have flowed overland from a low spot in the bank outside the assessment reach or be an artifact of irrigation or drainage management.
- Look for indicators that help identify bankfull stage (refer to channel condition element). If there is newly deposited debris (leaves and branches) or unvegetated mineral sediments (mud lines, sands, and silts) near the edge of the active channel, it is very likely that bankfull or higher flows have occurred in recent months.
- If channel bars are present, inspect the type and general age of vegetation. A vegetative commu-

nity dominated by invasive species or seedlings less than 2 years old is a good indicator that bankfull or higher flows have occurred in the last 2 years, or with some regularity. An absence of vegetation on bars could be interpreted in the same manner, unless the stream is braided (three or more channels with excessive sand, gravel and/or cobble substrates and a notable lack of permanent vegetation) and/or streamflow is significantly regulated.

- Evidence of flooding includes high water marks, such as water stain lines, sediment deposits, or stream debris, well above the stream channel. Look for these on streambanks, trees, rocks, or other structures such as bridge pilings or culverts.
- Water control structures are any feature that alters streamflow. Examples commonly include stream surface intakes (pump stations, flashboard or full-round risers, drop pipes, stop log structures, screw or flap gate structures), streamside infiltration galleries or ring wells, diversions, dikes, or dams (both temporary and permanent). Any water control structures that divert water directly out of a stream should be suitably screened to prevent entrapment or capture of fish.

(c) Element 3—Bank condition

Description and rationale for assessing bank condition

Stable streambanks are essential components of functional physical habitat and unimpaired biological communities. An excess of fine sediment in streams impacts aquatic species assemblages (Waters 1995) and results in significant water quality impacts with severe economic consequences (Pons 2003). Simon et al. (2000) found that unstable streambanks can contribute as much as 85 percent of the total sediment yield in an entire watershed. Severely unstable streambanks can result in the loss of valuable farmland, force changes in water tables, and endanger transportation infrastructure and other flood plain features.

Bank erosion is a natural mechanism in alluvial rivers, cannot be totally eradicated and provides important physical and ecological functions to the evolution of stream channels and flood plains (Wolman and Leopold 1957; Hooke and Redmond 1992). Excessive bank erosion usually occurs where riparian areas are degraded or when a stream is unstable because of changes in land management practices, hydrology, sediment dynamics, or isolation from its flood plain. Bank failures are generally attributed to the interaction of fluvial and gravitational forces (Thorne 1982)—high, steep banks with undercutting occurring at the base of the slopes are very prone to erosion or collapse.

A healthy riparian corridor with a well-vegetated flood plain contributes to bank stability. The roots of some perennial grasses, sedges, and woody vegetation can help hold bank soils together and physically protect the bank from scour during bankfull and higher flow events. Therefore, the type of vegetation covering streambanks is an important component of bank stability. For example, many trees, shrubs, sedges, and rushes have the type of root masses capable of withstanding high streamflow events, while Kentucky bluegrass does not. Further, native riparian vegetation generally provides better erosion resistance and bank stability than invasive species (Tickner et al. 2001). Finally, surface and subsurface soil types also influence bank stability. For example, banks with a thin soil cover over gravel or sand are more prone to collapse than are banks with deep, cohesive soil layers.
Score each bank individually and average the total to report a single, composite bank condition score.

Element 3 Bank condition

Banks are stable; protected by roots of natural vegetation, wood, and rock [1/] No fabricated structures present on bank No excessive erosion or bank failures [2/] No recreational or livestock access		Banks are moderately stable, protected by roots of natural vegetation, wood, or rock or a combination of materials Limited number of structures present on bank Evidence of erosion or bank failures, some with reestablishment of vegetation Recreational use and/or grazing do not negatively impact bank condition	Banks are moderately unstable; very little protection of banks by roots of natural wood, vegetation, or rock Fabricated structures cover more than half of reach or entire bank Excessive bank erosion or active bank failures Recreational and/or livestock use are contributing to bank instability	Banks are unstable; no bank protection with roots, wood, rock, or vegetation Riprap and/or other structures dominate banks Numerous active bank failures Recreational and/or livestock use are contributing to bank instability
Right bank	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**
Left bank	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**

1/ Natural wood and rock does not mean riprap, gabions, log cribs, or other fabricated revetments.
2/ Bank failure refers to a section of streambank that collapses and falls into the stream, usually because of slope instability.

What to look for

- Evaluate the entire length of all banks along the assessment reach, and then consider the proportion of unstable to stable banks. Obviously, if a quantifiable portion of the reach shows signs of accelerated erosion or bank failures, bank stability is a problem and should be scored as such. Conversely, if the majority of the reach shows minimal erosion and no signs of bank failure, bank stability is likely good. Finally, it is best to score this element during the summer or whenever flows in the assessment reach are low.
- Signs of erosion and possible bank stability problems include unvegetated stretches, exposed tree roots, and scalloped edges (sections of eroded bank between relatively intact sections).
- When observing banks from within the active channel or below bankfull elevation, look for piping holes, rills, and or gullies. Each of these concentrated flow paths is associated with eventual bank stability problems or outright failures.
- Look for tension cracks while walking along streambanks. Tension cracks will appear as vertical fissures or crevices running along the top of the streambank roughly parallel to the flow.
- Evidence of construction, vehicular, or animal paths near banks or grazing areas leading directly to the water's edge suggest conditions that may lead to bank collapse.
- Sections of streambank lying instream adjacent to existing banks are a telltale sign of active bank erosion and instability.

(d) Elements 4 and 5—Riparian area quantity and quality

Description and rationale for assessing riparian area conditions

Riparian areas are the vegetated areas adjacent to stream channels that function as transitional areas between the stream and uplands. Riparian vegetation thrives on the moisture provided by streamflow and ground water associated with the stream corridor. Riparian areas may or may not include flood plains and associated wetlands, depending on the valley form of the stream corridor. For example, steep mountainous streams in narrow V-shaped valleys often do not have obvious flood plains. Riparian areas are among the most biologically diverse habitats of landscapes and are sources of wood, leaves, and organic matter for the stream. These areas provide important habitat and travel corridors for numerous plants, insects, amphibians, birds, and mammals.

Ecological processes that occur in the stream corridor are linked to those in uplands via intact riparian areas and flood plains, if present. Riparian areas themselves also provide valuable functions that maintain or improve stream and flood plain conditions. The capacity for riparian areas to sustain these functions depends in part on the quality and quantity of the riparian vegetation and how it interacts with the stream ecosystem. The quality of the riparian area increases with the width, complexity, and linear extent of its vegetation along a stream. A complex riparian community consists of diverse plant species native to the site or functioning similarly to native species, with multiple age-classes providing vertical structural diversity suitable for the site. As explained previously, the quality of riparian areas is influenced by the hydrological features of the stream, as well as upland and bank conditions. Well-established and connected riparian areas perform critical functions for maintaining healthy, resilient stream ecosystems by providing:

- a vegetative filter for surface runoff, reducing pollutants and sediment entering streams, and no concentrated flow from upland areas
- roughness that slows water and the erosive effects of floodwater
- root systems that bind soil, protect streambank integrity, and build flood plain surfaces
- moisture, soil conditions, surface macrotopography and microtopography, and microclimates for a diversity of riparian plants, animals, and microorganisms
- structurally diverse habitat for migratory songbirds, as well as resident species of wildlife that are especially dependent on woody riparian vegetation for reproduction and feeding
- shade or overhanging vegetation to maintain cooler water temperatures for aquatic species
- large wood to forested stream channels, which offers instream cover, creates pools, traps sediments, and provides habitat for stream biota
- organic material (leaves, twigs, grass) and insects for stream and riparian food chains
- undercut banks important to fish for hiding and resting
- diverse, complex off-channel habitats, such as backwaters, wetlands, and side channels formed by the interaction of streamflow, riparian vegetation, and often large wood. These areas of slower water provide critical refuge during floods for a variety of aquatic species and serve as rearing areas for juvenile fish
- a diversity of plant species of multiple age classes, adapted to the site and providing critical habitat for both resident and migratory birds and other riparian wildlife species

Well-established riparian areas are critical for stream health and fish and wildlife habitat. For this reason, it is important to evaluate both the quantity (Element 4) and the quality (Element 5) of the riparian area, and score the riparian conditions of the entire stream within a property boundary. Visually score the entire stream, if possible. If the stream is too extensive to score using SVAP2, score only the assessment reach visually, and use recent aerial photos (less than 2 years old) to score those riparian areas of the stream outside of the assessment reach.

Element 4 Riparian area quantity

	Natural plant community extends at least two bankfull widths or more than the entire active flood plain and is generally contiguous throughout property	Natural plant community extends at least one bankfull width or more than 1/2 to 2/3 of active flood plain and is generally contiguous throughout property Vegetation gaps do not exceed 10% of the estimated length of the stream on the property	Natural plant community extends at least 1/2 of the bankfull width or more than at least 1/2 of active flood plain Vegetation gaps do not exceed 30% of the estimated length of the stream on the property	Natural plant community extends at least 1/3 of the bankfull width or more than 1/4 of active flood plain Vegetation gaps exceed 30% of the estimated length of the stream on the property	Natural plant community extends less than 1/3 of the bankfull width or less than 1/4 of active flood plain Vegetation gaps exceed 30% of the estimated length of the stream on the property
Right bank	**10 9**	**8 7**	**6 5**	**4 3 2**	**1 0**
Left bank	**10 9**	**8 7**	**6 5**	**4 3 2**	**1 0**

Note: Score each bank separately. Scores should represent the entire stream riparian area within the property. Score for this element = left bank score plus right bank score divided by 2. If the score of one bank is 7 or greater and the score of the other bank is 4 or less, subtract 2 points from final score.

Riparian area quantity: what to look for

- This element rates the extent of the riparian area on the property (length × width). Estimate the width of the vegetation area from the edge of the active channel outward to where natural riparian vegetation ends and other land use/land cover begins.
- Vegetation gaps are lengths of streamside with no natural vegetation ecologically suitable for the site and at a density and spacing uncharacteristic of the plant community being assessed. Estimate gap percentage by dividing the total length of gaps by the total length of the stream within the property boundary multiplied by 100.
- For this element, natural plant community means one with species native to the site or introduced species that have become naturalized and function similarly to native species of designated reference sites, growing at densities characteristic of the site. Regional plant guidebooks are useful to have in the field for scoring this element.
- Compare the width of the riparian area to the bankfull channel width. In steep, V-shaped valley forms, there may not be enough room for a flood plain riparian area to extend as far as one or two active channel widths. In this case, a score may be adjusted to a higher value based on reference site conditions.

Element 5 Riparian area quality

	Natural and diverse riparian vegetation with composition, density and age structure appropriate for the site	Natural and diverse riparian vegetation with composition, density and age structure appropriate for the site: Little or no evidence of concentrated flows through area	Natural vegetation compromised	Little or no natural vegetation
	No invasive species or concentrated flows through area	Invasive species present in small numbers (20% cover or less)	Evidence of concentrated flows running through the riparian area Invasive species common (>20% <50% cover)	Evidence of concentrated flows running through the riparian area Invasive species widespread (>50% cover)
Right bank	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**
Left bank	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**

Notes: Score should represent the entire stream riparian area within the property.
Score for this element = left bank score plus right bank score divided by 2.

Riparian area quality: what to look for

- Plant species should be native or naturalized and consist of multiple structural layers (grasses and forbs, shrubs, and/or trees if suitable for the site). Forested sites should also have a diverse mix of shrubs, understory trees, and new shrub and tree regeneration. Early successional sites (recently disturbed by fire, tree harvesting, grazing, land clearing) should have representative native species (typically herbaceous, woody, and tree seedlings). Continually disturbed sites usually have only a few species, and often these include nonnative invasive species. As early vegetation matures, the structure of the plant community becomes more diverse with a multilayer canopy. Finally, the plant community reaches a mature stage with regeneration, growth, and mortality occurring in all layers. In forested streams, mature trees with potential for falling into the stream are present. Regional plant guidebooks are useful for scoring this element.
- Vigorously growing vegetation in the riparian area on both sides of the stream is important for healthy stream and riparian conditions. In doing the assessment, examine both sides of the stream, and note on the site diagram which side of the stream has problems. For the highest ratings, there should be no evidence of concentrated flows through the riparian area that are not adequately buffered or intended to short-circuit the riparian area or buffer and no nonnative invasive species.
- The type, timing, intensity, and extent of activities in riparian areas are critical in determining the impact on these areas. Note these in the Summary Sheet. Riparian areas that have roads, agricultural activities, residential or commercial structures, excessive animal use, or significant areas of bare soils have reduced functional value for the stream and its watershed.

(e) Element 6—Canopy cover

Description and rationale for assessing canopy cover

In forested riparian areas, shading of the stream is important because it helps maintain cool water temperatures and limits algal growth. Cool water has a greater oxygen holding capacity than warm water. In many cases, when streamside trees are removed, the stream is exposed to the warming effects of the sun, causing the water temperature to increase for longer periods during the daylight hours and for more days during the year. This shift in light intensity and temperature often causes a decline in the numbers of certain species of fish, insects, and other invertebrates and some aquatic plants. They may be replaced altogether by other species that are more tolerant of increased light intensity, lower dissolved oxygen, and warmer water temperature. For example, trout and salmon require cool, oxygen-rich water and may rely on food organisms produced by detritus-based food chains. Loss of streamside vegetation that causes increased water temperature and decreased oxygen levels contributes to the decrease in abundance of trout and salmon from many streams that historically supported these species. Warm-water species also benefit from canopy cover to keep streams from exceeding optimal temperatures. Increased light and the warmer water also promote excessive growth of submerged macrophytes (vascular plants) and algae that can cause a shift from a detritus-based to an algae-based food chain, thus altering the biotic community of the stream. Although some stream food webs are detritus-based, others (especially some warm-water streams) are algae-based and require a certain amount of light to be naturally productive. *Therefore, this element is particularly sensitive to the type of stream (stream class) and fish community that is being assessed and calibration of scoring may be necessary.* Remember that many of the features of this element are influenced by the degree of upstream shading in addition to flow volume, degree of flow alterations, channel type, and other factors. Therefore, the element is assessed for canopy over the entire property rather than at a single assessment reach. Choose the matrix appropriate for the stream and its native fauna. For example, if the stream is a trout stream, use the matrix for cold-water streams. If the stream is naturally warmer than 70 degrees Fahrenheit, use the matrix for warm-water streams. Lastly, percentages in the scoring matrix should be modified according to the site's potential for plant communities that will provide shade to the stream.

Element 6 Canopy cover

(a) Cold-water streams

>75% of water surface shaded within the length of the stream in landowner's property	75–50% of water surface shaded within the length of the stream in landowner's property	49–20% of water surface shaded within the length of the stream in landowner's property	<20% of water surface shaded within the length of the stream in landowner's property
10 9	**8 7 6**	**5 4 3**	**2 1 0**

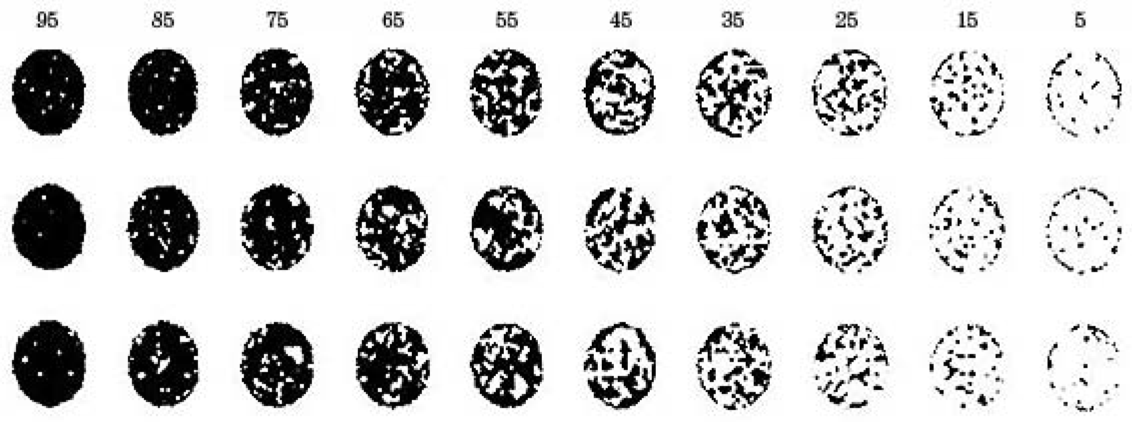
(b) Warm-water streams

50–75% of water surface shaded within the length of the stream in landowner's property	>75% of water surface shaded within the length of the stream in landowner's property	49–20% of water surface shaded within the length of the stream in landowner's property	<20% of water surface shaded within the length of the stream in landowner's property
10 9	**8 7 6**	**5 4 3**	**2 1 0**

What to look for

- Estimate the percent of the stream surface area that is shaded over the entire property. This may require cover estimates at several points within and outside the assessment reach. Time of the year, time of the day, and weather can affect the observation of shading. Therefore, the relative amount of shade is estimated by assuming that the sun is directly overhead and the vegetation is in full leaf-out. To enhance accuracy of the assessment, aerial photographs taken during full leaf-out should be used to supplement visual assessments. Figure 25 may be used as a guide for both visual and aerial estimates.

Figure 25 Percent canopy cover. Numbers above the ovals refer to the percent black (= shade/cover). (USDA Forest Service FIA Manual, http://www.fia.fs.fed.us/library/)



(f) Element 7—Water appearance

Description and rationale for assessing water appearance

The water appearance assessment element compares turbidity, color, and other visual characteristics of the water with those of a reference stream. The assessment of turbidity is the depth to which an object can be clearly seen. Clear water indicates low turbidity. Cloudy or opaque water indicates high turbidity. Turbidity is caused mostly by particles of soil and organic and inorganic matter suspended in the water column.

Streams often show some turbidity after a storm event because of soil and organic particles carried by runoff into the stream or suspended by turbulence. Intrinsic characteristics of a watershed, such as geology and soils unaffected by human activities, should be considered in reference conditions and assessment. For example, glacial flour creates high turbidity and is considered a natural process of erosion in glacial streams. Tea-colored water due to tannins from a natural process in bogs and wetlands may also affect clarity in some streams. Altered clarity due to natural processes would not receive low ratings.

Element 7 Water appearance

Water is very clear, or clarity appropriate to site; submerged features in stream (rocks, wood) are visible at depths of 3 to 6 feet No motor oil sheen on surface; no evidence of metal precipitates in streams	Water is slightly turbid, especially after storm event, but clears after weather clears; submerged features in stream (rocks, wood) are only visible at depths of 1.5 to 3 feet No motor oil sheen on surface or evidence of metal precipitates in stream	Water is turbid most of the time; submerged features in stream (rocks, wood) are visible at depths of only .5 to 1.5 feet **and/or** Motor oil sheen is present on water surface or areas of slackwater **and/or** There is evidence of metal precipitates in stream	Very very turbid water most of the time; submerged features in stream (rocks, wood) are visible only within .5 feet below surface **and/or** Motor oil sheen is present on the water surface or areas of slackwater
10 9 8	**7 6 5**	**4 3 2**	**1 0**

What to look for

- Clarity of the water is an obvious and easy feature to assess. The deeper an object in the water can be seen, the lower the amount of turbidity. This measure should be taken after a stream has had the opportunity to settle down following a storm event.
- A stream should not smell like oil or have pronounced motor oil sheen on its surface.
- Use the depth that objects are visible only if the stream is deep enough to evaluate turbidity using this approach. For example, if the water is clear, but only 1 foot deep, do not rate it as if an object became obscured at a depth of 1 foot.

Clear visibility	3–6 ft
Slightly turbid	1–5-3 ft
Turbid	0.5–1.5 ft
High turbidity	<0.5

(g) Element 8—Nutrient enrichment

Description and rationale for assessing nutrient enrichment

Nutrients are necessary for stream food webs by promoting algal and aquatic plant growth, which provide habitat and food for aquatic organisms. However, an excessive amount of algal and plant growth is detrimental to stream ecosystems. High levels of nutrients (especially phosphorus and nitrogen) lead to increased growth of algae and aquatic plants. Subsequently, respiration and decomposition of plant organic matter consume dissolved oxygen in the water, lowering the concentration of oxygen available to aquatic organisms and possibly contributing to significant die-offs. A landowner may have seen fish gulping for air at the water surface during warm weather, indicating a lack of dissolved oxygen. Streams respond differently to nutrient loading. The presence of algal blooms—thick mats of algae and an overabundance of aquatic plants (macrophytes)—are often indicators that nutrients are high. However, the absence of such blooms may not always be indicative of nutrient concentrations. Stream velocity, light availability, temperature, and types of stable substrate present in a stream are important factors that affect algal and plant abundances. Water quality problems that arise from excess turbidity, herbicides, or salinity will also affect the abundance or absence of algae or macrophytes. If there is little or no algal growth, assess the factors described in the *What to look for* section, and summarize the findings accordingly. Nutrient enrichment is difficult to assess visually. If a score of less than 5 is determined, a simple quantitative assessment, such as water quality testing for total phosphorus, may be warranted.

Element 8 Nutrient enrichment

Clear water along entire reach Little algal growth present	Fairly clear or slightly greenish water Moderate algal growth on substrates	Greenish water particularly in slow sections Abundant algal growth, especially during warmer months **and/or** Slight odor of ammonia or rotten eggs **and/or** Sporadic growth of aquatic plants within slack water areas	Pea green color present; thick algal mats dominating stream **and/or** Strong odor of ammonia or rotten eggs **and/or** Dense stands of aquatic plants widely dispersed
10 9	**8 7 6**	**5 4 3**	**2 1 0**

What to look for

- Streams with high velocity greater than .33 foot per second and high concentrations of nutrients are typically not dominated by filamentous algae. Thus, the water may appear very clear, yet still have high nutrient concentrations.
- If light is a limiting factor due to shading from riparian vegetation, look for algal growth on rocks and boulders in reaches exposed to light.
- Most algae grow more rapidly at higher temperatures. Within a range of 32 to 77 degrees Fahrenheit, increasing temperature by 18 degrees Fahrenheit typically doubles the rate of algal growth.
- Low complexity of substrate reduces filamentous algal growth.
- The presence of dense stands of aquatic macrophytes may be an indicator of nutrient availability. Diversity with the aquatic plant community should be noted and considered. Some species typically associated with springs, such as watercress, may not be associated with heavy nutrient loading. Clear water and a diverse, dispersed aquatic plant community are optimal for this characteristic.

(h) Element 9—Manure or human waste presence

Description and rationale for assessing manure or human waste presence

Manure and human waste increase nutrients and biochemical oxygen demand in streams, which alter food webs and nutrient cycles of stream/riparian ecosystems. Ask the property manager if and when livestock have access to the stream. Manure from livestock contaminates water if livestock have direct access to the stream or runoff from corrals, pastures, or paddocks is not diverted away from the stream. Similarly, wastewater piped or diverted directly to a stream is a health risk to aquatic species and humans. *Score this element on the entire property and all properties where SVAP2 is completed.*

Element 9 Manure or human waste presence

Livestock do not have access to stream No pipes or concentrated flows discharging animal waste or sewage directly into stream	Livestock access to stream is controlled and/or limited to small watering or crossing areas No pipes or concentrated flows discharging animal waste or sewage directly into stream	Livestock have unlimited access to stream during some portion of the year Manure is noticeable in stream **and/or** Pipes or concentrated flows discharge treated animal waste or sewage directly into stream	Livestock have unlimited access to stream during entire year Manure is noticeable in stream **and/or** Pipes or concentrated flows discharge untreated animal waste or sewage directly into stream
10 9	**8 7 6**	**5 4 3**	**2 1 0**

What to look for

- Indications of livestock droppings in or adjacent to the stream channel
- Features such as fences, water gaps, and hardened crossings that limit livestock access to stream
- Areas with slow moving water and sunlight with unusually dense vegetation or algal blooms
- Pipes or concentrated flow areas that may be dumping livestock or human waste directly into the stream

(i) Element 10—Pools

Description and rationale for assessing pools

Regardless of the stream channel type, pools are important resting, hiding, and feeding habitat for fish. Streams with a mix of shallow and deep pools offer diverse habitat for different species of fish and other aquatic species. In fish-bearing streams, a general rule of thumb to distinguish deep pools from shallow pools is this: a deep pool is 2 times deeper than the maximum depth of its upstream riffle, while a shallow pool is less than 2 times deeper than the maximum depth of its upstream riffle. This general rule may not apply to extremely high-gradient streams dominated by cascades, however. Continuous pools (those not separated by riffles, wood jams, rock steps, or fast-water) provide less diverse habitat and are indicative of poor stream structure and should not be considered for scoring in the first three boxes (only the last). Fish use such cover to rest, hide from predators, catch food items in the swirling currents that occur around submerged structures, and avoid territorial conflicts. Isolated pools occur when streamflows are so low that portions of the stream are essentially dewatered temporarily. If deep enough, these isolated pools serve as refuges for stranded fish and other aquatic species until rains restore continuous flow in the system and reconnect the pools to their previously dry riffles.

Fish habitat is often limited by the amount of available cover, such as submerged logs, boulders, tree roots, and undercut banks, in pools. Stream alteration often reduces the amount and complexity of pools, thus degrading fish habitat. On the other hand, beavers often create pools in streams, which may add habitat diversity and enhance pool habitats; however, their effects may also inundate riffles and other shallow water habitats. Thus, it is important to assess SVAP stream reaches in the correct context, that is, in relation to local reference conditions. States are encouraged to modify scoring of this element according to local pool-to-riffle ratios generally present in reference stream reaches. Remember, representative reaches of streams throughout the area are being assessed, and if conditions should change dramatically within the property due to alteration or other influences affecting the structure and function of the stream, additional reaches should be assessed.

Only one pool morphology type (low gradient or high gradient) should be used per assessment reach.

Element 10 Pools: Low-gradient streams (<2%) scoring matrix

More than two deep pools separated by riffles, each with greater than 30% of the pool bottom obscured by depth, wood, or other cover Shallow pools also present	One or two deep pools separated by riffles, each with greater than 30% of the pool bottom obscured by depth wood, or other cover At least one shallow pool present	Pools present but shallow (<2 times maximum depth of the upstream riffle) Only 10–30% of pool bottoms are obscured due to depth or wood cover	Pools absent, but some slow water habitat is available No cover discernible **or** Reach is dominated by shallow continuous pools or slow water
10 9	**8 7 6**	**5 4 3**	**2 1 0**

Element 10 Pools: high-gradient streams (>2%) scoring matrix

More than three deep pools separated by boulders or wood, each with greater than 30% of the pool bottom obscured by depth, wood, or other cover. For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide adequate cover for resident fish Shallow pools also present	Two to three deep pools, each with greater than 30% of the pool bottom obscured by depth wood or other cover; at least one shallow pool present. For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide some cover for resident fish At least one shallow pool also present	Pools present but relatively shallow, with only 10–30% of pool bottoms obscured by depth or wood cover. For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide minimal cover for resident fish No shallow pools present	Pools absent
10 9	**8 7 6**	**5 4 3**	**2 1 0**

What to look for (low-gradient streams)

- The number of pools per assessment reach is estimated based on walking the stream or probing from the streambank with a stick or pole. You should find deep pools on the outside of meander bends. Pools are typically separated by riffles or other shallow water habitats. In drier climates, deep pools may be temporarily isolated from their riffles, yet still provide important refuge habitat. Pools are formed by obstructions in the stream channel such as fallen trees, accumulations of wood (jams), beaver dams, boulders, root wads, rock outcrops, beaver dams, and accumulated plant debris.
- Assess pool cover by estimating the percent of the pool bottom that is obscured by cover features or depth, assuming one is positioned directly over the feature looking straight down at the stream bottom. In shallow, clear streams a visual inspection may provide an accurate estimate.

What to look for (high-gradient streams)

- In high-gradient streams, energy is dissipated by alternating slow and fast water conditions with step-pools and rapids/scour pools. Step-pools operate similar to stair steps with water dropping vertically over nearly complete channel obstructions (often a large rock and/or large wood) scouring out small depressions or plunge pools (Hunter 1991). Streams with step-pool conditions usually have gradients greater than 4 percent and pools are spaced at one pool every 1.5 to 4 bankfull channel widths. Pool spacing decreases as gradient increases (Rosgen 1996).
- Streams with gradients between 2 and 4 percent are often rapids and lateral scour pool dominated. Scour pool spacing is typically one pool every 4 to 5 bankfull channel widths and is created by channel confinements and wood or sediments.
- Plunge pools and scour pools are important aquatic habitat features providing resting and hiding cover for fish and aquatic species. With these pools, turbulence, large rock, wood, and the depth of water all contribute hiding cover for fish.

(j) Element 11—Barriers to aquatic species movement

Description and rationale for assessing barriers to aquatic species movement

Most aquatic organisms move around their habitats or undertake daily, seasonal, or annual migrations. For example, anadromous trout and salmon spawn and rear in freshwater, move to marine environments to grow to adulthood, and return to freshwater after a period of months or years to reproduce and die (Groot and Margolis 1991). Other fish commonly use estuaries, river mouths, and the lower reaches of rivers within a span of a few days for feeding, sheltering, or as refuge from predators (Gross et al. 1988). Others use headwater streams for spawning and downstream lakes or rivers for feeding as they mature. Consequently, barriers that block the movement of fish or other aquatic organisms are important components of stream assessment.

Instream features or water management practices can create barriers that limit or prohibit the passage of aquatic organisms either seasonally or annually. Passage barriers may prevent the movement or migration of fish, deny access to important breeding or foraging habitats, and isolate populations of fish and other aquatic animals. Both natural and fabricated barriers occur within river and stream systems, and natural physical barriers include waterfalls, cascades, and large rapids. Common fabricated physical barriers include dams, diversions, culverts, weirs, excessively high-grade control structures or buried sills with broad crests. Chemical and biological barriers, such as water quality and quantity (temperature and low stream flows) and predation from nonnative species, also exist in many rivers across the United States. However, these types of passage problems are often seasonal and can be difficult to identify with limited field time and site-specific data.

Passage barriers are typically categorized by characteristics such as water velocity, water depth, and barrier height in relation to the passage requirements of a given species and/or life stage.

Three commonly used barrier classes are:

- *Partial*—impassable to some species or certain age classes all or most of the time
- *Temporary*—impassable during some times to all or most species and/or age classes (e.g., during low flow conditions)
- *Complete*— impassable to all fish at all times

For example, a poorly designed or damaged culvert may be a temporary barrier to upstream migrating adults when flows are high because velocities within the culvert barrel exceed their natural swimming capabilities. Some highly migratory fishes like Pacific salmonids can leap 6 feet or more to bypass a waterfall, whereas shad in the same river will be faced with a complete barrier (Bell 1990; Haro and Kynard 1997). Many State and Federal agencies have laws that are applicable to this element. Conservationists should become familiar with State-applicable regulations as part of the preliminary assessment.

When addressing this element, assess a length of stream at least 12 times the bankfull width or the entire stream length on the landowner's property, whichever is greater. Be sure to detail in the notes the species and life stages of aquatic organisms for which barriers are being evaluated.

Element 11 Barriers to aquatic species movement scoring matrix

No artificial barriers that prohibit movement of aquatic organisms during any time of the year	Physical structures, water withdrawals and/or water quality seasonally restrict movement of aquatic species			Physical structures, water withdrawals and/or water quality restrict movement of aquatic species throughout the year				Physical structures, water withdrawals and/or water quality prohibit movement of aquatic species		
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**

What to look for

- Ask the landowner about any dams or other barriers that may be present 3 to 5 miles upstream or downstream of his or her property.
- Note the presence of natural barriers along the assessment reach, their size.
- Beaver dams generally do not prevent fish migration and should not be identified as passage barriers unless supporting information exists.
- Livestock and/or equipment/vehicle crossings can be passage barriers if water flows fast and shallow (less than 6 in) across smooth or uniform surfaces at least half as wide (from upstream to downstream) as the bankfull width. For example, a 12-foot-wide hardened vehicle ford that crosses a stream with a bankfull width of 20 feet is likely a temporary passage barrier.
- Low-head dams are most likely temporary or complete barriers, especially if outfitted with a concrete apron that covers the streambed along the entire downstream face.
- Culverts can be especially problematic to migratory aquatic organisms. Unless specifically designed with passage purposes in mind, most culverts are partial upstream passage barriers for the smallest life stages of native fish. Culverts should be scored as temporary or complete passage barriers if the culvert:
  - alignment does not match the stream
  - width is less than bankfull width
  - slope is greater than channel slope
  - is not countersunk
  - is perched (elevated) above the outlet pool
  - inlet is plugged with debris
  - inlet or outlet shows sign of erosion or instability

(k) Element 12—Fish habitat complexity

Description and rationale for assessing fish habitat complexity

The dynamic features of stream corridors create diverse habitat types and conditions for fish and other aquatic species. Quality fish habitat is a mosaic of different types of habitats created by various combinations of water quality and quantity, water depth, velocity, wood, boulders, riparian vegetation, and the species that inhabit stream corridors. The greater the variety of habitat features, the more likely a stream is to support a diversity of aquatic species. Fish require these complex habitats with diverse types of hiding, resting, and feeding cover in parts of the stream and variable flow features. For example, deep pools (with slower currents) provide cover, thermal refuge, and a place to rest. Riffles (with faster currents) provide benthic invertebrates to prey on. Fast water is well aerated, providing more oxygen to the stream ecosystem. The more types of different structural features, the more resilient the habitat is to natural disturbances (such as floods), as well as human perturbations (such as water withdrawals). The dynamic nature of instream habitat features assures fish and other species are able to find suitable areas to rear, feed, grow, hide, and reproduce during the course of their life histories. Because fish habitat needs and types vary considerably from species to species and throughout the country, States should adjust scoring of this element to reflect reference conditions and species habitat features characteristic of their region.

Element 12 Fish habitat complexity scoring matrix

Ten or more habitat features available, at least one of which is considered optimal in reference sites (large wood in forested streams)	Eight to nine habitat features available	Six to seven habitat features available	Four to five habitat features available	Less than four habitat features available
10 9	**8 7**	**6 5**	**4 3**	**2 1 0**

Note: Fish habitat features: logs/large wood, deep pools, other pools (scour, plunge, shallow, pocket) overhanging vegetation, boulders, cobble, riffles, undercut banks, thick root mats, dense macrophyte beds, backwater pools, and other off-channel habitats

What to look for

Within the entire assessment reach, observe the number of different habitat features that provide diverse and complex habitats for fish. Each habitat feature must be present in appreciable amounts to score (as compared to suitable reference sites). Features include:

- **Logs, large wood—**fallen trees or parts of trees that are submerged in the water and large enough to remain in the assessment reach during normal flows. **Minimum 2/reach; #/reach: _____**
- **Small wood accumulations—**submerged accumulations of small wood pieces, twigs, branches, leaves, and roots. Though likely to be temporary components of stream habitats, their pieces will continue to provide structural complexity as the debris moves within the reach. **Minimum 1/reach; #/reach: _____**
- **Deep pools—**areas of slow water with smooth surface and deep enough to provide protective cover for fish species likely to be present in the stream. **Minimum 2/reach; #/reach: _____**
- **Secondary pools** (scour, plunge, pocket pools) —pools formed by boulders or wood that divert water and scour depressions below turbulent flows. **Minimum 4/reach; #/reach: _____**
- **Overhanging vegetation—**tree branches, shrub branches, or perennial herbaceous vegetation growing along the streambank and extending outward over the stream's surface, providing shade and cover. **Minimum 3/reach; #/reach: _____**
- **Large boulders**—submerged or partially submerged large rocks (>20 inches in diameter). **Minimum 3/reach if no wood. Minimum 2/reach if wood present; #/reach: _____**
- **Small boulder clusters—**groups of 2 or more smaller rocks (>10 and <20 inches in diameter) interspersed relatively close together in the channel. **Minimum 3/reach; #/reach: _____**
- **Cobble riffles—**fast, bubbly water flowing amongst and over small rocks between 2 and 10 inches in diameter. **Minimum 2/reach; #/reach: _____**
- **Undercut banks—**water-scoured areas extending horizontally beneath the surface of the bank, forming underwater pockets used by fish for hiding and thermal cover. **Minimum 3/reach or 25 percent of bank area; #/reach: _____**
- **Thick root mats—**mats of roots and rootlets, generally from trees but sometimes from mature dense shrubs at or beneath the water surface. **Minimum 3/reach; #/reach: _____**
- **Macrophyte beds—**beds of emergent, submerged, or floating leaf aquatic plants thick enough to serve as cover. **Minimum 1/reach; #/reach: _____**
- **Off-channel habitats—**side channels, flood plain wetlands, backwaters, alcoves. **Minimum 2/reach; #/reach: _____**
- **Other locally important habitat features (describe) _____**

(l) Element 13—Aquatic invertebrate habitat

Description and rationale for assessing aquatic invertebrate habitat

Four functional groups characterize the feeding functions of most aquatic invertebrates: shredders, collectors, grazers, and predators. Some species can be placed in more than one functional feeding group. The groups are typically present in all streams, although the dominance of groups will vary from headwater streams to larger streams and rivers. These functional feeding groups help predict the location and diverse substrate needs of specific invertebrates within the stream. Substrates are materials that provide a base for invertebrates to live and colonize. In a healthy stream, substrates are varied, free of sediment, abundant, and in place long enough to allow colonization by invertebrates. High stream velocities, high sediment loads, and frequent flooding may deplete substrate or cause it to be unsuitable habitat, at least temporarily until recolonization occurs.

Wood and riffle areas with boulders/cobbles support the bulk of the invertebrate community in temperate streams (Benke et al. 1984). Wood typically supports a more diverse invertebrate community, while boulders and cobble within riffles typically support higher numbers (abundance) of species. High numbers of habitat types for fish often equate to high invertebrate habitat types. The scale of habitat assessment is necessarily much smaller for invertebrates because their range of mobility limits the size of their habitat, or microhabitat. Therefore, an array of different types of habitat should be found within a smaller area of the reach. Assess the number of different types of habitat within a representative subsection of the assessment reach that is equivalent in length to five times the active channel width. To score, habitat types should be present in appreciable amounts (as expected in reference conditions or least impaired conditions).

Element 13 Aquatic invertebrate habitat scoring matrix

At least 9 types of habitat present A combination of wood with riffles should be present and suitable in addition to other types of habitat (If nonforested stream, consider reference site's optimal habitat type needed for this high score)	8 to 6 types of habitat Site may be in need of more wood or reference habitat features and stable wood-riffle sections	5 to 4 types of habitat present	3 to 2 types of habitat present	None to 1 type of habitat present
10 9	**8 7 6**	**5 4**	**3 2**	**1 0**

Note: Aquatic invertebrate habitat types, in order of importance: Logs/large wood, cobble within riffles, boulders within riffles. Additional habitat features should include: leaf packs, fine woody debris, overhanging vegetation, aquatic vegetation, undercut banks, pools, and root mats.

What to look for

- **Logs, large wood—**fallen trees or parts of trees that are submerged or partially submerged in the water and large enough to remain in the assessment reach during normal flows. **Minimum 2/subreach; #/subreach: _____**
- **Large boulders within riffles**—submerged or partially submerged large rocks (>20 inches in diameter); **Minimum 2/subreach if no wood; minimum 1/subreach if wood present; #/subreach: _____**
- **Small boulders in riffles clusters—**groups of two or more smaller rocks (>10 and <20 inches in diameter) interspersed relatively close together in the channel. **Minimum 2/subreach; #/subreach: _____**
- **Fine woody debris—**accumulations of twigs, branches, leaves, and roots. Though likely to be temporary components of stream habitats, their pieces will continue to provide structural complexity and substrate for invertebrates as the debris moves within the reach. **Minimum 2/subreach**; **#/subreach: _____**
- **Overhanging vegetation—**tree branches, shrub branches, or perennial herbaceous vegetation growing along the streambank and extending outward over the stream's surface, providing shade, cover and food. **Minimum 1/subreach; #/subreach: _____**
- C**obble riffles—**fast, "bubbly" water flowing amongst and over small rocks between 2 and 10 inches in diameter. **Minimum 1/subreach; #/subreach: _____**
- **Undercut banks—**water-scoured areas extending horizontally beneath the surface of the bank, forming underwater pockets used by aquatic insects for resting and feeding. **Minimum 1/subreach or 25 percent of bank area; #/subreach: _____**
- **Pools**—slow water, deeper than riffles. **No minimum subreach; #/subreach: _____**
- **Thick root mats—**mats of roots and rootlets, generally from trees but sometimes from mature dense shrubs at or beneath the water surface. **Minimum 1/subreach; #/subreach: _____**
- **Macrophyte beds—**emergent submerged, or floating leaf aquatic plants thick enough to serve as cover. **Minimum 1/subreach; #/subreach: _____**
- **Other locally important habitat features (describe) ____________________________**

(m) Element 14—Aquatic invertebrate community

Description and rationale for assessing aquatic invertebrate community

This important element reflects the ability of the stream to support aquatic invertebrates such as crayfish, mussels, dragonflies, and caddisflies. However, successful assessments require knowledge of the life cycles of some aquatic insects and other macroinvertebrates and the ability to identify them. For this reason, this is an optional element.

Aquatic invertebrates include crustaceans (such as crayfish), mollusks (such as snails), spiders, and aquatic insects. These organisms are important to aquatic food webs. To better understand aquatic invertebrate functions, habitat needs and interrelationships within the food web, ecologists have categorized these organisms into four major functional feeding groups:

- ***Shredders*** process leaves, sticks, and twigs. Their habitats are distinguished by areas that trap and retain organic matter (leaf packs). They are generally found in headwater streams.
- ***Collectors*** are made up of two types of aquatic invertebrates, also generally found in headwater streams:
  - ***Filterers*** process smaller organic matter, suspended in the water. Their habitats are large stable rock or logs.
  - ***Gatherers*** actively collect their food, plant and animal material. Their habitat is usually medium to large rocks.
- ***Grazers*** feed on algae in areas of streams receiving sunlight. Like gatherers, their habitat is medium to large rocks.
- ***Predators*** feed on other animals. Their habitats include logs, medium to large rocks, water column, pools, and leaf litter.

The presence of a diversity of intolerant macroinvertebrate species (pollution sensitive) indicates healthy, resilient stream conditions. Macroinvertebrates, such as stoneflies, mayflies, and caddisflies, are sensitive to pollution and do not tolerate polluted water. These intolerant orders of insects comprise group I. Group II macroinvertebrates are facultative, meaning they can tolerate limited pollution. This group includes damselflies, aquatic sowbugs, and crayfish. The dominant presence of group III macroinvertebrates, including midges, craneflies and leeches, without the presence of group I suggests the water is significantly polluted. The presence and abundance of only one or two species from group I species in a reach community does not generally indicate diversity is good. As with all elements in the SVAP, comparison with reference conditions or those found in least impaired streams in the area are encouraged.

Element 14 Aquatic invertebrate community scoring matrix

Invertebrate community is diverse and well represented by group I or intolerant species One or two species do not dominate	Invertebrate community is well represented by group II or facultative species, and group I species are also present One or two species do not dominate	Invertebrate community is composed mainly of groups II and III **and/or** One or two species of any group may dominate	Invertebrate community composition is predominantly group III species **and/or** only one or two species of any group is present and abundance is low
10 9 8	**7 6 5**	**4 3 2**	**1 0**

What to look for

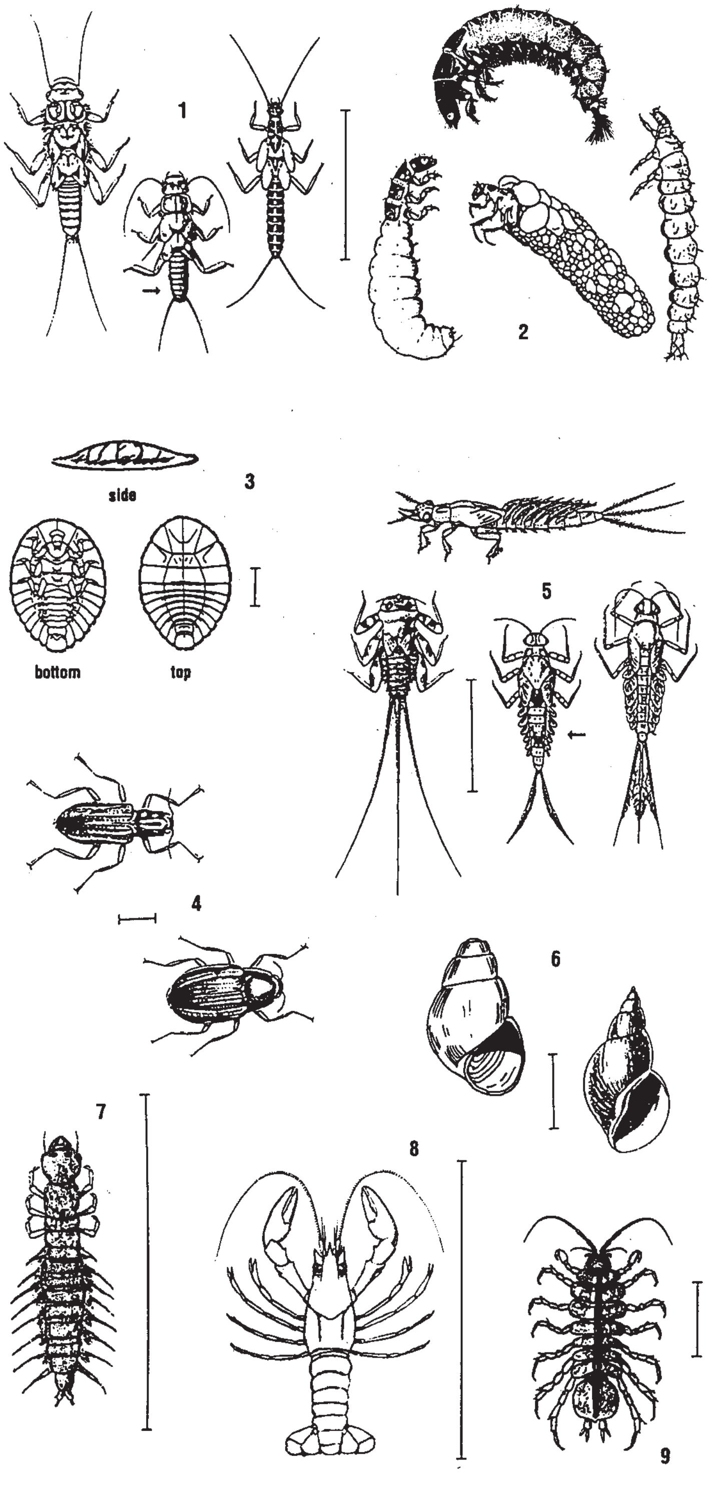
Figure 26 shows illustrations for each of the three groups of macroinvertebrates with the listing of invertebrate taxonomic order. This rating is qualitative and therefore potential biases should be avoided to provide accurate representation of each site.

- Collect macroinvertebrates by picking up cobbles, gravel, leaf packs, silt, fine woody debris, and other submerged objects in the water. Sample all types of potential insect habitat (refer to insect/invertebrate habitat element) for an equal amount of time to reduce biases and improve accuracy.
- A healthy and stable invertebrate community will be consistent in its proportional representation (evenness) of species, though individual species abundance may vary in magnitude. Note the kinds of macroinvertebrates (group type), approximate number of each species, and relative abundance of each species sampled. Determine if one or two species dominate the aquatic invertebrate community. An abundance of an individual species, such as caddisflies or snails, is often equated to a tolerance of stress, such as poor water quality, and lower diversity.

Element 15 Riffle embeddedness scoring matrix

Gravel or cobble substrates are <10% embedded	Gravel or cobble substrates are 10–20% embedded	Gravel or cobble substrates are 21–30% embedded	Gravel or cobble substrates are 31—0% embedded	Gravel or cobble substrates are >40% embedded
10 9	**8 7**	**6 5**	**4 3**	**2 1 0**

Figure 26 Stream invertebrates (Source: Izaak Walton League of America)



Bar lines indicate relative size

Group I Taxa: Pollution-sensitive taxa found in good quality water.

1 Stonefly: Order Plecoptera. .5 to 1.5 inches, six legs with hooked antenna, two hair-line tails. Smooth (no gills) on lower half of body (see arrow).

2 Caddisfly: Order Trichoptera. Up to 1 inch, six hooked legs on upper third of body, two hooks at back end. May be in a stick, rock, or leaf case with head sticking out. May have fluffy gill tufts on underside.

3 Water Penny: Order Coleoptera. 1/4 inch, flat saucer-shaped body with a raised bump on one side and six tiny legs and fluffy gills on the other side. Immature beetle.

4 Riffle Beetle: Order Coleoptera. 1/4 inch, oval body covered with tiny hairs, six legs, antennae. Walks underwater. Swims beneath surface.

5 Mayfly: Order Ephemeroptera. 1/4 to 1 inch, brown, moving, plate-like or feathery gills on sides of lower body (see arrow), six large hooked legs, antennae, two to three long hair-like tails that may be webbed together.

6 Gilled Snail: Class Gastropoda. Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

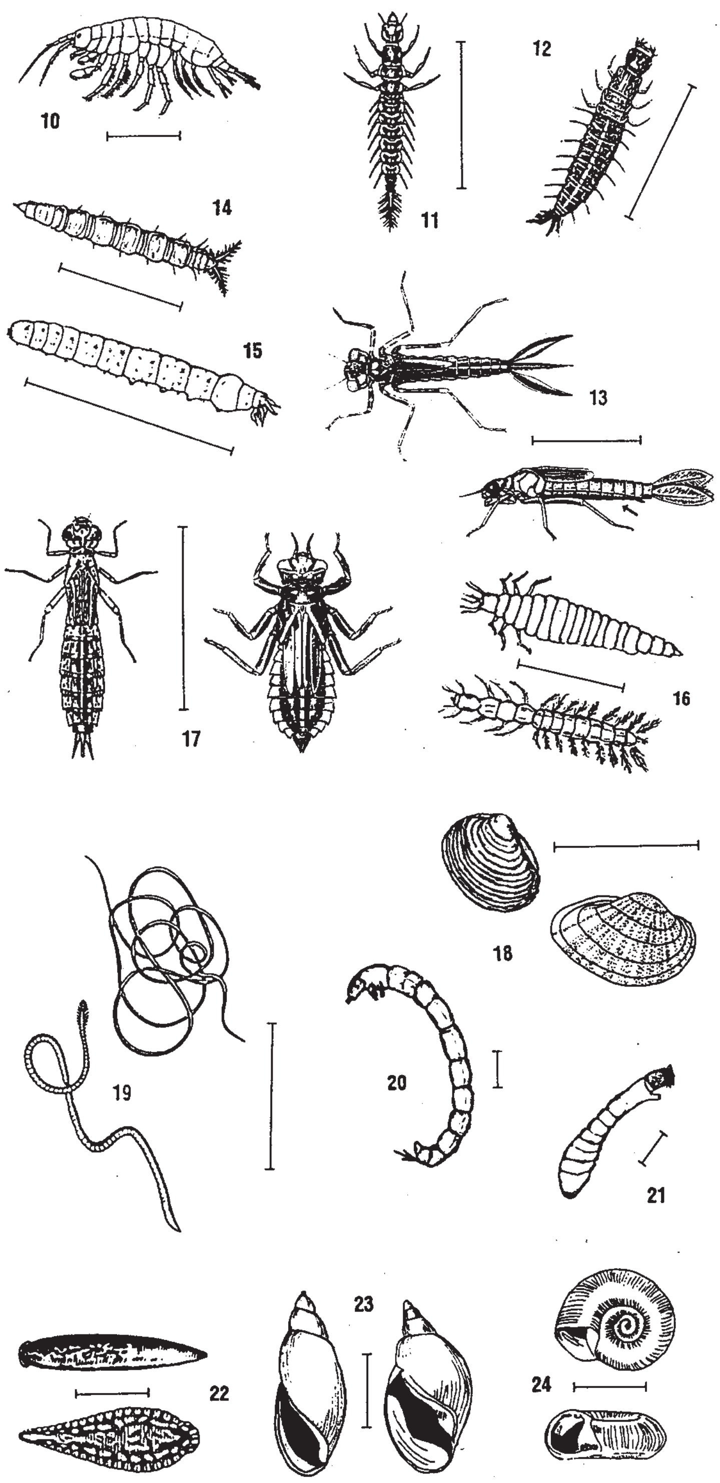
7 Dobsonfly (hellgrammite): Family Corydalidae. 3/4 to 4 inches, dark-colored, six legs, large pinching jaws, eight pair of feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, two tails, and two pair of hooks at end.

Group II Taxa: Somewhat pollution tolerant taxa found in good or fair quality water.

8 Crayfish: Order Decapoda. Up to 6 inches, 1 large claw, eight legs, resembles lobster.

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

Figure 26 Stream invertebrates (Source: Izaak Walton League of America)—Continued



Bar lines indicate relative size

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

11 Alderfly Larva: Family Sialidae. 1 inch long. Looks like small hellgrammite, but has long, thin, branched tail at back end (no hooks), no gill tufts below.

12 Fishfly Larva: Family Cordalidae. Up to 1 1/2 inch long. Looks like small hellgrammite, but often light reddish-tan color or with yellowish streaks. No gill tufts underneath.

13 Damselfly: Suborder Zygoptera. 1/2 to 1 inch, large eyes, six thin hooked legs, three broad, oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body (arrow).

14 Watersnipe Fly Larva: Family Athericidae (Atherix). 1/4 to 1 inch, pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 Crane Fly: Suborder Nematocera. 1/3 to 2 inches, milky, green, or light brown, plump caterpillar-like segmented body, four finger-like lobes at back end.

16 Beetle Larva: Order Coleoptera. 1/4 to 1 inch, light colored, six legs on upper half of body, feelers, antennae.

17 Dragon Fly: Suborder Anisoptera. 1/2 to 2 inches, large eyes, six hooked legs. Wide, oval to round abdomen.

18 Clam: Class Bivalvia.

Group III Taxa: Pollution-tolerant organisms can be in any quality of water.

19 Aquatic Worm: Class Oligochaeta, 1/4 to 2 inches, can be tiny, thin, worm-like body.

20 Midge Fly Larva: Suborder Nematocera. Up to 1/4 inch, dark head, worm-like segmented body, two legs on each side.

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

22 Leech: Order Hirudinea. 1/4 to 2 inches, brown, slimy body, end with suction pads.

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

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

(n) Element 15—Riffle embeddedness

Description and rationale for assessing riffle embeddedness

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

Do not assess this element unless riffles or swift-flowing water and coarse substrates are present or a natural feature that should be present.

Element 15 Riffle embeddedness scoring matrix

Gravel or cobble substrates are <10% embedded	Gravel or cobble substrates are 10–20% embedded	Gravel or cobble substrates are 21–30% embedded	Gravel or cobble substrates are 31—0% embedded	Gravel or cobble substrates are >40% embedded
10 9	**8 7**	**6 5**	**4 3**	**2 1 0**

What to look for

- This element should be assessed only in streams where riffles are a natural feature.
- The measure is the depth to which objects are buried by sediment. This assessment is made by picking up particles of gravel or cobble with fingertips at the fine sediment layer. Pull the particle out of the bed, and estimate what percent of the particle was buried.
- Some streams have been so smothered by fine sediment that the original stream bottom is not visible. Test for complete burial of a streambed by probing with a measuring stick. Does substrate move easily when the substrate is moved around with one's feet? If not, substrate material is likely greater than 40 percent embedded.

(o) Element 16—Salinity (if applicable)

Description and rationale for assessing salinity

The origin of elevated salinity levels in streams is often associated with irrigation of salt-laden soils, dryland crop/fallow systems that produce saline seeps, oil and gas well operations, and animal waste. Salt accumulation in streambanks can cause break down of soil structure, decreased infiltration of water, and toxicity. High salinity in streams affects aquatic vegetation, macroinvertebrates, and fish. If observed impacts of salt are a product of natural weathering processes of soil and geologic material uninfluenced by humans, this element should not be scored.

Element 16 Salinity scoring matrix

No wilting, bleaching, leaf burn, or stunting of riparian vegetation No streamside salt-tolerant vegetation present	Minimal wilting, bleaching, leaf burn, or stunting of riparian vegetation Some salt-tolerant streamside vegetation	Riparian vegetation may show significant wilting, bleaching, leaf burn, or stunting Dominance of salt-tolerant streamside vegetation	Severe wilting, bleaching, leaf burn, or stunting; presence of only salt tolerant riparian vegetation Most streamside vegetation is salt tolerant
10 9 8	**7 6 5**	**4 3**	**2 1 0**

Note: Do not assess this element unless elevated salinity levels caused by people are suspected.

What to look for

- High salinity levels can cause a burning or bleaching of riparian vegetation. Wilting, loss of plant color, decreased productivity, and stunted growth are visible signs.
- Other indicators include whitish salt accumulations on streambanks and displacement of salt intolerant vegetation by more tolerant species.

614.06 References

Allan, J.D. 1995. Stream ecology: structure and function of running waters. Chapman and Hall, Inc. New York, NY.

Bell, M.C. 1990. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program, U.S. Army Corps of Engineers, North Pacific Division. Portland, OR. 290 pp.

Benke, A.C., T.C. Van Arsdall, Jr., D.M. Gillespie, and F.K. Parrish. 1984. Invertebrate productivity in a subtropical blackwater river: the importance of habitat and life history. Ecological Monographs 54:25–63.

Booth, D.B. 1990. Stream-channel incision following drainage-basin urbanization. Water Resources Bulletin 26:407–417.

Booth, D.B., and C.R. Jackson. 1997. Urbanization of aquatic systems-degradation thresholds, stormwater detention, and limits of mitigation: Journal of American Water Resources Association 33:1077–1090.

Calow, P., and G.E. Petts. 1994. The rivers handbook: hydrological and ecological principles, volumes One and Two. Blackwell Scientific Publications, Oxford, UK.

Forshay, K.J., and E.H. Stanley. 2005. Rapid nitrate loss and denitrification in a temperate river flood plain. Biogeochemistry 75:43–64.

Giller, P.S., and B. Malmqvist. 1998. The biology of streams and rivers. Oxford University Press, Oxford, UK. 296 pp.

Groot, C., and L. Margolis. 1991. Pacific salmon life histories. University of British Columbia Press, Vancouver, BC.

Gross, M.R., R.M Coleman, and R.M. McDowall. 1988. Aquatic productivity and the evolution of diadromous fish migration. Science 239:1291–1293.

Gurnell, A.M., K.J. Gregory, and G.E. Petts. 1995. The role of coarse woody debris in forest aquatic habitats: implications for management. Aquatic Conservation 5:143–166.

Haro, A., and B. Kynard. 1997. Video evaluation of passage efficiency of American shad and sea lamprey in a modified Ice Harbor fishway. North American Journal of Fisheries Management 17:981–987.

Hooke, J.M., and C.E. Redmond. 1992. Causes and nature of river planform change. *In* Dynamics of gravel bed rivers. P. Billi, et al. (eds). John Wiley & Sons, New York, NY. pp 559–571.

Hunter, C.J. 1991. Better trout habitat, a guide to stream restoration and management. Island Press, Washington DC. 320 pp.

Jones, J.A., and G.E. Grant. 1996. Long-term stormflow responses to clearcutting and roads in small and large basins, western Cascades, Oregon. Water Resources Research 32: 959–974.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-flood plain systems. *In* Proceedings of the International Large River Symposium. D.P. Dodge (ed.). Canadian Special Publication in Fisheries and Aquatic Science 106: 110–127.

Karr, J.R., K.D. Fausch, P.L. Angermier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Naural History Survey Special Publication 5. Champaign, IL. 28 pp.

Lane, E.W. 1955. The importance of fluvial geomorphology in hydraulic engineering. Proceedings of the American Society of Civil Engineers 81:1–17.

Leopold, L.B. 1994. A view of the river. Harvard University Press, Cambridge, MA. 298 pp.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial processes in geomorphology. W.H. Freeman and Company, San Francisco, CA.

Matthews, W.J. 1998. Patterns in freshwater fish ecology. Chapman and Hall, International Thompson Publishing, New York, NY.

Maxwell, J.R., C.J. Edwards, M.E. Jenson, S.J. Paustiam, H. Parrott, and D.M. Hill. 1995. A hierarchical framework of aquatic ecological units in North America (Nearctic Zone). Forest Service, General Technical Report NC–176, North Central Forest Experiment Station, MN. 72 pp.

Meyer, J.L. 1997. Stream health: Incorporating the human dimension to advance stream ecology. Journal of the North American Benthological Society 16: New Concepts in Stream Ecology: Proceedings of a Symposium. pp. 439–447.

Montgomery, D.R., and J.R. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Report TFW–SH10–93–002 prepared for the SHAMW committee of the Washington State Timber/Fish/Wildlife Agreement. 84 pp.

Pearsons, T.N., H.W. Li, and G.A. Lamberti. 1992. Influence of habitat complexity on resistance to flooding and resilience of stream fish assemblages. Transactions of the American Fisheries Society 121:427–436.

Platts, W.S. 1991. Livestock grazing. *In* Influences of Forest and rangeland management on salmonid fishes and their habitats. W.R. Meehan (ed.). American Fisheries Society Special Pub. 19:389–423. Bethesda, MD.

Poff, N.L., and J.V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure: A regional analysis of streamflow patterns. Canadian Journal of Fisheries and Aquatic Sciences 46:1805–1817.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: A paradigm for river conservation and restoration. BioScience 47:769–784.

Pons, L. 2003. Helping states slow sediment movement: a high-tech approach to Clean Water Act sediment requirements. Agriculture Research 51: 12–14.

Rosgen, D.L. 1994. A classification of natural rivers. Catena. 22:169–199.

Rosgen, D. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO. 352 pp.

Schlosser, I. J.1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecological Monographs 52:395–414.

Schueler, T.R. 1994. The importance of imperviousness. Watershed Protection Techniques. 1(3):100–111.

Schumm, S.A., Harvey, M.D., and Watson, C.C. 1984. Incised channels: morphology, dynamics, and control. Water Resource Publications, Littleton, CO.

Simon, A., A. Curini, S.E. Darby, and E.J. Langendoen. 2000. Bank and near-bank processes in an incised channel. Geomorphology 35:193–217.

Thorne, C.R. 1982. Processes and mechanisms of river bank erosion. *In* Gravel-Bed Rivers. R.D. Hey, J.C. Bathurst, and C.R. Thorne (eds.). John Wiley & Sons. New York, NY. pp 227–259.

Tickner, D.P., P.G. Angold, A.M. Gurnell, and J.O. Mountford. 2001. Riparian plant invasions: hydrogeomorphological control and ecological impacts. Progress in Physical Geography 25: 22–52.

U.S. Environmental Protection Agency (EPA). 2003. Level III ecoregions of the Continental United States (revision of Omernik, 1987): Corvallis, Oregon, USEPA National Health and Environmental Effects Research Laboratory, Map M–1, various scales.

Waters, T.F. 1995. Sediment in streams: Sources, biological effects and controls. American Fisheries Society Monograph 7. Bethesda, MD.

Williams, G.P. 1978. Bankfull discharge of rivers. Water Resources Research 14:1141–1154.

Wolman, M.G., and L.B. Leopold. 1957. River flood plains: Some observations on their formation. USGS Professional Paper 282–C. U.S. Geological Survey. Washington, DC.

Wolman, M.G., and J.P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. Journal of Geology 68:54–74.

Wolman, M.G., and R. Gerson. 1978. Relative scales of time and effectiveness of climate in watershed geomorphology. Earth Surface Processes and Landforms 3:189–208.

Stream Visual Assessment Protocol 2 Summary Sheet

Owner's name ___________________________ Evaluator's name_______________________________

Stream name ____________________________ Tributary to: __________________________HUC: ____

1. Preliminary Assessment

A. Watershed Description

Ecoregion or MLRA___________________ Watershed Drainage area (acres or mi^2)______________

Watershed management structures: (no.): dams___ water controls _____ irrigation diversions___

No. of miles of contiguous riparian cover/mile of entire stream in watershed (estimated)__________

Land use within watershed (%): cropland _____ hayland _____ grazing/pasture _____ forest ____

urban _____ industrial ______ other (specify) _____

Agronomic practices in uplands include: ____

Confined animal feeding operations (no.) ______ Conservation (acres) ______industrial(acres) _______

Number of stream miles on property_________________ Number of total stream miles____________

Stream hydrology: _____intermittent; months of year wetted : _________________

_____perennial; months of year at baseflow:_________________

B. Stream/Reach Description:

Stream Gage Location/Discharge: __________________________/____________ft^3/s

Applicable Reference Stream: ____________________ Reference Stream Location: ____/_____

Information Sources:

2. Field Assessment

A. Preliminary Field Data

Date of assessment________________ Weather conditions today__________________________
(ambient temp.\ % cloud cover)

Weather conditions over past 2 to 5 days: ____.
(No. of days precip/average daytime temp.)

Reach location (UTM or Lat./Long.) _______/_______ Channel type/classification scheme_______/_______

Riparian Cover Type(s): Tree____ % Shrub____% Herbaceous ____% Bare ____%

Bank Profile: Stratified___ Homogeneous____ Cohesive Soil___ Noncohesive Soil ____

Gradient (√ one): Low (0-2%)___ Moderate (>2<4%)___ High (>4%) ___

Bankfull channel width ______ft Reach length _______ft Flood plain width_______ft

Average riparian zone width_______ ft Method used (e.g., Range finder): ______________________

Average height of woody shrubs _______ Method used (e.g., Range finder): ______________________

Flood plain wetlands, if present ________ acres/reach

Dominant substrate (%): boulder ____ cobble ____ gravel ____ sand____ fine sediments ____
(> 250 mm) (60-250mm) (2-60 mm) (2-.06 mm) (< .06 mm)

Photo Point Locations and Descriptions:

Photo Pt. #	GPS Coordinates/Waypoints	Description
1		
2		
3		

SVAP Start Time/Water Temp: ________/________SVAP End Time/Water Temp: _____/________

Notes:

B. Element Scores

Element	Score	Element	Score
1. Channel Condition		14. Aquatic Invertebrate Community	
2. Hydrologic Alteration		15. Riffle Embeddedness	
3. Bank Condition		16. Salinity	
4. Riparian Area Quantity		**A. Sum of all elements scored**	
5. Riparian Area Quality		**B. Number of elements scored**	
6. Canopy Cover		**Overall score: A/B** ________ 1 to 2.9 Severely Degraded 3 to 4.9 Poor 5 to 6.9 Fair 7 to 8.9 Good 9 to 10 Excellent	
7. Water Appearance			
8. Nutrient Enrichment			
9. Manure or Human Waste			
10. Pools			
11. Barriers to Movement			
12. Fish Habitat Complexity			
13. Aquatic Invertebrate Habitat			

Suspected causes of SVAP scores less than 5 (does not meet quality criteria for stream species)

____

____

____

Recommendations for further assessment or actions:

____

____

____

Riparian wildlife habitat recommendations:

____

____

____

C. Site Diagram: indicate approximate scale, major features, resource concerns, etc.

1 to 2.9 Severely Degraded
3 to 4.9 Poor

Provide notes related to each element scored on back of site diagram, as needed.

Appendix A Additional References for Further Reading

Watershed health and assessment

Collins, B.D., D.R. Montgomery, A.J. Sheikh. 2002. Reconstructing the historical riverine landscape of the Puget lowland. *In* Restoration of Puget Sound Rivers. D.R. Montgomery, S. Bolton, D.B. Booth, and L. Wall (eds.). University of Washington Press, Seattle, WA.

Cushing, B., and J. Allen. 2001. Streams: their ecology and life. Academic Press, San Diego, CA.

Karr, J.R. 1999. Defining and measuring river health. Fresh Water Biology 41:221–234.

Kondolf, G.M., and P.W. Downs. 1996. Catchment approach to planning river channel restoration. *In* River Channel Restoration. A. Brookes and F.D. Shields., Jr. (eds.). John Wiley & Sons, Chichester, UK. pp 129–148.

Naiman, R.J., T.J. Beechie, L.E. Benda, D.R. Berg, P.A. Bisson, L.H. MacDonald, M.D. O'Connor, P.L. Olson, and E.A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest Coastal Ecoregion. *In* Watershed management: balancing sustainability and environmental change. R.J. Naiman (ed). Springer-Verlag, New York, NY. pp.127–188.

National Research Council. 1992. Restoration of Aquatic Ecosystems. National Academy Press, Washington, DC.

National Research Council. 2002. The Missouri River Ecosystem: exploring the prospects for recovery. National Academy Press, Washington, DC.

Stanford, J.A., and J.V. Ward. 1992. Management of aquatic resources in large catchments: recognizing interactions between ecosystem connectivity and environmental disturbance. *In* Watershed Management. R.J. Naiman (ed.). Springer-Verlag, New York, NY. pp 91–124.

Wang, L., J. Lyons, P. Kanehl, and R. Gatti. 1997. Influences of watershed land use on habitat quality and biotic integrity in Wisconsin streams. Fisheries 22:6–12.

Wang, L., J. Lyons, P. Kanehl, and R. Bannerman. 2001. Impacts of urbanization on stream habitat and fish across multiple spatial scales. Environmental Management. 28:255–266.

Ward, J.V., and J.A. Stanford. 1995. Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers 11:105–119.

Ward, J.V., K. Tockner, U. Uehlinger, and F. Malard. 2001. Understanding Natural Patterns and Processes in River Corridors as the Basis for Effective River Restoration. Regulated Rivers: Research and Management. 17:311–323.

Stream classification

Bryce, S.A., and S.E. Clarke. 1996. Landscape-level ecological regions: linking state-level ecoregion frameworks with stream habitat classifications. Environmental Management 20:297–311

Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. Environmental Management 10:199–214.

Hawkes, H.A. 1975. River zonation and classification. *In* River ecology. B.A. Whitton (ed.). University of California Press, Berkeley, CA. pp. 312–374.

Kondolf, G.M. 1995. Geomorphological stream channel classification in aquatic habitat restoration: uses and limitations. Aquatic Conservation: Marine and Freshwater Ecosystems 5:127–141.

Montgomery, D.R., and J.M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Washington State Timber, Fish, and Wildlife. p. 67.

Rosgen, D.L. 1994. A classification of natural rivers. Catena 22:169–199

Thorne, C.R. 1997. Channel types and morphological classification. Applied Fluvial Geomorphology for River Engineering and Management. John Wiley & Sons, Chichester, UK. pp.176–222.

Reference conditions

Hughes, R.M., D.P. Larsen, and J.M. Omernik. 1986. Regional reference sites: a method for assessing stream potentials. Environmental Management 10:629–635.

Hughes, R.M. 1995. Defining acceptable biological status by comparing with reference conditions. *In* Biological Assessment and Criteria: Tools for Water Resource Planning. W.S. Davis, and T.P. Simon (eds.). Lewis Publishers, Boca Raton, FL. 31–47.

Reynoldson, T.B., R.H. Norris, V.H. Resh, K.E. Day, and D.M. Rosenberg. 1997. The reference condition: a comparison of multimetric and multivariate approaches to assess water-quality impairment using benthic macroinvertebrates. Journal of the North American Benthological Society. 16:833–852

Channel condition

Leopold, L.B. 1994. A View of the River. Harvard University Press, Cambridge, MA.

Leopold, L.B., M.G. Wolman., and J.P. Miller. 1964. Fluvial processes in geomorphology. W.H. Freeman and Company, San Francisco, CA.

Schumm, S.A., M.D. Harvey, and C.C. Watson. 1984. Incised Channels: Morphology, Dynamics and Control. Water Resources Publications, Littleton, CO. 200 p.

Hydrologic alteration

Andrews, E.D. 1984. Bed-material entrainment and hydraulic geometry of gravel-bed rivers in Colorado. Geological Society of America Bulletin 95:371–378.

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman and Company, New York, NY. 818 pp.

Gore, J.A. and G.E. Petts. 1989. Alternatives in regulated river management. CRC Press, Inc., Boca Raton, FL.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian areas. Bioscience 41:540–551.

Hill, M.T., W.S. Platts, and R.L. Beschta. 1991. Ecological and geomorphological concepts for instream and out-of-channel flow requirements. Rivers 2: 198–210.

Hynes, H.B.N. 1975. The stream and its valley. Verhandlungen, Internationale Vereinigung fur theoretische und Aufewandte Limnologie 19:1–15.

Jackson, W.L., and R.L. Beschta. 1992. Instream flows for rivers: maintaining stream form and function as a basis for protecting dependent uses. *In* Interdisciplinary approaches in hydrology and hydrogeology. M.E. Jones, and A. Laeanen (eds.) St. Paul, MN. American Institute of Hydrology. pp. 524–53.

Ligon, F.K., W.E. Dietrich, and W.J. Trush. 1995. Downstream ecological effects of dams. BioScience 45:183–192.

Middleton, B.A. 2002. Flood pulsing in wetlands: restoring the natural hydrological balance. John Wiley & Sons, New York, NY.

Molles, M.C., C.S. Crawford, L.M. Ellis, H.M. Valett, and C.N. Dahm. 1998. Managed flooding for riparian ecosystem restoration. BioScience 48:749–756.

Montgomery, W.L., S.D. McCormick, R.J. Naiman, F.G. Whoriskey, and G.A. Black. 1983. Spring migratory synchrony of salmonid, catastomid, and cyprinid fishes in Riviere je la Truite, Quebec. Canadian Journal of Zoology 61:2495–2502.

Naesje T., B. Jonsson, and J. Skurdal. 1995. Spring floods: a primary cue for hatching of river spawning Coregoninae. Canadian Journal of Fisheries and Aquatic Sciences 52: 2190–2196.

Nesler, T.P., R.T. Muth, and A.F. Wasowicz. 1988. Evidence for baseline flow spikes as spawning cues for Colorado Squawfish in the Yampa River, Colorado. American Fisheries Society Symposium 5:68–79.

Platts, W.S., and R.L. Nelson. 1985. Impacts of rest-rotation grazing on stream banks in forested watersheds in Idaho. North American Journal of Fisheries Management 5:547–556.

Power, M.E., A. Sun, G. Parker, W.E. Dietrich, and J.T. Wootton. 1995. Hydraulic food chain models. BioScience 45:159–167.

Resh, V.H., A.V. Brown, A.P. Covich, M.E. Gurtz, H.W. Li, G.W. Minshall, S.R. Reice, A.L. Sheldon, J.B Wallace, and R. Wissmar. 1988. The role of disturbance in stream ecology. Journal of the North American Benthological Society 7:433–455.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10: 1163–1174.

Schlosser, I.J. 1985. Flow regime, juvenile abundance, and the assemblage structure of stream fishes. Ecology 66:1484-1490.

Schmidt, L.J., J.P. Potyondy. 2004. Quantifying channel maintenance instream flows: an approach for gravel-bed streams in the Western United States. General Technical Report RMRS–GTR–128. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO. 33 pp.

Seegrist, D.W. and R. Gard. 1972. Effects of floods on trout in Sagehen Creek, California. Transactions of the American Fisheries Society 10:478–482.

Simon, A. 1989. A model of channel response in distributed alluvial channels. Earth Surface Processes and Landforms 14:11–26.

Sparks, R.E. 1995. Need for ecosystem management of large rivers and their flood plains. Bioscience 45:168–182.

Stanford, J.A., J.V. Ward, W.J. Liss, C.A. Frissell, R.N. Williams, J.A. Lichatowich, and C.C. Coutant. 1996. A general protocol for restoration of regulated rivers. Regulated Rivers 12:391–413.

Trepanier S., M.A. Rodriguez, and P. Magnan. 1996. Spawning migrations in landlocked Atlantic salmon: time series modeling of river discharge and water temperature effects. Journal of Fish Biology 48:925–936.

Troendle, C.A. and R.M. King. 1987. The effect of partial cutting and clearcutting on the Deadhorse Creek watershed. Journal of Hydrology 90:145–157.

Ward J.V., and J.A. Stanford (eds.). 1979. The Ecology of Regulated Streams. Plenum Press, New York, NY. 398 pp.

Welcomme, R.L. 1992. River conservation: Future prospects. *In* River Conservation and Management. P.J. Boon, R. Calow, and G. E. Petts (eds). John Wiley & Sons, New York, NY. pp. 454–462

Whiting, P.J. 2002. Streamflow necessary for environmental maintenance. Annual Reviews of Earth and Planetary Science 30:181-206.

Wilcock, P.R., G.M. Kondolf, W.V.G. Matthews, and A.F. Barta. 1996. Specification of sediment maintenance flows for a large gravel-bed river. Water Resources Research 32:2911–2921.

Williams, G.P., and M.G. Wolman. 1984. Downstream effects of dams on alluvial rivers. U.S. Geological Survey Professional Paper No. 286.

Bank condition

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the Western United States. Journal of Soil Water Conservation 54:419–431.

Clary, W.P., and J. W. Kinney. 2002. Streambank and vegetation response to simulated cattle grazing. Wetlands 22:139–148.

Hooke, J.M. 1979. An analysis of the processes of river bank erosion. Journal of Hydrology 42:39–62.

Hooke, J.M. 1980. Magnitude and distribution of rates of river bank erosion. Earth Surfaces and Processes. 5:143–157.

Knox, J.C. 2001. Agricultural influence on landscape sensitivity in the Upper Mississippi River Valley Catena 42:193–224

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications—a review. Journal of Range Management 37:430–438.

Lawler, D.M. 1993. The measurement of river bank erosion and lateral channel change: a review. Earth Surface Processes and Landforms 18:777–821.

Odgaard, A.J. 1987. Streambank erosion along two rivers in Iowa. Water Resources Research 23:1225–1236.

Schmetterling, D.A., C.G. Clancy, and T.M. Brandt. 2001. Effects of rip-rap bank reinforcement on stream salmonids in the Western United States. Fisheries 26:6-13.

Simon, A. and M. Rinaldi. 2000. Channel instability in the loess area of the Midwestern United States. Journal of the American Water Resources Association 36:133–150.

Trimble, S.W. 1997. Contribution of stream channel erosion to sediment yield from an urbanizing watershed. Science 278:1442–1444.

Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7. Bethesda, MD.

Barriers to aquatic species movement

Clay, C.H. 1995. Design of fishways and other fish Facilities. Second Edition. CRC Press, Inc., Boca Raton, FL. 248 pp.

Graf, W.L. 1999. Dam nation: a geographic census of American dams and their large-scale hydrologic impacts. Water Resources Research 35:1305–1311.

Groot C., L. Margolis, and W. C. Clarke (eds.). 1995. Physiological ecology of Pacific salmon. University of. British Columbia Press, Vancouver, BC.

Gross, M.R., R.M Coleman, and R.M. McDowall. 1988. Aquatic productivity and the evolution of diadromous fish migration. Science 239:1291–1293.

Jungwirth, M., S. Schmutz, and S. Weiss (eds.). 1998. Fish Migration and Fish Bypasses. Fishing News Books, Oxford, UK. 438 pp.

Lang, M., M. Love, and W. Trush. 2004. Improving fish passage at road crossings. Final report to the National Marine Fisheries Service, produced in cooperation with Humboldt State University Foundation under NMFS contract 50ABNF800082. Arcata, CA. 128 pp.

Monk, B., D. Weaver, C. Thompson, and F. Ossiander. 1989. Effects of flow and weir design on the passage behavior of American shad and salmonids in an experimental fish ladder. North American Journal of Fisheries Management 9:60–67.

Taylor, R.N. and M. Love. 2003. Fish passage evaluation at stream crossings. Part IX *in* California Stream Habitat Restoration Manual, 3rd edition, 1998. Prepared by G. Flosi, S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. Sacramento, CA. 100 electronic pp.

U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). 2006. Fish passage and screening designs. Technical Supplement 14–N to NEH 654, Stream Restoration Design Handbook. Washington, DC.

Washington Department of Fish and Wildlife. 2000. Fishway guidelines for Washington State. Olympia, WA. 57 pp.

Washington Department of Fish and Wildlife. 2000. Fish passage barrier and surface water diversion screening and prioritization manual. WDFW Habitat Program, Environmental Restoration Division, Salmon Screening, Habitat Enhancement and Restoration Section, Olympia, WA. 158 pp.

Washington Department of Fish and Wildlife. 2003. Design of road culverts for fish passage. Olympia, WA. 110 pp.

Aquatic invertebrates and habitat

Benke, A.C., and J.B. Wallace. 2003. Influence of wood on invertebrate communities in streams and rivers. *In* The Ecology and Management of Wood in World Rivers. S.V. Gregory, K.L. Boyer, and A. Gurnell (eds.). American Fisheries Society. Bethesda, MD. pp. 149–177

Gregory, B.M. 2005. Microhabitat Preferences by Aquatic invertebrates Influence Bioassessment Metrics in Piedmont Streams of Georgia and Alabama. Proceedings of the 2005 Georgia Water Resources Conference.

Taylor, C.A., M.L. Warren, J.F. Fitzpatrick, H.H. Hobbs, R.F. Jezerinac, W.L. Pflieger, and H.W. Robison. 1996. Conservation status of crayfishes of the United States and Canada. Fisheries 21:25–38.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The River Continuum Concept. Canadian Journal of Fisheries and Aquatic Sciences. 37:130–137

Fish habitat complexity

Allan, J.D., and A.S. Flecker. 1993. Biodiversity conservation in running waters. BioScience 43:32–43

Bayley, P.B. 1991. The flood pulse advantage and the restoration of river-flood plain systems. Regulated Rivers: Research and Management. 6:75–86

Dolloff, C.A. and M.L. Warren, Jr. 2003. Fish relationships with large wood in small streams. *In* The Ecology and Management of Wood in World Rivers. S.V. Gregory, K.L. Boyer, and A. Gurnell (eds.). American Fisheries Society. Bethesda, MD. pp. 179–193

Beechie, T., and S. Bolton. 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds. Fisheries 24:6–15.

Fausch, K.D., C.L. Hawkes, and M.G. Parsons. 1988. Models that predict standing crop of stream fish from habitat variables: 1950–85. Gen. Tech. Rept. PNWGTR–213. U.S. Dept. Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. 52 p.

Fausch, K.D., C.E. Torgerson, C.V. Baxter, and H.W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. BioScience 52:483–498.

Federal Interagency Stream Restoration Working Group (FISRWG). 1998. Stream corridor restoration: principles, processes and practices. National Technical Information Service, U.S. Department of Commerce, Springfield, VA. Also published as U.S. Department of Agriculture Natural Resources Conservation Service (1998) Stream corridor restoration: principles, processes, and practices. National Engineering Handbook (NEH), Part 653. Washington, DC.

Frissell, C.A., and R.K. Nawa. 1992. Incidence and causes of physical failure of artificial habitat structures in streams of western Oregon and Washington. North America Journal of Fisheries Management 12:182–197.

Gregory, S.V., K.L. Boyer, and A. Gurnell. 2003. The ecology and management of wood in world rivers. American Fisheries Society. Bethesda, MD.

Hawkins, C.P., R.H. Norris, J.N. Hogue, and J.W. Feminella. 2000. Development and evaluation of predictive models for measuring the biological integrity of streams. Ecological Applications 10:1456–1477.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-flood plain systems. *In* Proceedings of International Large River Symposium (LARS), Toronto, Ontario, September 14–21, 1986. D.P. Dodge(ed.). Canadian Special Publication of Fisheries and Aquatic Sciences. pp. 110–127

Karr, J. R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Special Publication 5. Illinois Natural History Survey. Champaign, IL.

Maser, C., and J.R. Sedell. 1994. From the forest to the sea: the ecology of wood in streams, rivers, estuaries, and oceans. St. Lucie Press, Delray Beach, FL.

Poff, N.L., and J.V. Ward. 1990. Physical habitat template of lotic systems: recovery in the context of historical pattern of spatiotemporal heterogeneity. Environmental Management. 14:629–645.

Poff, L.N., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47:769–784.

Reich, M., J.L. Kershner, and R.C. Wildman. 2003. Restoring streams with large wood: a synthesis. *In* The Ecology and Management of Wood in World Rivers. S.V. Gregory, K.L. Boyer and A. Gurnell (eds.). American Fisheries Society. Bethesda, MD. pp. 355–366

Schlosser, I.J. 1987. A conceptual framework for fish communities in small warmwater streams. *In* Community and Evolutionary Ecology of North American Stream Fishes. W. J. Matthews and D. C. Heins (eds.). University of Oklahoma. Norman, Oklahoma, and London, UK.

Sedell, J.R., G.H. Reeves, F.R. Hauer, J.A. Stanford, and C.P. Hawkins. 1990. Role of refugia in recovery from disturbances: modern fragmented and disconnected river systems. Environmental Management 14:711–724.

Shields, F.D., Jr., and R.T. Milhous. 1992. Sediment and aquatic habitat in river systems. Final Report, American Society of Civil Engineers Task Committee on Sediment Transport and Aquatic Habitat. Journal of Hydraulic Engineering 118:669–687.

Shields, F. D., Jr., S.S. Knight, and C.M. Cooper. 1998. Rehabilitation of aquatic habitats in warmwater streams damaged by channel incision in Mississippi. Hydrobiologia 382:63–86.

Townsend, C.R. 1989. The patch dynamics concept of stream community ecology. Journal of the North American Benthological Society 8:36–50.

U.S. Environmental Protection Agency (USEPA). 2000. Water quality conditions in the United States: The 1998 National Water Quality Inventory Report to Congress. Report No. EPA841–R–00–001, USEPA, Washington, DC.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130–137.

Wang, L., and J. Lyons. 2003. Fish and benthic macroinvertebrate assemblages as indicators of stream degradation in urbanizing watersheds. *In* Biological response signatures: indicator patterns using aquatic communities. T.P. Simon (ed.). Regulated Rivers: Research and Management. 17:311–323.

Ward, J.V., and J.A. Stanford. 1983. The intermediate disturbance hypothesis: an explanation for biotic diversity patterns in lotic ecosystems. *In* Dynamics of lotic ecosystems. T.D. Fontaine, and S.M. Bartell, (eds.). Ann Arbor Press, Ann Arbor, MI. pp. 347–356.

White, D.S. 1993. Perspectives on defining and delineating hyporheic areas. Journal of the North American Benthological Society 12:61–69.

Williams, J.E., J.E. Johnson, D.A. Hendrickson, S. Contreras-Balderas, J.D. Williams, M. Navarro-Mendoza, D.E. McAllister, and J.E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern. Fisheries 14:3–20.

Williams, J.D., M.L. Warren Jr., K.S. Cummings, J.L. Harris, and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18:6–22.

Yount, J.D., and G.J. Niemi. 1990. Recovery of lotic communities and ecosystems from disturbance—a narrative review of case studies. Environmental Management 14:547–569.

Riparian areas

Baker, M.B., Jr., P.F. Ffolliott, L.F. DeBano, and D.G. Neary. 2004. Riparian areas of the Southwestern United States: hydrology, ecology, and management. Lewis Publishers, CRC Press, Boca Raton, FL. 408 pp.

Baxter, C.V., K.D. Fausch, and W.C. Saunders. 2005. Tangled webs: reciprocal flows of invertebrate prey link streams and riparian areas. Freshwater Biology 50: 201–220

Bolton, S.M. and J. Shellberg. 2001. Ecological issues in flood plains and riparian corridors. Final White Paper prepared for Washington State Transportation.

Boyer, K.L., D.R. Berg, and S.V. Gregory. 2003. Riparian management for wood in rivers. *In* The Ecology and Management of Wood in World Rivers. S.V. Gregory, K.L. Boyer, and A. Gurnell (eds.). American Fisheries Society, Bethesda, MD. pp. 407–420.

Briggs, M.K. 1996. Riparian Ecosystem Recovery in Arid Lands: Strategies and References. The University of Arizona Press, Tucson, AZ. 159 pp.

Chambers, J.C., and J.R. Miller (eds). 2004. Great Basin Riparian Ecosystems—Ecology, Management and Restoration. Island Press, Covelo, CA. 303 pp.

Cooke, H.A., and S. Zack. In Press. Use of standardized visual assessments of riparian and stream condition to manage riparian bird habitat in eastern Oregon. Environmental Management.

Gregory, S.V., F.J. Swanson, A. McKee, and K.W. Cummins. 1991. Ecosystem perspectives of riparian areas. Bioscience 41:540–551.

Huggenberger, P., E Hoehn, R. Beschta, and W. Woessner. 1998. Abiotic aspects of channels and flood plains in riparian ecology. Freshwater Biology 40: 407–425.

Malanson, G.P. 1993. Riparian landscapes. Cambridge University Press, Cambridge, UK. 296 pp.

Naiman, R.J., and H. Decamps, 1997. The ecology of interfaces: riparian areas. Annual Review of Ecology and Systematics 28:621–658.

Naiman, R.J., H. Decamps, and M.E. McClain, 2005. Riparia: ecology, conservation, and management of streamside communities. Elsevier, Inc., London, UK. 430 pp.

National Research Council (NRC). 2002. Riparian Areas: Functions and Strategies for Management. National Academy Press, Washington, DC.

Stromberg, J.C. 2001. Restoration of riparian vegetation in the southwestern United States: importance of flow regimes and fluvial dynamism. Journal of Arid Environments 49:17–34.

Verry, E.S., J.W. Hornbeck, and C.A. Dolloff. 2000. Riparian management in forests of the Continental Eastern United States. Lewis Publishers, CRC Press, Boca Raton, FL.

Ward, J.V., K. Tockner, and F. Schiemer. 1999. Biodiversity of flood plain river ecosystems: ecotones and connectivity. Regulated Rivers: Research and Management 15:125–139

Wichert, G A., and D.J. Rapport. 1998. Fish community structure as a measure of degradation and rehabilitation of riparian systems in an agricultural drainage basin. Environmental Management 22:425–443.

Winward, A.H. 2000. Monitoring the vegetation resources in riparian areas. General Technical Report. RMRS–GTR–47. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO.

Water appearance

Stevenson, R.J., and J.P. Smol. 2002. Use of algae in environmental assessments. *In* Freshwater Algae in North America: Classification and Ecology. J.D. Wehr, and R.G. Sheath (eds.). Academic Press, San Diego, CA.

Digital Keys to Aquatic Insects
http://www.waterbugkey.vcsu.edu/

Riparian plant guidebooks

Common Arizona Riparian Plants
http://www.plant-materials.nrcs.usda.gov/pubs/azpmstn7363.pdf

Field Guide for Identification and Use of Common Riparian Woody Plants of the Intermountain West and Pacific Northwest Regions
http://www.plant-materials.nrcs.usda.gov/pubs/idpmcpu7428.pdf

Appendix B

Glossary

Active channel width	The width of the stream at the bankfull discharge. Permanent vegetation generally does not become established in the active channel.
Active flood plain	That part of a flood plain that is frequently inundated with water.
Aggradation	Geologic process by which a stream bottom or flood plain is raised in elevation by the deposition of material.
Alluvial	Deposited by running water, such as sediments.
Bankfull discharge	The stream discharge (flow rate, such as cubic feet per second) that forms and controls the shape and size of the active channel and creates the flood plain. This discharge generally occurs once every 1.5 years on average.
Bankfull flow	Discharge where water just begins to leave the stream channel and spread onto the flood plain. Bankfull flow is roughly equivalent to channel-forming (conceptual) and effective (calculated) discharge for alluvial streams in equilibrium, and generally occurs every 1 to 2 years (on average).
Bankfull stage	The stage at which water starts to flow over the flood plain; the elevation of the water surface at bankfull discharge
Baseflow	The portion of streamflow that is derived from natural storage of precipitation that percolates to ground water and moves slowly through substrate before reaching the channel. Baseflow sustains streamflow during periods of little or no precipitation and is the average stream discharge during low flow conditions.
Benthos	Bottom-dwelling or substrate-oriented organisms.
Boulders	Large rocks measuring more than 10 inches across.
Channel	With respect to streams, a channel is a natural depression of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks that serve to confine the stream's water.
Channel form	The morphology of the channel is typically described by thread (single or multiple channels in valley floor), and sinuosity (amount of curvature in the channel).
Channel roughness	Physical elements of a stream channel upon which flow energy is expended including coarseness and texture of bed material, the curvature of the channel, and variation in the longitudinal profile.
Channelization	Straightening of a stream channel to make water move faster.
Cobbles	Medium-sized rocks that measure 2.5 to 10 inches across.
Confined channel	A channel that does not have access to a flood plain.
Concentrated flow	Undispersed flow, usually flowing directly from an unbuffered area of overland flow; concentrated flow generally contains sediments and/or contaminants from areas beyond the stream corridor.
Degradation	Geologic process by which a stream bottom is lowered in elevation due to the net loss of substrate material. Often called downcutting.
Detritus	Materials such as leaves, twigs, or branches that enter a stream from the uplands or riparian area.
Downcutting	See Degradation.
Ecoregion	A geographic area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.

Embeddedness	The degree to which an object is buried in steam sediment.
Emergent plants	Aquatic plants that extend out of the water.
Ephemeral stream	A stream with a channel that is above the water table at all times and carries water only during and immediately after a rain event.
Flood plain	The level area of land near a stream channel, constructed by the stream in the present climate, and overflowed during moderate flow events (after Leopold 1994).
Flow augmentation	Artificially adding water to a stream channel with timing and magnitude that disrupts the natural flow regime. Examples include irrigation deliveries, trans-basin diversions, or wastewater from irrigated lands, treatment plants, or commercial facilities.
Fluvial	A feature of or pertaining to the action of moving water.
Forb	Any broad-leaved herbaceous plant other than those in the Gramineae (Poceae), Cyperacea, and Juncaceae families (Society for Range Management1989).
Gabions	A wire basket filled with rocks; used to stabilize streambanks and control erosion.
Geomorphology	The study of the evolution, process, and configuration of landforms.
Glide	A fast water habitat type that has low to moderate velocities, no surface agitation, and a U-shaped, smooth, wide bottom.
Gradient	Slope calculated as the amount of vertical rise over horizontal run expressed as feet per foot or as percent (ft/ft × 100).
Grass	An annual to perennial herb, generally with round erect stems and swollen nodes; leaves are alternate and two-ranked; flowers are in spikelets each subtended by two bracts.
Gravel	Small rocks measuring 0.825 to 2.5 inches across.
Habitat	The area or environment in which an organism lives.
Herbaceous	Plants with nonwoody stems.
Hydrology	The study of the properties, distribution, and effects of water on the Earth’s surface, soil, and atmosphere.
Hyporheic	Below the surface of the streambed, including interstitial spaces.
Incised channel	A channel with a streambed lower in elevation than its historic elevation in relation to the flood plain.
Intermittent stream	A stream that flows only certain times of the year, such as when it receives water from springs, ground water, or surface runoff.
Lateral migration	The adjustment of a stream channel from side to side often involving the recession of a streambank. In a braided river system, both streambanks may be recessing due to excessive channel filling and limited bedload transport capabilities (see fig. 18).
Macrophyte bed	A dense mat of aquatic plants.
Macrotopography	Depositional features within a flood plain developed by water flow and greater than 6 inches than the average land surface of the flood plain.

Microtopography	Features within a flood plain developed by water flow and less than 6 inches than the average land surface of the flood plain.
Meander	A winding section of stream with many bends that is at least 1.2 times longer, following the channel, than its straight-line distance. A single meander generally comprises two complete opposing bends, starting from the relatively straight section of the channel just before the first bend to the relatively straight section just after the second bend.
Macroinvertebrate	A spineless animal visible to the naked eye or larger than 0.5 millimeters.
Natural flow regime	The full range of daily, monthly, and annual streamflows critical to sustaining native biodiversity and integrity in a freshwater ecosystem. Important flow regime characteristics include natural variations in streamflow magnitude, timing, duration, frequency, and rates of change (see Poff et al. 1997 for further detail).
Nickpoint	The point where a stream is actively eroding (downcutting) to a new base elevation. Nickpoints migrate upstream (through a process called headcutting).
Oligotrophic	Having little or no nutrients and, thus, low primary production.
Perennial stream	A steam that typically flows continuously throughout the year.
Point bar	A gravel or sand deposit on the inside of a meander; actively mobile deposits.
Pool	Deeper area of a stream with slow-moving water.
Reach	A section of stream (defined in a variety of ways, such as the section between tributaries or a section with consistent characteristics).
Riffle	A shallow section in a stream where water is breaking over rocks, wood, or other partly submerged debris and producing surface agitation.
Riparian areas	Riparian areas are transitional areas between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems.
Riprap	Rock material of varying size used to stabilize streambanks and other slopes.
Run	A fast-moving section of a stream with a defined thalweg and little surface agitation.
Scouring	The erosive removal of material from the stream bottom and banks.
Sedge	A grass-like, fibrous-rooted herb with a triangular to round stem and leaves that are mostly three-ranked and with close sheaths; flowers are in spikes or spikelets.
Stormwater runoff	Overland runoff from a precipitation event not absorbed by soil, vegetation, or other natural means.
Substrate	The mineral or organic material that forms the bed of the stream; the surface on which aquatic organisms live.

Surface fines	That portion of streambed surface consisting of sand/silt (less than 6 mm).
Thalweg	The line followed by most of the streamflow. The line that connects the lowest or deepest points along the streambed.
Turbidity	Murkiness of water caused by particles such as fine sediment and algae.
Water control structures	Any physical feature located in or adjacent to a stream used to control the direction, magnitude, timing, and frequency of water for instream or out-of-stream uses. Examples include dams, pumps, water treatment or power plant outfalls, gated culverts, standpipes, subsurface drains, and ring wells.
Watershed	A ridge of high land dividing two areas that are drained by different river systems. The land area draining to a waterbody or point in a river system; catchment area, drainage basin, drainage area.

Appendix C

Technical Information to Support Implementation of the Stream Visual Assessment Protocol Version 2

Appendix C provides documentation to support the use of the Stream Visual Assessment Protocol Version 2 (SVAP2). The topics covered in this section include a summary of changes from Stream Visual Assessment Protocol Version 1 (SVAP) and development of SVAP2, context for use with other methods of stream assessment, summary of results of a validation study of the SVAP2, and instructions for modifying the protocol.

Summary of changes in SVAP2

Applications and uses of the SVAP evolved as more NRCS personnel became familiar with it. Most importantly, field and State Office personnel were asked to utilize SVAP for determination of eligibility for fish and wildlife resource conservation in Farm Bill programs, evaluation of the level at which aquatic habitat is being achieved in an RMS, preliminary evaluation of streams where restoration actions were being considered, and documentation of trends after stream and riparian project implementation. The uses for the protocol thus expanded beyond the original intent of the SVAP. Revisions are now made to allow field personnel to assess conditions relatively quickly and with a reasonable degree of accuracy and repeatability. Because SVAP Version 1 was designed for landowners to learn about streams with assistance from field office personnel, the cadre of specialists retained this objective in the development of SVAP2.

The following concerns of field users of SVAP Version 1 were addressed in the revision and are reflected in SVAP2:

- Revise SVAP to be congruent with existing wildlife habitat evaluation guides. A value of .5 is the threshold/difference between source and sink habitat for terrestrial wildlife. Using SVAP2, a score of 5 or above for a stream should be considered the threshold/difference between source and sink stream habitat for fish and wildlife.
- Revise wording and protocol elements to assure better consistency among and between States to allow repeat assessments over time.
- Revise critical scoring elements to better reflect the current state of the art and NRCS emphasis on stream corridor conservation. These elements are channel condition, hydrological alteration, riparian quality, riparian quantity, and bank condition.

The SVAP Version 1 and SVAP2 were developed by combining parts of several existing assessment procedures. Many of these sources are listed in the references section. Three drafts of SVAP2 were developed and reviewed by the workgroup and others between the fall of 2006 and the spring of 2008. During the summer of 2007, the workgroup conducted a field trial evaluation of the third draft. Subsequently, additional revisions were made, and the fourth draft was sent to all NRCS State Offices, selected Federal agencies, and other partners for review and comment during the spring of 2008. Comments were received from eight NRCS State Offices, Bureau of Land Management, and several NRCS national specialists. Comments were, for the most part, uniformly supportive of the need for user guidance and for the document as drafted. Many reviewers provided suggestions that improved explanatory text for the supporting descriptions accompanying the assessment elements. Most of the suggested revisions were incorporated into the final draft of the protocol.

Context for use of SVAP2

The SVAP2, like its predecessor, is intended to be a relatively simple, yet comprehensive assessment of stream condition that maximizes ease of use. It is suitable as a *general approximation* of stream condition at the time in which the protocol is used. It can also be used to identify the need for more precise quantitative assessment methods that focus on a particular aspect of the aquatic system. These would include geomorphic analysis, quantitative habitat condition, and biological surveys. The SVAP2 is applicable nationwide because it utilizes ecological and physical factors that are least sensitive to regional differences. However, regional differences are a significant aspect of stream assessment, and therefore, the protocol's scoring elements are expected to be modified to reflect regional differences in physical landscape features and weather patterns. The national SVAP2 is viewed as a framework that will evolve over time to better reflect State or within-State regional differences. Instructions for modification are provided later in this document.

The SVAP2 is issued as a component of the National Biology Handbook. States are encouraged to incorporate it within the Field Office Technical Guide. The document may be modified by States. The electronic file for the document may be downloaded from the NRCS Web site.

Summary of validation study of SVAP2

SVAP2 was field tested regionally and nationally, along with three alternative protocols designed to evaluate physical habitat condition of streams. The protocols evaluated were NRCS's SVAP2, the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), the EPA's Rapid Bioassessment Protocol (EPA–RBP), and a quantitative protocol developed by EPA's Environmental Monitoring and Assessment Program (EMAP–QTPH). The contractors sampled one site on each of 51 wadeable agricultural streams in the summer of 2007. Sites were distributed throughout the United States, except for the Deep South because of high waters, and they included 8 sites in California (Central Valley), 10 in Oregon (Willamette Valley), 4 in North Dakota (Northern Plains), 8 in South Dakota (Northern Plains), 4 in Nebraska (Western Corn Belt), 5 in Iowa (Western Corn Belt), 2 in Minnesota (Western Corn Belt), 6 in Pennsylvania (ridge and valley), 3 in Maryland (ridge and valley), and 1 in West Virginia (ridge and valley).

Precision was assessed through use of scatter plots, coefficients of variation, and a signal/noise test (among-site variance/within-site observer variance) for all four protocols. Results indicated high precision among field technicians for all qualitative protocols, but greater precision for the quantitative protocol. Overall, all four methods produced similar assessment precision results, although SVAP2 elements riffle embeddedness and nutrient enrichment demonstrated low observer precision. Depending on the purpose for completing the SVAP2, a simple quantitative assessment of these elements such as pebble counts or water quality testing for total phosphorus may be warranted if element scores are lower than 5. Salinity and macroinvertebrate elements were not included in the study.

Accuracy of SVAP2 was evaluated by comparing qualitative index scores against a quantitative physical habitat index (EMAP–QTPH), qualitative metric scores against quantitative (EMAP–QTPH) metric scores, and qualitative and quantitative habitat index scores against quantitative biological index scores (fish assemblage tolerance index, fish IBI, macroinvertebrate EPT, macroinvertebrate IBI). The results indicated acceptable levels of accuracy for all four habitat indices, but greater accuracy for the quantitative protocol. Also, comparisons between each of the four habitat indexes, and the biological indexes were only weakly correlated. These comparisons were likely confounded by other stressors, such as water quality or landscape-scale perturbances, and their effects on aquatic biota.

Four SVAP2 elements (channel condition, hydrological alteration, water appearance, and nutrient enrichment) were found to be less accurate in characterizing these stream features than the quantitative EMAP metrics. However, the EMAP metric used to make three of these comparisons (hydrological alteration, water appearance, nutrient enrichment) were only weakly comparable, which may explain some of the variation between the two methods. The comparison of the EMAP metric (bed stability) to the SVAP2 channel condition was relatively comparable, and so the lack of strong correlation between these two methods is likely due to the complexity of visually assessing these stream features (table C–1). This finding reinforces the need to complete a quantitative assessment of channel condition if SVAP2 scores for this element are lower than 5.

Instructions for modification of SVAP2 to better reflect local conditions

The NRCS SVAP2 may be used in many locales without modification when the objective of the user is to learn about features that determine overall stream and riparian conditions. As its predecessor, SVAP2 was designed to use assessment elements that are the least sensitive to regional differences. Nonetheless, when using the tool to evaluate trends in stream corridor habitat conditions over time, the elements and scoring categories should be calibrated to reflect conditions characteristic of the geographic area. If narrative descriptions of scoring elements match local features and hydrologic regimes the SVAP2 will be:

- easier to use locally
- more responsive to changes in local stream condition over time
- more precise and accurate

Two parts of the SVAP2 may be modified—the individual elements and their narrative descriptions and the rating scale for assigning an overall condition rating. The simplest approach to modifying the SVAP2

Table C–1 Correlations between qualitative SVAP metrics and quantitative EMAP metrics. Individual observers combined, n=102 (LRBS data were missing for 22 sites)

SVAP metric	**EMAP metric***	**Pearson correlation**	**Spearman correlation**
Channel Condition	LRBS (n=80)	0.27	0.29
Hydrologic Alteration	LRBS (n=80)	0.16	0.13
Bank Condition (Left/Right)	XGB	–0.50/–0.51	–0.44 /–0.44
Riparian Area Quantity (Left/Right)	XCMGW	0.54 /0.64	0.48/0.52
Riparian Area Quality (Left/Right)	XCMG	0.52 /0.56	0.47/0.52
Canopy Cover	XCDENMID	0.76	0.74
Water Appearance	XFCALG+XFCAQM	–0.14	–0.05
Nutrient Enrichment	Log10 Total P	–0.10	–0.07
Manure	W1H_PSTR	–0.73	–0.60
Pools	RPGT20	0.64	0.66
Barriers	PCT_DRS	–0.48	–0.43
Invertebrate Habitat	PCT_FN	–0.61	–0.66
Fish Habitat	SDDEPTH	0.61	0.55
Embeddedness	PCT_FN	–0.61	–0.69

*LRBS: $\log_{10}$ relative bed stability; XGB: sum of riparian bare ground cover
XCMGW: sum of woody canopy, mid-layer and ground vegetation cover
XCMG: sum of canopy, mid-layer and ground vegetation cover
XCDENMID: mean % canopy midstream
XFCALG+XFCAQM: % areal cover of filamentous algae and aquatic macrophytes
LOG10 TOTAL P: $\log_{10}$ of total phosphorus; W1H_PSTR: sum of riparian pasture, hay
RPGT20: number of residual pools >20 cm deep
PCT_DRS: % stream dry stream bed
PCT_FN: % silt, clay and muck; SDDEPTH: standard deviation of thalweg depth

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

Step 1 Decide on tentative number of versions.

Is the desire to develop a revised version for the State, for each ecoregion within the State, or for several stream classes within each ecoregion?

Step 2 Develop a tentative stream classification.

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

Step 3 Assess sites.

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

Step 4 Rank the sites.

Begin the data analysis by ranking all the sites from most impacted to least impacted. Rank sites according to the independent assessment results (preferred) or by the SVAP scores. Initially, rank all of the sites in the State data set. Classifications will be tested in subsequent iterations.

Step 5 Display scoring data.

Prepare a chart of the data from all sites in the State. The columns are the sites arranged by the ranking. The rows are the assessment elements, overall numerical score, and narrative rating. If independent assessment data is available, create a second chart by plotting the overall SVAP scores against the independent scores.

Step 6 Evaluate responsiveness.

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

Step 7 Evaluate the narrative rating breakpoints.

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

Step 8 Evaluate tentative classification systems.

Go back to step 4 and display the data this time by the tentative classes (ecoregions or stream classes). In other words, analyze sites from each ecoregion or each stream class separately. Repeat steps 5 through 7. If the responsiveness is significantly different from the responsiveness of the State-wide data set or the breakpoints appear to be significantly different, adopt the classification system, and revise the protocol for each ecoregion or stream class. If not, a single statewide protocol is adequate. After the initial modification of the SVAP, the State may want to set up a process to consider future revisions. Field offices should be encouraged to locate and assess least impacted reference sites to build the database for interpretation and future revisions. Ancillary data should be collected to help evaluate whether a potential reference site should be considered a reference site. Caution should be exercised when considering future revisions. Revisions complicate comparing SVAP scores determined before and after the implementation of conservation practices if the protocol is substantially revised in the intervening period. Developing information to support refining the SVAP can be carried out by research partners working cooperatively with NRCS.