

**ALBERTA LOTIC WETLAND HEALTH ASSESSMENT  
FOR STREAMS AND SMALL RIVERS**  
*(Derived by the computer from the Alberta Lotic Wetland Inventory Form)*  
**USER MANUAL**  
*(Current as of 5/16/2023)*

The user manual is intended to accompany the *Alberta Lotic Wetland Health Assessment Form For Streams and Small Rivers* (less than 15 m [50 ft] wide), which is based on data contained in the *Alberta Lotic Wetland Inventory Form*. Another form entitled the *Alberta Lotic Health Assessment For Large River* for the evaluation of riparian areas along large river systems (those with channels wider than 15 m [50 ft]).

### ACKNOWLEDGEMENTS

Development of these assessment tools has been a collaborative and reiterative process. Many people from many agencies and organizations have contributed greatly their time, effort, funding, and moral support for the creation of these documents, as well as to the general idea of devising a way for people to look critically at wetlands and riparian areas in a systematic and consistent way. Some individuals and the agencies/organizations they represent who have been instrumental in enabling this work are Dan Hinckley, Tim Bozorth, and Jim Roscoe of the USDI Bureau of Land Management in Montana; Karen Rice and Karl Gebhardt of the USDI Bureau of Land Management in Idaho; Bill Haglan of the USDI Fish and Wildlife Service in Montana; Barry Adams and Gerry Ehlert of Alberta Sustainable Resource Development; Lorne Fitch of Alberta Environmental Protection; and Greg Hale and Norine Ambrose of the Alberta Cows and Fish Program.

### BACKGROUND INFORMATION

#### Introduction

Public and private land managers are being asked to improve or maintain lotic (riparian) habitat and stream water quality on lands throughout western North America. Three questions that are generally asked about a wetland site are: 1) What is the potential of the site (e.g., climax or potential natural community)? 2) What plant communities currently occupy the site? and 3) What is the overall health (condition) of the site? For a lotic (flowing water) site, the first two questions can be answered by using the Alberta Lotic Wetland Inventory Form along with a document such as *Classification and Management of Riparian and Wetland Sites of the Alberta Grassland Natural Region and Adjacent Subregions* (Thompson and Hansen 2002), *Classification and Management of Riparian and Wetland Sites of Alberta's Parkland Natural Region and Dry Mixedwood Natural Subregion* (Thompson and Hansen 2003), *Classification and Management of Riparian and Wetland Sites of the Saskatchewan Prairie Ecozone and Parts of Adjacent Subregions* (Thompson and Hansen 2001) or a similar publication written for the region in which you are working.

The *Alberta Lotic Wetland Health Assessment Form* is a method for addressing the third question above: what is the site's overall health (condition)? It provides a site rating useful for setting management priorities and stratifying riparian sites for remedial action or more rigorous analytical attention. It is intended to serve as a first approximation, or coarse filter, by which to identify lotic wetlands in need of closer attention so that managers can more efficiently concentrate effort. We use the term riparian health to mean the ability of a riparian reach (including the riparian area and its channel) to perform certain functions. These functions include sediment trapping, bank building and maintenance, water storage, aquifer recharge, flow energy dissipation, maintenance of biotic diversity, and primary production. Excellent sources of practical ideas and tips on good management of these streamside wetland sites are found in *Caring for the Green Zone* (Adams and Fitch 1995), *Riparian Areas: A User's Guide to Health* (Fitch and Ambrose 2003), and *Riparian Health Assessment for Streams and Small Rivers* (Fitch and others 2001). In Saskatchewan some excellent resources are *Streambank Stewardship, Your Guide to Caring For Riparian Areas in Saskatchewan* (Huel 1998) and *Managing Saskatchewan Wetlands—A Landowner's Guide* (Huel 2000).

#### Lotic (Riparian) Health

As noted above, the health of a lotic site (a wetland, or riparian area, adjacent to flowing water) may be defined as the ability of that system to perform certain wetland functions. These functions include sediment trapping, bank building and maintenance, water storage, aquifer recharge, flow energy dissipation, maintenance of biotic diversity, and primary biotic production. A site's health rating may also reflect management considerations. For example, although *Cirsium arvense*

(Canada thistle) or *Euphorbia esula* (leafy spurge) may help to trap sediment and provide soil-binding properties, other functions (i.e., productivity and wildlife habitat) will be impaired; and their presence should be a management concern.

No single factor or characteristic of a wetland site can provide a complete picture of either site health or the direction of trend. The lotic health assessment is based on consideration of physical, hydrologic, and vegetation factors. It relies heavily on vegetative characteristics as integrators of factors operating on the landscape. Because they are more visible than soil or hydrologic characteristics, plants may provide early indications of riparian health as well as successional trend. These are reflected not only in the types of plants present, but also by the effectiveness with which the vegetation carries out its wetland functions of stabilizing the soil, trapping sediments, and providing wildlife habitat. Furthermore, the utilization of certain types of vegetation by animals may indicate the current condition of the wetland and may indicate trend toward or away from potential natural community (PNC).

In addition to vegetation factors, an analysis of site health and its susceptibility to degradation must consider physical factors (soils and hydrology) for both ecologic and management reasons. Changes in soil or hydrologic conditions obviously affect functioning of a wetland ecosystem. Moreover, degradation in physical characteristics are often (but not always) more difficult to remedy than vegetative changes. For example, extensive incisement (down-cutting) of a stream channel may lower the water table and thus change site potential from a *Salix lutea/Cornus stolonifera* (yellow willow/red-osier dogwood) habitat type to an *Bromus inermis* (awnless brome) community type or even to an upland (non-riparian) type. Sites experiencing significant hydrologic, edaphic (soil), or climatic changes will likely also have a change in plant community potential.

This assessment method attempts to balance the need for a simple, quick index of health against the reality of an infinite variety of wetland situations. Although this approach will not always work perfectly, we believe in most cases it will yield a usefully accurate rating of riparian health. Some more rigorous methods to determine status of a stream's channel morphology are Dunne and Leopold (1978), Pfankuch (1975), and Rosgen (1996). These relate their ratings to degree of channel degradation, but do not integrate other riparian functions into the rating. Other methods are available for determining condition from perspectives that also include vegetation, such as the USDI Bureau of Land Management (BLM) proper functioning condition (PFC) methodology (1998).

This assessment procedure has been tested in Montana, Idaho, North Dakota, South Dakota, and other surrounding states and western Canada since 1992. Some potential uses for this rating are: 1) for stratifying streams or stream reaches by degree of ecologic dysfunction, 2) for identifying ecologic problems, and 3) when repeated over time, for monitoring to detect functional change. A less direct, but also important, value of an environmental assessment of this kind is its educational potential. By getting land managers to focus on individual riparian functions and ecologic processes, they may come to better understand how the parts work together and are affected by human activities.

This method is not designed for an in-depth and comprehensive analysis of ecologic processes. Such analysis may be warranted on a site and can be done after this evaluation has identified areas of concern. Nor does this approach yield an absolute rating to be used in comparison with streams in other areas or of other types. Comparisons using this rating with streams of different types (Rosgen 1996), different orders (size class), or from outside the immediate locality should be avoided. Appropriate comparisons using this rating can be made between segments of one stream, between neighbouring streams of similar size and type, and between subsequent assessments of the same site.

A single evaluation provides a rating at only one point in time. Due to the range of variation possible on a riparian site, a single evaluation cannot define absolute status of site health or reliably indicate trend (whether the site is improving, degrading, or stable). To monitor trend, health assessments should be repeated in subsequent years during the same time of year. Evaluation should be conducted when most plants can be identified in the field and when hydrologic conditions are most nearly normal (e.g., not during peak spring runoff or immediately after a major storm). Management regime should influence assessment timing. For example, in assessing trend on rotational grazing systems, one should avoid comparing a rating after a season of use one year to a rating another year after a season of rest.

There are some visible changes to riparian area health, which we have no simple way to measure. An obvious and commonly encountered example is excess entrained sediment. This may indicate serious degradation, but we leave it out of the assessment due to difficulty in knowing how much is normal. Instead, we address on-site causes of sediment production: bare ground, banks with poor root mass protection, and human-caused structural damage to the banks. Another potentially serious degrading factor for which we have no simple measurement yet is de-watering of the system by irrigation diversion/pumping and by upper drainage retention dams.

## DATA FORM ITEMS

**Record ID No.** This is the unique identifier allocated to each polygon. This number will be assigned in the office when the form is entered into a database.

**Polygon No.** Polygon number is a sequential identifier of the actual piece of land being surveyed. This is referenced to the water body code list from the Training Manual.

### Administrative Data

**A1.** Identify what organization is doing the evaluation field work.

**A2a.** Name of the Funding Agency/Organization (who is providing funding for the work being done/who is being invoiced for the work).

**A2b.** Name of the Funding Source or Grant (source of funding by the organization providing funding).

**A3.** Date that the field data was collected: Use the format: month/day/year.

**A4.** Record the year that the field data was collected.

**A5.** Observers: Name the evaluators recording the data in the field.

*Land ownership may include more than one entity or person, but more than one type of landownership (eg. private and government) should only be selected after considering a number of factors. Factors to consider are the level of detail that the client is looking to extrapolate, the proportion of the area relative to the rest of the polygon and whether it is a typical situation where the multiple types (e.g., crown or non crown land) will not be included. For example, where very minimal Crown bed and shore area exists within the polygon (such as just at the waterline), as part of a primarily privately owned parcel, the private ownership may be listed as the only ownership type.*

**A6a.** Indicate whether the polygon is representative, which requires that stratification has been done to assist in selection of representative sites. Answer “Yes,” “No,” or “Unknown.”

**A6b.** If A6a was answered “Yes,” select the broadest (largest) scale at which the site is representative. For example, if it is representative (based on stratification) of both the “project area” and the “land holding,” then choose “project area,” to indicate the site represents the larger area. The choices are:

- Representative of a water body (may include multiple management units or land holdings);
- Representative of a management unit within a land holding;
- Representative of a land holding that may contain multiple management units;
- Representative of a project area that may contain multiple land holdings; or
- Unknown.

**A6c.** Identify how the site was selected or chosen by choosing one of the options. (**ANSWER THIS QUESTION REGARDLESS OF THE ANSWER TO QUESTION A6a.**)

- Random (i.e., some objective random method was used to pick the site location.);
- Selective (i.e., the site location was chosen for some reason; such as sign up lists, demonstration site, project monitoring, or other particular criteria.); (**NOTE:** Representative sampling [A6b] can include sites chosen randomly or selectively); or
- Unknown.

**A7a, b.** Identify any National, Provincial, or Rural/Urban Municipal, or other Park(s) on which work is being done. If Yes, identify which type of park is established. More than one type may occur.

**A7c.** Indicate the full **official** name of the National, Provincial, or Rural/Urban park on which work is being done. If Other kind of park, identify the type of park and its established name.

**A8a, b.** Identify any **other types of protected areas** on which work is being done. If Yes, properly identify the type and name of the protected area that is established. (*Exclude National, Provincial, or Rural/Urban, or other Park(s) recorded in A7.*)

This question includes all areas with regulatory or administrative protection, other than parks, which are covered in A7. There are many types, including:

**Conservation Easement** are land with a registered easement for the purposes of maintaining conservation value.

**Ecological Reserves** are areas of Crown Land (Provincial Government), which have the potential to contain representative, rare and fragile landscapes, plants, animals and geological features. The intent is for the preservation of natural ecosystems, habitats and features associated with biodiversity. Public access to ecological reserves is by foot only; public roads and other facilities do not normally exist and will not be developed.

**Environmental Reserve** generally are those lands that are considered un-developable and may consist of a swamp, gully, ravine, coulee or natural drainage course, flood prone areas, steep slopes or land immediately adjacent to lakes, rivers, stream or other bodies of water. Governed by *The Municipal Government Act (Alberta)*.

**Municipal Reserve** may also be known, in part, as reserve, park reserve, park or community reserve. Municipal reserves are lands that have been given to the municipality by the developer of a subdivision as part of the subdivision approval process. Governed by *The Municipal Government Act (Alberta)*.

**Other types of Protected Area (Designated Nationally, Provincially, or Municipally)** such as, Provincial Recreation Areas, Wilderness areas, Natural Areas, Heritage Rangelands, National Historic Sites, and Migratory Bird Sanctuaries.

**A9.** If this polygon has an association with a Watershed Group/Community Affiliation name the group.

**A10.** Identify the organizations project name. This may be a internal name not recognized by the Watershed Group or Community Affiliation but a name used to group a series of polygons. Use “Individual” if not a group and not a demo.

**A11.** Identify if work was done on Private Land? Answer Yes or No. If applicable give the Landowners Name.

**A12a-d.** Identify if work is being done on Private Land that is rented out? Answer Yes or No. If applicable give Renters Name, their Legal Land Description of residence, and County name, if different from the one where the work is being done.

**A13a-d.** Public Land is land that is administered by a Federal, Provincial, or Municipal agency. Provincial Public lands are owned by the provincial government and administered under the authority of the Public Lands Act. Identify if work was done on Public Land. Answer “Yes” or “No.” If applicable give Managers Name(s), as well as the Provincial office and their department associated with the management of this land to which work is being done (*Note: for Multi Land Use areas or zones, there may be more than one land manager*).

**A14a.** Identify if site is a Grazing lease or Grazing reserve on which work is being done. If applicable give Lessees/Group name.

**A14c.** Identify which Disposition this land falls under and its license number associated with it. i.e., GRL: Grazing Lease, GRP Grazing Permit, GRR Grazing Reserve, FGL Forest Grazing License, CUP Cultivation Permit.

**A14d.** Give any other grazing name (e.g. Community Pasture) to identify where the work is being done.

**A15a, b.** A Public Land Use Zone (PLUZ) is an area of public land to which legislative controls apply under authority of the Public Land Administration Regulation to assist in the management of recreational land uses. Each PLUZ may have conditions and regulations that are specific to that land base. **A15a.** Identify if site is within a PLUZ (“Yes” or “No”). **A15b.** Identify the name of the PLUZ.

**A16.** The several parts of these items identify various ways in which a data record may represent a resampling of a polygon that may have been inventoried again at some other time. The data in this record may have been collected on an area that coincides precisely with an area inventoried at another time and recorded as another record in the database. It may also represent the resampling of only a part of an area previously sampled. This would include the case where this polygon overlaps, but does not precisely and entirely coincide with one inventoried at another time. One other case is where more than one polygon inventoried one year coincides with a single polygon inventoried another year. All of these cases are represented in the database, and all have some value for monitoring purposes, in that they give some information on how the status on a site changes over time. ***This is done in the office with access to the database; field evaluators need not complete these items.***

**A16a.** Has any part of the area within this polygon been inventoried previously, or subsequently, as represented by another data record in the database? Such other records would logically carry different dates as well as Identification Numbers.

**A16b.** If A13a is answered “Yes,” then enter the years of any inventories of this exact polygon.

**A16c.** Does the area extent of this polygon exactly coincide with that of any other inventory represented in the database? In many cases, subsequent inventories only partially overlap spatially.

**A16d.** If A16c is answered “Yes,” identify those database record ID numbers for other polygons that can be compared as representing exactly the same ground area.

**A17a.** Even though this polygon is not a re-inventory of the exact same area as any other polygon, does it share at least some common area with one or more polygons inventoried at another time?

**A17b.** If A17a is answered “Yes,” enter the record ID number(s) of any other polygon(s) sharing common area with this one.

**A18a, b.** Has a management change been implemented on this polygon or that directly/clearly influences the polygon? Simply answer “Yes,” “No,” or “Unknown.” If applicable, in what year was the management change implemented and describe the management change implemented?

**A19.** *The primary contact is the person (landowner, land manager, or renter, etc.; include agency name if appropriate) who initiated the contact with the funding organization to have this riparian work conducted. Therefore, if the renter initiated the contact, the land owner would be a secondary contact.*

**Location Data**

**B1.** Province in which the field work is being done (i.e., where the polygon is located).

**B2.** Municipality or Reserve Type: (drop down list in the database). Choose one of the following: **Indian Reserve, Military Reserve, Rural Municipality** (*MD or County, Hamlet, Improvement District [which includes all National Parks]*), *Métis Settlements, Special Areas, Specialized Municipality (5 in the province)* or **Urban Municipality** (*City, Town, Village, Summer Village*). **For further clarification on the three types of Municipalities in Alberta, see insert in the back of the field manual.**

**B3a.** Indian Reserve Name (drop down list in database)

**B3b.** Military Reserve Name (drop down list in database)

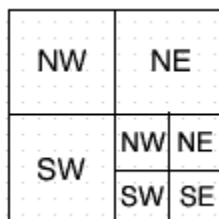
**B4a, b.** Rural or Specialized Municipality Name (drop down list in database). If applicable, list the Hamlet name in B4b.

**B5a-d.** The name of the city, town, or village in which the fieldwork is being done. If applicable list the subdivision plan number, block number and lot number of the area to which the work was being done on.

**B6a.** Name the water body or area on which the field work is being done.

**B6b.** Identify the side of the polygon that the Assessment is completed for by using North, South, East or West, if assessment includes both sides enter Both.

**B7.** The location of the polygon is presented as a legal land description (1/4, 1/4 section, 1/4 section, Township, Range, and Meridian) are read from smallest to largest unit.



**B8a, b.** Identify the Natural Region and Sub-Region in which the field work is being done. Use the Natural Regions and Subregions of Alberta (Alberta Natural Heritage Information Centre [1999]).

**B9a.** Name the major watershed (e.g. North Saskatchewan River) of which the site being surveyed is a part. List one of the seven major Basins by AESRD: Hay River, Peace/Slave River, Churchill River, North Saskatchewan River, South Saskatchewan River, and Missouri River Watersheds.

**B9b.** Name the minor watershed (e.g. Battle River) of which the site being surveyed is a part. This is normally subordinate to the major watershed named above in B9a.

**B9c.** Name the sub-basin in which you are working (e.g. Iron Creek). This is the third level down from the largest (major watershed) (e.g., North Saskatchewan River—Battle River—***Iron Creek***; or South Saskatchewan River—Red Deer River—***Little Red Deer River***). Although you may be working on an even lower level tributary, the sub-basin flows directly into and is subordinate to the minor watershed named above in B9b. ***For example:*** You are doing an inventory on Pekisko Creek—***this creek is not the sub-basin.*** The order should be: South Saskatchewan River—Bow River—Highwood River. If you are doing a site on a Major or Minor Watershed, then the Sub-basin may be the same as the Major or Minor basin, respectively.

**B10a-b.** Universal Transverse Mercator (UTM) coordinates are recorded for the upper and lower ends of the polygon using Trimble or GPS units in the field.

Enter the UTM coordinates data, including the UTM zone and the identifying waypoint number on the form for each point collected. Save the data in the Trimble /GPS unit for downloading to the computer later.

**B10c-d.** Identify the Trimble/GPS unit used, and the name or number designator of the waypoints saved for the upper and lower ends of the polygon and for other locations. Describe any comments worth noting about the waypoints (i.e., monument referenced or general location descriptions). Record the projection setting of the unit in use (If using the Trimble unit this will be set during setup in ArcGIS).

**B11a-c.** Record the name(s), scale, and publication year of the quadrangle map(s) or any other map(s) locating the polygon. Use precisely the name listed on the map sheet. Provision is made for listing two maps in case the polygon crosses between two maps.

**B12.** Record identifying data for any aerial photos used on this polygon.

### Selected Summary Data

**C1.** Wetland type is a categorical description of the predominant polygon character. Select from the following list of categories that may occur within a lotic system the one that best characterizes the majority of the polygon. Observers will ***select only one category*** as representative of the entire polygon. If significant amounts of other categories are present, indicate this in Vegetation Comments (item D17) or consider dividing the original polygon into two or more polygons.

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#### Category Description

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**Perennial Stream.** A stream or stretch of stream that flows continuously for most of most years. Perennial streams are generally fed in part by springs or discharge from groundwater. Perennial streams are distinguished from larger rivers by size. Streams wider than 15 m (50 ft) are considered rivers for the purpose of this inventory (see below).

**Intermittent Stream.** A stream or stretch of stream which flows only at certain periods of the year when it receives water from springs, discharge from groundwater, or melting snow in mountainous areas. These streams generally flow continuously at least one month most years.

**Ephemeral Stream.** A stream or stretch of stream that flows in normal water years only in direct response to precipitation. In normal years, it receives no water from springs and no extended supply from melting snow or other surface source. Ephemeral streams are not in contact with groundwater and normally do not flow continuously for as long as one month. Not all ephemeral streams support riparian plant communities.

**Subterranean Stream.** A stream that flows underground for part of the stream reach. This occurs on systems composed of coarse textured, porous substrates. Surface flow may disappear and re-emerge farther downstream.

**Pooled Channel Stream.** An intermittent stream that has significant channel pools after surface flow ceases. Pools are generally at meander curves and are usually considerably deeper than the rest of the channel bottom. Water sources for the pools may be springs or

contact with subsurface groundwater. This stream type is typical of fine textured sedimentary plains in semi-arid regions where headwater drainages lack the extended runoff of deep mountain snowpack. This stream type may not be apparent early in the season when flow is continuous.

**River.** Rivers are generally larger than streams. They flow year around, in years of normal precipitation and when significant amounts of water are not being diverted out of them. Those watercourses having bankfull channel widths greater than 15 m (>50 ft) will be classified as rivers for the purpose of this inventory.

**Beaver Dams.** A system that is predominantly characterized by beaver dams that change the character of the system from a regular flowing channel to a stepped system of ponds where water is spread wide and flow velocity is apparent only at each dam outlet before it enters the next pond. Water is still flowing through the riparian system.

**Wet Meadow.** This type of wetland may occur in either running water (lotic) or in still water (lentic) systems. A lotic wet meadow has a defined channel or flowing surface water nearby, but is typically much wider than the riparian zone associated with the classes described above. This is often the result of the influence of lateral groundwater not associated with the stream flow. Lotic and lentic wet meadows may occur in proximity (e.g., when enough groundwater emerges to begin to flow from a mountain meadow, the system goes from lentic to lotic). Such communities are typically dominated by herbaceous hydrophytic vegetation that requires saturated soils near the surface, but tolerates no standing water for most of the year. This type of wetland typically occurs as the filled-in basin of old beaver ponds, lakes, and potholes.

**Spring/Seep.** Groundwater discharge areas. In general, springs have more flow than seeps. This wetland type may occur in a running water (lotic) or still water (lentic) system.

**Irrigation Canal.** Includes all types of canals and ditches associated with irrigation systems.

**Other.** Describe the water source (e.g., irrigation return flow, industrial discharge, etc.).

**Nonriparian (Upland).** This designation is for those areas which are included in the inventoried polygon, but which do not support functional wetland vegetation communities. Such areas may be undisturbed inclusions of naturally occurring high ground or such disturbed high ground as roadways and other elevated sites of human activity.

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**C2.** The size (acres/hectares) of polygons large enough to be drawn as enclosed units on 1:20,000 or 1:50,000 scale maps is determined in the office using a planimeter, dot grid, or GIS. For polygons too small to be accurately drawn as enclosed units on the maps, and which are represented by line segments on the map along the drainage bottom, polygon size is calculated using polygon length and average polygon width (items C5 and C7a).

**C3a-d.** Evaluators may be asked to survey some areas that have not been determined to be wetlands for the purpose of making such a determination. Other polygons include areas supporting non-wetland vegetation types. A Yes answer to C3a indicates that no part of the polygon keys to a riparian habitat type or community type (HT/CT). **Areas classified in item D15 as any vegetation type described in a riparian and/or wetland classification document for the region in which you are working are counted as functional wetlands.** Areas listed as UNCLASSIFIED WETLAND TYPE are also counted as functional wetlands. Other areas are counted as non-wetlands, or uplands. The functional wetland fraction of the polygon area is listed in item C3c in acres and as a percentage of the entire polygon area in item C3d.

**C4.** Some riparian areas do not contain an unvegetated, defined stream channel. In some cases, these polygons are in ephemeral systems which may flow infrequently, but which do support riparian plant communities. In other cases, these polygons may be associated with larger river systems that have wide floodplains where polygons may be delineated in areas not adjacent to the channel.

**C5.** Channel length—the length of channel contained within or adjacent to the polygon—is measured by scaling from the map. This data is considered accurate to the nearest 0.16 km (0.1 mi).

**C6.** In some cases, the polygon record is used to characterize, or represent, a larger portion of a stream system. The length represented by the polygon is given. For example, a 0.8 km (0.5 mi) polygon may be used to represent 6.4 km (4 mi) of a stream. In the case, 0.8 km (0.5 mi) is the channel length of the polygon (item C5), and 6.4 km (4 mi) is entered in item C6.

**C7a.** Record average width of the polygon, which on smaller streams corresponds to the width of the riparian zone. To determine this width, subtract the width of the non-vegetated stream channel (item F9) from the distance between the two opposite riparian/upland boundaries. In the case of very wide systems where the polygon inventoried does not extend across the full width of the riparian zone (e.g., area with riparian vegetation communities lies outside the polygon), record the average width of the polygon inventoried and make note of the situation in the narrative comments.

**C7b.** Record the range of width (ft/m), narrowest to widest, of the riparian zone in the polygon.

**C7c.** Determine whether the assessed riparian area is along a stream or small river (**channel** is less than 15 m wide [less than 50 ft]) or along a large river (**channel** is greater than 15 m wide [greater than 50 ft]). This question is used by the computer to determine whether to derive a lotic wetland health assessment for streams and small rivers, or to derive one for large rivers. On the field form, write in either **Stream/Small River** or **Large River** to answer this question.

**C8.** List the riparian habitat type(s) and/or community type(s) found in the polygon using a manual for identifying types in the region in which you are working, such as *Classification and Management of Riparian and Wetland Sites of the Alberta Grassland Natural Region and Adjacent Subregions* (Thompson and Hansen 2002), *Classification and Management of Riparian and Wetland Sites of Alberta's Parkland Natural Region and Dry Mixedwood Natural Subregion* (Thompson and Hansen 2003), *Classification and Management of Riparian and Wetland Sites of the Saskatchewan Prairie Ecozone and Parts of Adjacent Subregions* (Thompson and Hansen 2001) or the applicable Sustainable Resource Development (SRD) Guide for the natural sub-region in which you are working. If the habitat type cannot be determined for a portion of the polygon, then list the appropriate community type(s) of that portion. If neither the habitat type nor community type can be determined for any portion of the polygon (or in areas where the habitat and community types have not been named and described), list the area in question as unclassified wetland type and give the dominant species present. Indicate with the appropriate abbreviation if these are habitat types (HT), community types (CT), or dominance types (DT), for example, SALILUT/CORNSTO HT (*Salix lutea*/*Cornus stolonifera* [yellow willow/red-osier dogwood] Habitat Type). For each type listed, estimate the percent of the polygon represented. If known, record the successional stage (i.e., early seral, mid-seral, late seral, and climax), or give other comments about the type. As a minimum, list all types that cover 5% or more of the polygon. The total must approximate 100%. Slight deviations due to use of class codes or to omission of types covering less than 5% of the polygon are allowed. **NOTE:** For any area designated as an unclassified wetland type, it is important to list any species present that can indicate the wetness or dryness of the site.

The things listed in item D15 (HTs, CTs, and other coverages) should account for the entire polygon area. These values are used in analyses calculations that must account for the whole polygon. The list of nonriparian vegetation types is shown below, but it is somewhat dynamic, so that if others are encountered, they can be added. These other “types” are important to understand what is happening on the polygon.

- **Artificial Open Water** (regardless of depth, this refers to open water on the polygon that is artificially created/constructed [i.e., dugout]);
- **Building Complex;**
- **Cropland;**
- **Gravel Surface** (human constructed);
- **Hayfield** (refers to a purposefully converted riparian area into a hayfield [seeded] and insufficient native species exist to help identify HT/CT type vs. land use type);
- **Lawn** (use Lawn instead of POAPRAT CT when the site has been purposefully/physically manipulated due to seeding or sodding);
- **Natural Open Water** (refers to open water in the polygon that does not have emergent vegetation and is less than 2 m {6.6 ft} deep);
- **Paved Surface;**
- **Shelterbelt** (refers to trees and/or shrubs planted as a barrier to reduce wind speed and to protect crops, livestock, buildings, work areas, and roads from wind and snow);
- **Unvegetated Mine Tailings;**
- **Upland Artificial** (refers to an upland area artificially created within the riparian area being assessed [i.e., spoil piles, overburden]. Do not include built-up roads/surfaces—these would still be included as paved surface or gravel surface.);
- **Upland Natural** (refers to naturally occurring areas within the riparian area being assessed), and;
- **Unclassified Wetland Type UNC** (as per CF updated protocol [2012] included with Habitat Classification Keys in CF manual).

**NOTE #1:** The term “Unclassified Wetland Type” signifies a natural vegetation that does not yield a name when put through an HT/CT key, but which can be described by species dominance in upper and lower stories. You normally should only need to use “Unclassified Wetland Type” when working in an area lacking a classification.

**NOTE #2:** The following describes how to account for 100% of polygon in open water situations.

- Natural situation—the open water is a small pond typically **greater than 2 m [6.0 ft] deep and plants do not emerge above the water**—then do not include in the polygon.



- If there is open water that is less than 2 m [6.0 ft] deep and there is no emergent veg and is natural—call this “**Natural Open Water**” and include in the HT/CT.
- If the open water is artificially created regardless of depth, then call this “Artificial Open Water” and include in the HT/CT section. Describe in the comments. The entire area is included in the polygon as human-caused alteration.
- If unnatural upland areas (spoil piles, overburden, etc.) are created within the riparian area due to the deposit of material from excavated areas, call this **Upland Artificial**. The entire **Upland Artificial** area (i.e., spoil pile) is in the polygon regardless of height. *(By including the Upland Artificial area, we can account for a plant community or bare ground on the slopes and on top of the pile as well as alterations on the slopes and on top of the pile because it is still within the polygon boundary land area.)*

## FACTORS FOR ASSESSING LOTIC WETLAND HEALTH FOR STREAMS/SMALL RIVERS

**NOTE:** In the following instructions the corresponding *Lotic Wetland Inventory Form* item numbers (from which the health is derived) are shown in parentheses. Details of how these source data items are collected are located in the *Lotic Wetland Inventory Form User Guide*. For polygons contained in the Lotic Wetland database, all calculations are done by the computer. Some factors on the evaluation may not apply on all sites. For example, sites without potential for woody species are not rated for tree and shrub regeneration or utilization.

**1. Vegetative Cover of Floodplain and Streambanks (D12).** Vegetation cover helps to stabilise banks, control nutrient cycling, reduce water velocity, provide fish cover and food, trap sediments, reduce erosion, and reduce the rate of evaporation (Platts and others 1987). On most streams the area of the channel bottom is excluded from the polygon. (**NOTE:** *Although the whole channel width extends from right bankfull stage to left bankfull stage; we need to include the lower streambanks in all polygons. Therefore exclude ONLY the relatively flat and lowest area of the channel—the channel bottom.*) This allows data to be collected on the riparian area while excluding the aquatic zone, or open water, of the stream. The aquatic zone is the area covered by water and lacking persistent emergent vegetation. Persistent emergent vegetation consists of perennial wetland species that normally remain standing at least until the beginning of next growing season, e.g., *Typha* species (cattails), *Scirpus* species (bulrushes), *Carex* species (sedges), and other perennial graminoids.

In many systems, large portions of the channel bottom may become exposed due to seasonal irrigation use, hydroelectric generation, and natural seasonal changes such as are found in many prairie ecosystems. In these cases, especially the prairie streams, the channel bottom may have varying amounts of herbaceous vegetation, and the channel area is **included** in the polygon as area to be inventoried. Typically these are the pooled channel stream type that has scour pools scattered along the length, interspersed with reaches of grass, bulrush, or sedge-covered channel bottom. If over half (>50%) the channel bottom area has a canopy cover of persistent vegetation cover (perennial species), taken over the entire length of the polygon as a whole, then it qualifies for inclusion within the inventoried polygon area. If the you are in doubt whether to include the channel bottom in the polygon, then leave it out, but be sure to indicate this in the comment section. This is important so that future assessments of the polygon will be looking at the same area of land.

The evaluator is to estimate the fraction of the polygon covered by plant growth. Vegetation cover is ocularly estimated using the canopy cover method (Daubenmire 1959). For field determination of vegetative cover related questions (questions D2 through D14) include **all rooted plant material** (live or dead). Do not include fallen wood or other plant litter. Do not consider the polygon area covered by water (such as between emergent plants). **NOTE:** For field determination of vegetative cover include **all rooted plant material** (live or dead). Do not include fallen wood or other plant litter. Do not consider the polygon area covered by water (such as between emergent plants).

### Scoring:

- 6** = More than 95% of the polygon area is covered by rooted plant material (live or dead).
- 4** = 85% to 95% of the polygon area is covered by rooted plant material (live or dead).
- 2** = 75% to 85% of the polygon area is covered by rooted plant material (live or dead).
- 0** = Less than 75% of the polygon area is covered by rooted plant material (live or dead).

**2. Invasive Plant Species (Weeds) (D13c).** Invasive plants (weeds) are alien species whose introduction does or is likely to cause economic or environmental harm. Whether the disturbance that allowed their establishment is natural or human-caused, weed presence indicates a degrading ecosystem. While some of these species may contribute to some riparian functions, their negative impacts reduce overall site health. This item assesses the degree and extent to which the site is infested by invasive plants. The severity of the problem is a function of the density/distribution (pattern of occurrence), as well as canopy cover (abundance) of the weeds. In determining the health score, all invasive plant species are considered collectively, not individually. A weed list should be used that is standard for the locality and that indicates which species are being considered (i.e., *Invasive Weed and Disturbance-caused Undesirable Plant List* [Cows and Fish 2002]).

The site's health rating on this item combines two factors: weed density/distribution class and total canopy cover. A perfect score of 6 out of 6 points can only be achieved if the site is weed free. A score of 4 out of the 6 points means the weed problem is just beginning (i.e., very few weeds and small total canopy cover [less than 1%]). A moderate weed problem gets 2 out of 6 points. It has a moderately dense weed plant distribution (a class between 4 and 7) and moderate total weed canopy cover (between 1% and 15%). A site scores 0 points if the density/distribution is in class 8 or higher, or if the total weed canopy cover is 15% or more.

**NOTE:** For field determination of vegetative cover include *all rooted plant material* (live or dead). Do not include fallen wood or other plant litter. Do not consider the polygon area covered by water (such as between emergent plants).

**2a. Total Canopy Cover of Invasive Plant Species (Weeds).** This item rates the total percentage of polygon area occupied by the combined canopy cover of all species of invasive plants.

**Scoring:**

- 3 = No invasive plant species (noxious weeds) on the site.
- 2 = Invasive plants present with total canopy cover less than 1% of the polygon area.
- 1 = Invasive plants present with total canopy cover between 1% and 15% of the polygon area.
- 0 = Invasive plants present with total canopy cover more than 15% of the polygon area.

**2b. Density/Distribution Pattern of Invasive Plant Species (Weeds).** This item rates the polygon for weed plant density/distribution based on categories illustrated in Item D13 of the Lotic Wetland Inventory.

**Scoring:**

- 3 = No invasive plant species (noxious weeds) on the site.
- 2 = Invasive plants present with density/distribution in categories 1, 2, or 3.
- 1 = Invasive plants present with density/distribution in categories 4, 5, 6, or 7.
- 0 = Invasive plants present with density/distribution in categories 8, or higher.

**NOTE:** Prior to the 2001 season, the health score for weed infestation was assessed from a single numerical value that does not represent weed canopy cover, but instead represents the fraction of the polygon area on which weeds had a well established population of individuals (i.e., the area infested).

**3. Disturbance-Increaser Undesirable Herbaceous Species (D14b).** A large cover of disturbance-increaser undesirable herbaceous species, native or exotic, indicates displacement from the potential natural community (PNC) and a reduction in riparian health. These species generally are less productive, have shallow roots, and poorly perform most riparian functions. They usually result from some disturbance, which removes more desirable species. Invasive plant species considered in the previous item are not reconsidered. As in the previous item, the evaluator should state the list of species considered. A partial list of undesirable herbaceous species appropriate for use in Alberta follows. A list should be used that is standard for the locality and that indicates which species are being considered (i.e., *Invasive Weed and Disturbance-caused Undesirable Plant List* [Cows and Fish 2001]). The evaluator should list any additional species included.

<i>Antennaria</i> species (pussy-toes)	<i>Hordeum jubatum</i> (foxtail barley)	<i>Potentilla anserina</i> (silverweed)
<i>Brassicaceae</i> (mustards)	<i>Plantago</i> species (plantains)	<i>Taraxacum</i> species (dandelion)
<i>Bromus inermis</i> (awnless brome)	<i>Poa pratensis</i> (Kentucky bluegrass)	<i>Trifolium</i> species (clovers)
<i>Fragaria</i> species (strawberries)	_____	_____
_____	_____	_____

**NOTE:** For field determination of vegetative cover include *all rooted plant material* (live or dead). Do not include fallen wood or other plant litter. Do not consider the polygon area covered by water (such as between emergent plants).

**Scoring:**

- 3 = Less than 5% of the site covered by disturbance-increaser undesirable herbaceous species.
- 2 = 5% to 25% of the site covered by disturbance-increaser undesirable herbaceous species.
- 1 = 25% to 50% of the site covered by disturbance-increaser undesirable herbaceous species.
- 0 = More than 50% of the site covered by disturbance-increaser undesirable herbaceous species.

**4. Preferred Tree and Shrub Regeneration (D2 and D6c).** (*This item is skipped if the site lacks potential for trees or shrubs.*) Not all riparian areas can support trees and/or shrubs. However, on those sites where such species do belong, they play important roles. The root systems of woody species are excellent bank stabilisers, while their spreading canopies provide protection to soil, water, wildlife, and livestock. Young age classes of woody species are important for the continued presence of woody communities not only at a given point in time but into the future. Woody species potential can be determined by using a key to site type (Thompson and Hansen 2001, 2002, 2003, etc.). On severely disturbed sites, the evaluator should

seek clues to potential by observing nearby sites with similar landscape position. (**NOTE:** Vegetation potential is commonly underestimated on sites with a long history of disturbance.)

The following species are excluded from the evaluation (those not listed are considered preferred):

- *Artemisia cana* (silver sagebrush), including subsp. *cana* and *viscidula*;
- *Caragana* species (caragana)
- *Crataegus* species (hawthorn);
- *Elaeagnus angustifolia* (Russian olive);
- *Elaeagnus commutata* (silverberry/wolf willow);
- *Potentilla fruticosa* (shrubby cinquefoil);
- *Rhamnus catharticus* (European/common buckthorn);
- *Rosa* species (rose);
- *Sarcobatus vermiculatus* (greasewood);
- *Symphoricarpos* species (buckbrush/snowberry);
- *Tamarix* species (salt cedar); and
- Non-native species.

These are species that may reflect long-term disturbance on a site, that are generally less palatable to browsers, and that tend to increase under long-term moderate-to-intense grazing pressure; **AND** for which there is rarely any problem in maintaining presence on site. Examples of the latter include *Artemisia cana* (silver sagebrush) and *Sarcobatus vermiculatus* (greasewood). Both are considered climax species in many riparian situations and rarely have any problem maintaining a presence on a site. Only under extreme long-term grazing pressures will these species be eliminated from a site. *Elaeagnus angustifolia* (Russian olive), *Caragana* species (caragana), *Rhamnus catharticus* [European/common buckthorn], and *Tamarix* species [salt cedar] are considered especially aggressive, undesirable exotic plants.

The main reason for excluding these plants is they are far more abundant on many sites than are species of greater concern (i.e., *Salix* species [willows], *Cornus stolonifera* [red-osier dogwood], *Amelanchier alnifolia* [Saskatoon serviceberry], and many other taller native riparian species), and they may mask the ecological significance of a small amount of a species of greater concern. **FOR EXAMPLE:** A polygon may have *Symphoricarpos occidentalis* (buckbrush/snowberry) with 30% canopy cover showing young plants for replacement of older ones, while also having a trace of *Salix exigua* (sandbar willow) present, but represented only by older mature individuals. We feel that the failure of the willow to regenerate (even though there is only a small amount) is very important in the health evaluation, but by including the buckbrush/snowberry and willow together on this polygon, the condition of the willow would be hidden (overwhelmed by the larger amount of buckbrush/snowberry).

For shrubs in general, seedlings and saplings can be distinguished from mature plants as follows. For those species having a mature height generally over 1.8 m (6.0 ft), seedlings and saplings are those individuals less than 1.8 m (6.0 ft) tall. For species normally not exceeding 1.8 m (6.0 ft), seedlings and saplings are those individuals less than 0.45 m (1.5 ft) tall or which lack reproductive structures and the relative stature to suggest maturity. Count plants installed by human planting if they have survived at least one full year after planting. To be successfully the new plants need to have at least one complete growing season on the site. Many new plants do not survive the first growing season. (**NOTE:** Evaluators should take care not to confuse short stature resulting from intense browsing with that due to young plants.)

The computer evaluates this item on the basis of data recorded on the *Lotic Wetland Inventory Form* for the fraction of tree and shrub species cover on the site that is in the young age classes.

**Scoring:** (If the site has no potential for trees or shrubs [except for the species listed above to be excluded], the computer automatically replaces both the Actual Score and Possible Score with zero.)

**6** = More than 15% of the total canopy cover of preferred trees/shrubs is seedlings and/or saplings.

**4** = 5% to 15% of the total canopy cover of preferred trees/shrubs is seedlings and/or saplings.

**2** = Less than 5% of the total canopy cover of preferred tree/shrubs is seedlings and/or saplings.

**0** = Preferred tree/shrub seedlings and saplings absent.

**5a. Browse Utilization of Available Preferred Trees and Shrubs (D5a and D6c).** (Skip this item if the site lacks trees or shrubs; for example, the site is a herbaceous wet meadow or cattail marsh, or all woody plants have already been removed.) Livestock and/or wildlife browse many riparian woody species. Excessive browsing can eliminate these important plants from the community and result in their replacement by undesirable invaders. With excessive browsing, the plant loses vigour,

is prevented from flowering, or is killed. Utilization in small amounts is normal and not a health concern, but concern increases with greater browse intensity.

The following species are excluded from the evaluation:

- *Artemisia cana* (silver sagebrush), including subsp. *cana* and *viscidula*;
- *Caragana* species (caragana)
- *Crataegus* species (hawthorn);
- *Elaeagnus angustifolia* (Russian olive);
- *Elaeagnus commutata* (silverberry/wolf willow);
- *Potentilla fruticosa* (shrubby cinquefoil);
- *Rhamnus catharticus* (European/common buckthorn);
- *Rosa* species (rose);
- *Sarcobatus vermiculatus* (greasewood);
- *Symphoricarpos* species (buckbrush/snowberry);
- *Tamarix* species (salt cedar); and
- Non-native species.

These are species that may reflect long-term disturbance on a site, that are generally less palatable to browsers, and that tend to increase under long-term moderate-to-intense grazing pressure; **AND** for which there is rarely any problem in maintaining presence on site. Examples of the latter include *Artemisia cana* (silver sagebrush) and *Sarcobatus vermiculatus* (greasewood). Both are considered climax species in many riparian situations and rarely have any problem maintaining a presence on a site. Only under extreme long-term grazing pressures will these species be eliminated from a site. *Elaeagnus angustifolia* (Russian olive), *Caragana* species (caragana), *Rhamnus catharticus* [European/common buckthorn], and *Tamarix* species [salt cedar] are considered especially aggressive, undesirable exotic plants.

As discussed above, the main reason for excluding these plants is they are far more abundant on many sites than are species of greater concern (e.g., *Salix* species [willows], *Cornus stolonifera* [red-osier dogwood], *Amelanchier alnifolia* [Saskatoon serviceberry], and many other taller native riparian species), and they may mask the ecological significance of a small amount of a species of greater concern. **FOR EXAMPLE:** A polygon may have *Symphoricarpos occidentalis* (buckbrush/snowberry) with 30% canopy cover showing young plants for replacement of older ones, while also having a trace of *Salix exigua* (sandbar willow) present, but represented only by older mature individuals. We feel that the failure of the willow to regenerate (even though there is only a small amount) is very important in the health evaluation, but by including the buckbrush/snowberry and willow together on this polygon, the condition of the willow would be hidden (overwhelmed by the larger amount of buckbrush/snowberry).

Consider as available all tree and shrub plants to which animals may gain access and that they can reach. For tree species, this means mostly just seedling and sapling age classes. When estimating degree of utilization, count browsed second year and older leaders on representative plants of woody species normally browsed by ungulates. Do not count current year's use, because this would not accurately reflect actual use when more browsing can occur later in the season. Browsing of second year or older material affects the overall health of the plant and continual high use will affect the ability of the plant to maintain itself on the site. Determine percentage by comparing the number of leaders browsed or utilized with the total number of leaders available (those within animal reach) on a representative sample (at least three plants) of each tree and shrub species present. Do not count utilization on dead plants, unless it is clear that death resulted from over-grazing. **NOTE:** If a shrub is entirely mushroom/umbrella shaped by long-term intense browse or rubbing, count browse utilization of it as heavy.

**Scoring:** (Consider all shrubs within animal reach and seedlings and saplings of tree species. If the site has no potential for trees or shrubs [except for the species listed above to be excluded], the computer automatically replaces both the Actual Score and Possible Score with zero.)

**3** = None (0% to 5% of available second year and older leaders of preferred species are browsed).

**2** = Light (5% to 25% of available second year and older leaders of preferred species are browsed).

**1** = Moderate (25% to 50% of available second year and older leaders of preferred species are browsed).

**0** = Heavy (More than 50% of available second year and older leaders of preferred species are browsed).

**5b. Live Woody Vegetation Removal by Other Than Browsing (D6e).** Excessive cutting or removing parts of plants or whole plants by agents other than browsing animals (e.g., human clearing, cutting, beaver activity, etc.) can result in many of the same negative effects to the community that are caused by excessive browsing. However, other effects from this kind of

removal are direct and immediate, including reduction of physical community structure and wildlife habitat values. **Do not include natural phenomena such as natural fire, insect infestation, etc. in this evaluation.**

Removal of woody vegetation may occur at once (a logging operation), or it may be cumulative over time (annual firewood cutting or beaver activity). **This question is not so much to assess long-term incremental harvest, as it is to assess the extent that the stand is lacking vegetation that would otherwise be there today.** Give credit for re-growth. Consider how much the removal of a tree many years ago may have now been mitigated with young replacements.

**Invasive woody species or genera are excluded from consideration because these are aggressive, invasive exotic plants that should be removed.** They are *Berberis vulgaris* (common barberry), *Caragana arborescens* (common caragana), *Clematis tangutica* (yellow clematis), *Elaeagnus angustifolia* (Russian olive), *Elaeagnus umbellata* (Autumn olive), *Rhamnus cathartica* (European/common buckthorn), and *Tamarix* species (salt cedar).

Determine the extent to which woody vegetation (trees and shrubs) is lacking due to being physically removed (i.e., cut by beaver, cut by humans, mowed, trimmed, logged, or otherwise removed from their growing position). The timeframe is less important than the ecological effect. Time to recover from this kind of damage can vary widely with site characteristics. The objective is to measure the extent of any damage remaining **today** to the vegetation structure resulting from woody removal. We expect that the woody community will recover over time (re-grow), just as an eroding bank will heal with re-growing plant roots. **This question simply asks how much woody material is still missing from what should be on the site?** The amount of time since removal doesn't really matter, if re-growth has been allowed to progress. If 20 years after logging, the site has a stand of sapling spruce trees, then it should get partial re-growth credit, but not full credit, since the trees still lack much of their potential habitat and ecological value. (**NOTE:** In general, the more recent the removal, the more entirely it should be fully counted; and conversely, the older the removal, the more likely it will have been mitigated by re-growth.)

This question is really looking at volume (three dimensions) and not canopy cover (two dimensions). For example, if an old growth spruce tree is removed, a number of new seedlings/saplings may become established and could soon achieve the same canopy cover as the old tree had. However, the value of the old tree to wildlife and overall habitat values is far greater than that of the seedling/saplings. It will take a very long time before the seedlings/saplings can grow to replace all the lost habitat values that were provided by the tall old tree. On the other hand, shrubs, such as willows, grow faster and may replace the volume of removed plants in a much shorter time. **Answer this question by estimating the percent of woody material that is missing from the site due to having been removed by human action or beaver (active or inactive) or other methods regardless of timeframe. Select a range category from the choices given that best represents the percent of missing woody material.**

**Note 1:** If the polygon does not have the ability to support (potential for) any trees and shrubs (example: prairie/saline conditions) and there is no evidence that it ever had any, **record as NA** and record the reason in D6g.

**Note 2:** If the polygon has potential for trees and shrubs but they are not present, look for evidence (i.e. stumps or cut woody plants within the polygon or other indicators [e.g. adjacent lands, across the fence, surrounding landscape, personal communication, historical imagery]).

**Note 3:** When insufficient data/evidence is available to make a call, **record as NC** and record the reason in D6g. Also used for old polygons when data was not collected.

**Scoring:** (If the polygon does not have the ability to support [potential for] any trees and shrubs and there is no evidence that it ever had any, replace both Actual Score and Possible Score with **NA**. When insufficient data/evidence is available to make a call, replace both Actual Score and Possible Score with **NC**.)

**3** = None (0% to 5% of live woody vegetation expected on the site is lacking due to cutting).

**2** = Light (5% to 25% of live woody vegetation expected on the site is lacking due to cutting).

**1** = Moderate (25% to 50% of live woody vegetation expected on the site is lacking due to cutting).

**0** = Heavy (More than 50% of live woody vegetation expected on the site is lacking due to cutting).

**6. Standing Decadent and Dead Woody Material (D2b and D6c).** (Skip this item if the site lacks trees or shrubs; for example, the site is a herbaceous wet meadow or cattail marsh.) The amount of decadent and dead woody material on a site can be an indicator of the overall health of a riparian area. Large amounts of decadent and dead woody material may indicate

a reduced flow of water through the stream (dewatering) due to either human or natural causes. Dewatering of a site, if severe enough, may change the site vegetation potential from riparian species to upland species. In addition, decadent and dead woody material may indicate severe stress from over browsing. Finally, large amounts of decadent and dead woody material may indicate climatic impacts, disease and insect damage. For instance, severe winters may cause extreme die back of trees and shrubs, and cyclic insect infestations may kill individuals in a stand. In all these cases, a high percentage of dead and decadent woody material reflects degraded vegetative health, which can lead to reduced streambank integrity, channel incisement, and excessive lateral cutting, besides reducing production and other wildlife values.

The most common usage of the term **decadent** may be for over mature trees past their prime and which may be dying, but we use the term in a broader sense. We count decadent plants, both trees and shrubs, as those with 30% or more dead wood in the upper canopy. In this item, scores are based on the percentage of total woody canopy cover which is decadent or dead, not on how much of the total polygon canopy cover consists of dead and decadent woody material. Only decadent and dead standing material is included, not that which is lying on the ground. The observer is to ignore (not count) decadence in poplars or cottonwoods which are decadent **due to old age** (rough and furrowed bark extends substantially up into the crowns of the trees) (species: *Populus deltoides* [plains cottonwood], *P. angustifolia* [narrow-leaf cottonwood], and *P. balsamifera* [balsam poplar]), because cottonwoods/poplars are early seral species and naturally die off in the absence of disturbance to yield the site to later seral species. The observer is to consider (count) decadence in these species if apparently caused by de-watering, browse stress, climatic influences, or parasitic infestation (insects/disease). The observer should comment on conflicting or confounding indicators, and/or if the cause of decadence is simply unknown (*but not due to old age*). Do not count plants installed by human planting, that are less than one year old, as dead/decadent.

**Scoring:** (If the site has no potential for trees or shrubs [except for the species listed above to be excluded], the computer automatically replaces both the Actual Score and Possible Score with zero.)

**3** = Less than 5% of the total canopy cover of woody species is decadent and/or dead.

**2** = 5% to 25% of the total canopy cover of woody species is decadent and/or dead.

**1** = 25% to 50% of the total canopy cover of woody species is decadent and/or dead.

**0** = More than 50% of the total canopy cover of woody species is decadent and/or dead.

**7. Streambank Root Mass Protection (F7).** Vegetation along streambanks performs the primary physical functions of stabilizing the soil with a binding root mass and of filtering sediments from overland flow. Few studies have documented depth and extent of root systems of plant species found in wetlands. Despite this lack of documented evidence, some generalizations can be made. All tree and shrub species are considered to have deep, binding root masses. Among wetland herbaceous species, the first rule is that annual plants lack deep, binding roots. Perennial species offer a wide range of root mass qualities. Some rhizomatous species such as the deep rooted *Carex* species (sedges) are excellent bank stabilisers. Others, such as *Poa pratensis* (Kentucky bluegrass), have only shallow roots and are poor bank stabilisers. Still others, such as *Juncus balticus* (wire rush), are intermediate in their ability to stabilise banks. The size and nature of the stream will determine which herbaceous species can be effective. The evaluator should try to determine if the types of root systems present in the polygon are in fact contributing to the stability of the streambanks.

In situations where you are assessing a high, cut bank (usually on an outside bend), the top may be upland, but the bottom is riparian. Do not assess the area that is non-riparian. In cases of tall, nearly vertical cut banks, assess the bottom portion that comes in contact with floodwaters. Omit from consideration those areas where the bank is comprised of bedrock, since these neither provide binding root mass, nor erode at a perceptible rate.

**NOTE 1:** Access both sides of the stream, so total bank length evaluated will be approximately twice the stream reach length.

**NOTE 2:** Rip-rap does not substitute for, act as, or preclude the need for deep, binding root mass.

Since the kind and amount of deep, binding roots needed to anchor a bank is dependent on size of the stream, use the following table as a general guide to determine width of a band along the banks to assess for deep, binding roots. This is a rule of thumb for guidance that requires only estimated measurements.

Stream Size (Bankfull Channel Width)	Width of Band to Assess for Deep, Binding Roots
Rivers (Larger Than 15 m [50 ft])	15 m (50 ft)
Small Rivers and Large Streams (Approx. 5-15 m [16-49 ft])	5 m (16 ft)
Small Streams (Up To Approx. 5 m [16 ft])	2 m (6 ft)

**Scoring:**

- 6** = More than 85% of the streambank has a deep, binding root mass.
- 4** = 65% to 85% of the streambank has a deep, binding root mass.
- 2** = 35% to 65% of the streambank has a deep, binding root mass.
- 0** = Less than 35% of the streambank has a deep, binding root mass.

**8. Human-Caused Bare Ground (F15c).** Bare ground is soil not covered by plants, litter or duff, downed wood, or rocks larger than 6 cm (2.5 in). Hardened, impervious surfaces (e.g., asphalt, concrete, etc.) are not bare ground—these do not erode nor allow weeds sites to invade. Bare ground caused by human activity indicates a deterioration of riparian health. Sediment deposits and other natural bare ground are excluded as normal or probably beyond immediate management control. Human land uses causing bare ground include livestock grazing, recreation, roads, and industrial activities. The evaluator should consider the causes of all bare ground observed and estimate the fraction that is human-caused.

Stream channels that go dry during the growing season can create problems for polygon delineation. Some stream channels remain unvegetated after the water is gone. On most streams the area of the channel bottom is excluded from the polygon. (*NOTE: The whole channel width extends from right bankfull stage to left bankfull stage; however we need to include the lower banks in all polygons, therefore consider for exclusion ONLY the relatively flat and lowest area of the channel—the bottom.*) This allows data to be collected on the riparian area while excluding the aquatic zone, or open water, of the stream. The aquatic zone is the area covered by water and lacking persistent emergent vegetation. Persistent emergent vegetation consists of perennial wetland species that normally remain standing at least until the beginning of next growing season, e.g., *Typha* species (cattails), *Scirpus* species (bulrushes), *Carex* species (sedges), and other perennial graminoids.

In many systems, large portions of the channel bottom may become exposed due to seasonal irrigation use, hydroelectric generation, and natural seasonal changes such as are found in many prairie ecosystems. In these cases, especially the prairie streams, the channel bottom may have varying amounts of herbaceous vegetation, and the channel area is **included** in the polygon as area to be inventoried. Typically, these are the pooled channel stream type that has scour pools scattered along the length, interspersed with reaches of grass, bulrush, or sedge-covered channel bottom. If over half (>50%) the channel bottom area has a canopy cover of persistent vegetation cover (perennial species), taken over the entire length of the polygon as a whole, then it qualifies for inclusion within the inventoried polygon area. If you are in doubt whether to include the channel bottom in the polygon, then leave it out, but be sure to indicate this in the comment section. This is important so that future assessments of the polygon will be looking at the same area of land.

**Scoring:**

- 6** = Less than 1% of the polygon is human-caused bare ground.
- 4** = 1% to 5% of the polygon is human-caused bare ground.
- 2** = 5% to 15% of the polygon is human-caused bare ground.
- 0** = More than 15% of the polygon is human-caused bare ground.

**9. Streambank Structurally Altered by Human Activity (F6b).** Altered streambanks are those having impaired structural integrity (strength or stability) usually due to human causes. These banks are more susceptible to cracking and/or slumping. Count as streambank alteration such damage as livestock or wildlife hoof shear and concentrated trampling, vehicle or ATV tracks, and any other areas of human-caused disruption of bank integrity, including rip-rap or use of fill. The basic criterion is any disturbance to bank structure that increases erosion potential or bank profile shape change. One large exception is lateral bank cutting caused by stream flow, even if thought to result from upstream human manipulation of the flow. The intent of this item is to assess only direct, on-site mechanical or structural damage to the banks. Each bank is considered separately, so total bank length for this item is approximately twice the reach length of stream channel in the polygon (more if the stream is braided). *NOTE:* Constructed streambanks (especially those with rip-rap) may be stabilised at the immediate location, but are likely to disrupt normal flow dynamics and cause erosion of banks downstream. The width of the bank to be considered is proportional to stream size. The table below gives a conceptual guideline for how wide a band along the bank to assess.



Stream Size (Bankfull Channel Width)	Width of Band to Assess for Bank Alteration
Rivers (Larger Than 15 m [ $>50$ ft])	4 m (13 ft)
Small Rivers and Large Streams (Approx. 5-15 m [16-49 ft])	2 m (6 ft)
Small Streams (Up To Approx. 5 m [16 ft])	1 m (3 ft)

**Scoring:**

- 6** = Less than 5% of the bank is structurally altered by human activity.
- 4** = 5% to 15% of the bank is structurally altered by human activity.
- 2** = 15% to 35% of the bank is structurally altered by human activity.
- 0** = More than 35% of the bank is structurally altered by human activity.

**10. Human Physical Alteration to the Rest of the Polygon (F19d).** Within the remainder of the polygon area, outside the streambank area that was addressed in the previous question, estimate the amount of area that has been physically altered by human causes. The purpose of this question is to evaluate physical change to the soil, hydrology, etc. as it affects the ability of the natural system to function normally. Changes in soil structure will alter infiltration of water, increase soil compaction, and change the amount of sediment contributed to the water body. Every human activity in or around a natural site can alter that site. This question seeks to assess the accumulated effects of all human-caused change. Count such things as:

- **Soil Compaction.** This kind of alteration includes livestock-caused hummocking and pugging, recreational trails that obviously have compacted the soil, vehicle and machine tracks and ruts in soft soil, etc.
- **Plowing/Tilling.** This is disruption of the soil surface for cultivation purposes. It does not include the alteration of drainage or topographic pattern, which are included in the **Topographic Change** category.
- **Hydrologic Change.** Include area that is physically affected by removal or addition of water for human purpose. The physical effects to look for are structures, such as water diversions, ditches, and canals that affect the drainage pattern; as well as erosion due to reduced or increased water; bared soil surface that had water cover drained away; or area now flooded that previously supported a drier vegetation type.
- **Road/Railroad Bed.** Along many streams road and railroad beds are constructed adjacent to the stream channel. These structures represent disruption to the bank integrity, to the bank vegetation.
- **Topographic Change.** This is the deliberate alteration of terrain for human purposes. It may be a result of earth moving by mining or construction activities, for aesthetic reasons (i.e., landscaping), or other reasons.
- **Impervious Surface.** Including hardened surfaces like roads, sidewalks, roofs, boat launches, or any human made surface from which water will run off, rather than infiltrate the soil.
- **Other.** List any other kinds of physical alteration not described above, and describe them in the space provided.

**Scoring:**

- 3** = Less than 5% of the polygon is altered by human causes.
- 2** = 5% to 15% of the polygon is altered by human causes.
- 1** = 15% to 25% of the polygon is altered by human causes.
- 0** = More than 25% of the polygon is altered by human causes.

**11. Stream Channel Incisement (Vertical Stability) (F14).** An incised stream channel has experienced vertical downcutting of its bed. Incisement can lower the water table enough to change vegetation site potential. It can also increase stream energy by reducing sinuosity, reduce water retention/storage, and increase erosion. A stream becomes critically incised when downcutting lowers the channel bed so that the two-year flood event cannot overflow the banks. Some typical downcutting indicators are:

- a) Headcuts;
- b) Exposed cultural features (pipelines, bridge footings, culverts, etc.);
- c) Lack of sediment deposits;
- d) Exposed bedrock; and
- e) A low, vertical scarp at the bank toe on the inside of a channel bend.

**NOTE: When to NA Channel Incisement**

In sites with artificial, human-made ditched or channelized/straightened (meander removed) systems (even those that might have had some components that were natural systems), **NA the channel incisement question.**

For systems that have started to or have rebuilt meanders and new floodplain from old channelized systems and at least 50% of the site or more is showing healing aspects (signs of natural processes occurring), the channel incisement question can be included and assessed based on the normal criteria. Document your decision and supporting reasons in the comment section.

### **Process for Determining Channel Incisement**

A severe disturbance can initiate downcutting, transforming the system from one having a high water table, appropriate floodplain, and high productivity to one of degraded water table, narrow (or no) active floodplain, and low productivity. These stages of incisement can be categorized in terms of Schumm's stages of incised channel evolution (Schumm and others 1984). The following indicators, taken together, collectively will enable the observer to assess severity of channel incisement.

***Channel bed downcutting***—Look for headcuts, lack of bed load sediment and exposed bedrock, a low vertical scarp at toe of bank along straight reaches and inside curves, hanging culverts and exposed cultural features.

***Limited access to floodplain by flood flows of 1 to 3 year frequency***—Look for a lack of sediment deposits and debris deposits on lower floodplain elevations.

***Widening of the incised channel***—Look for lateral cutting and sloughing of the high banks. This is one of the early steps in the healing process on a severely incised channel. Initially, the downward bed erosion forms a narrow, deep channel that often resembles a gully. Flood waters in such a channel normally cannot deposit, but can only erode and transport, sediment; therefore the narrow incisement must be widened to provide lateral space for a new floodplain to form. This lateral cutting also supplies the sediment that may be deposited at the bottom to begin the formation of a new floodplain.

***New floodplain formation within the incised channel***—Look for small depositional bars and low, flat areas near the channel. These will increase in width and length, as the healing process proceeds. Look especially for perennial vegetation becoming established on these depositional features, as it is the vegetation that secures the newly gained floodplain increments. The relative width of the active floodplain (the lowest level, the one that is most frequently flooded) determines to what extent an incisement has healed. Remember that floodplain width is inversely proportional to stream gradient, so that higher gradient (B stream type) channels typically have narrow floodplains (typically less than one bankfull channel width), and C and E stream type have wide to very wide floodplains (typically greater than one bankfull channel width).

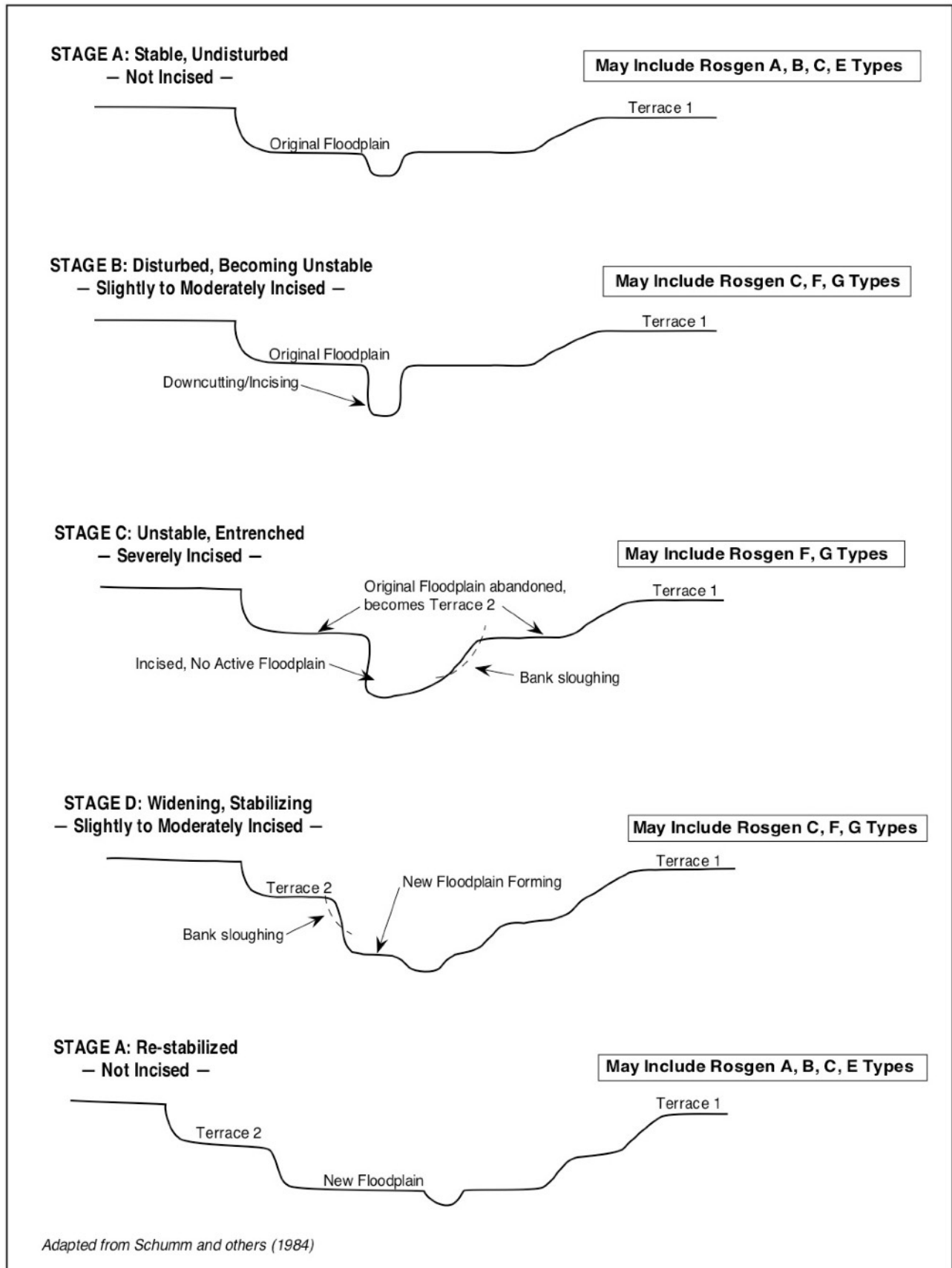
A top rating is given to un-incised channels from which the normal 1-2 year high flow can access a well formed floodplain. These can be meandering meadow streams (E stream type) and wide valley bottom streams (C stream type) which access floodplains much wider than the stream channel, or they may be mountain and foothill streams in V-shaped valleys which have narrow floodplains limited by topography or bedrock. These latter types are usually armoured (well-rocked) systems with highly stable beds and streambanks that are not susceptible to downcutting (typically mountain and foothill streams of A and B stream types). The lowest rating goes to entrenched channels (F or G stream types) where even medium high flows which occur at 5-10 year intervals cannot over-top the high banks. Intermediate stages may be either improving or degrading, and may reflect slightly incised channels that are not yet downcut so badly that some flood stages still cannot access the floodplain, or they may be old incisements that are now healing and rebuilding a new floodplain in the bottom of the ravine.

Because a channel can be incised in any of several stages, the observer is to examine the channel in the polygon for indicators of the degree of channel bed grade stability and stage of incisement, as illustrated in Figure 1. Figure 1 adapts the Schumm channel evolution model to show a generalized schematic of stages through which a channel progresses from destabilization and downcutting to healing and re-establishment of a new floodplain. Actual sites will often have characteristics that are difficult to match with the generalized drawings in Figure 1. However, make a best fit call for category of incisement based on available evidence. If the indicators are confusing and inconclusive, choose the higher (less incised) indicated category. Explain your call in the comment field, and be sure to provide photo documentation of evidence on severely incised channels.

The following table defines incisement severity categories in terms of Schumm's model of channel evolution stages, as adapted by Rosgen (2006). Note that with destabilizing disturbance and subsequent change to remove disturbance, a channel may progress through predictable stages of incisement and healing, returning again ultimately to a functional, stable system.

**Scoring:**

<b>Health Assessment Scoring</b>	<b>Incisement Class</b>	<b>Schumm's Channel Evolution Stages</b>	<b>Rosgen Types Included</b>	<b>Description of Incisement Situation</b>
<b>9</b>	None	A	A, B, C, E	Channel is vertically stable and not incised; 1-2 year high flows can begin to access a floodplain appropriate to stream type. Active downcutting is not evident. Any old incisement is characterized by a broad floodplain in which perennial riparian vegetation well established. This category includes a variety of stream types in all land forms and substrates. The floodplain may be narrow or wide, depending on the type of stream, but the key factor is vertical stability. The system may have once incised, and later become healed and is now stable again, with a new floodplain appropriate to its stream type. In this case, the erosion of the old gully side walls will have ceased, and stabilised. A mature, or nearly mature, vegetation community will occupy much of the new valley bottom.
<b>6</b>	Slight	B/D	C, F, G	This category contains both degrading and healing stages. In either case, the extent of incisement is minimal. In Stage B, the channel is just beginning to degrade, and a 2 year flood event may still access some floodplain, partially or in spots. Downcutting is likely progressing. In Stage D, the system is healing. Downcutting should have ceased at this stage. A new floodplain should be well established with perennial vegetation, although it may not be as wide as the stream type needs. This is indicated by ongoing lateral erosion of high side walls of the original incisement, as the system continues to widen itself at its new grade level.
<b>3</b>	Moderate	B/D	C, F, G	This category also contains both degrading and healing stages. In both cases, the extent of incisement is significant. In Stage B, the channel has downcut to a level that floods of the 1-5 year magnitude cannot reach a floodplain. Downcutting is likely still progressing, but the channel may already look like a gully. In Stage D, the system has only just begun to heal. A small floodplain along the new curves in the gully is forming, and perennial vegetation is starting to colonize new sediment features. The high side walls of the gully are actively eroding as the system widens, and much of the fallen materials is being incorporated along the bottom.
<b>0</b>	Severe	C	F, G	The worst case category, where there is no floodplain in the bottom of a deep entrenchment, and small-to-moderate floods cannot reach the original floodplain level. Downcutting may still be in progress. High side wall banks may have begun to collapse and erode into the bottom, but high flows typically just wash this material directly through the system, with none of it being trapped to build new floodplain. At this stage, the system has lost practically all of its riparian function and habitat value.



**Figure 1.** Schumm’s stages of stream channel evolution (Rosgen 2006), going from initial destabilization and incisement, through ultimate healing and re-stabilization with a new floodplain

**Calculating the Lotic Health Score For Streams/Small Rivers**

To arrive at the overall site health rating, the scores are totaled for all the factors, and that total is divided by the possible perfect score total. An example score sheet is shown below.

**An example score sheet of a site with no apparent potential for trees or shrubs**

<b>Vegetation Factors</b>	<b>Actual Pts</b>	<b>Possible Pts</b>
1. Vegetative Cover of Floodplain and Streambanks	6	6
2a. Total Canopy Cover of Invasive Plant Species (Weeds)	0	3
2b. Density/Distribution Pattern of Invasive Plant Species (Weeds)	1	3
3. Disturbance-Increaser Undesirable Herbaceous Species	2	3
4. Preferred Tree and Shrub Regeneration	NA	NA
5a. Browse Utilization of the Preferred Trees and Shrubs	NA	NA
5b. Live Woody Vegetation Removal by Other Than Browsing	NA	NA
6. Standing Decadent and Dead Woody Material	<u>NA</u>	<u>NA</u>
<b>Vegetative Score:</b>	<b>9</b>	<b>15</b>
<b>Soil/Hydrology Factors</b>		
7. Streambank Root Mass Protection	4	6
8. Human-Caused Bare Ground	2	6
9. Streambank Structurally Altered by Human Activity	6	6
10. Human Physical Alteration to the Rest of the Polygon	2	3
11. Stream Channel Incisement (Vertical Stability)	<u>9</u>	<u>9</u>
<b>Soil/Hydrology Score:</b>	<b>23</b>	<b>30</b>
<b>TOTAL SCORE:</b>	<b>32</b>	<b>45</b>

**Health Rating Formula:**      Health Rating = (Total Actual Score) / (Total Possible Score) x 100%

$$\text{Health Rating} = (32) / (45) \times 100\% = 71\%$$

**Health Category:**            80 to 100% = Proper Functioning Condition (Healthy)  
    60 to less than 80% = Functional At Risk (Healthy, but with Problems)  
    Less than 60% = Nonfunctional (Unhealthy)

A manager should realize that a less than perfect score is not necessarily cause for concern. An area rated at 80% is still considered to be functioning properly. At the same time, ratings of individual factors can be useful in detecting strengths or weaknesses of a site. A low score on any factor may warrant management focus. In the example reach above, low scores for invasive plants and bare ground (items 2 and 8) indicate factors that management might improve in a subsequent assessment.

## LITERATURE CITED

- Adams, Barry and Lorne Fitch. 1995. Caring for the green zone, riparian areas and grazing management. Alberta Riparian Habitat Management Project. Lethbridge, Alberta, Canada. 37 p.
- Alberta Natural Heritage Information Centre. 1999. Natural regions and subregions of Alberta. Internet website: <http://www.gov.ab.ca/env/parks/anhic/abnatreg.html>. Edmonton, Alberta, Canada. T5K 2J6.
- American Fisheries Society, Western Division. 1980. Position paper on management and protection of western riparian stream ecosystems. American Fisheries Society, Bethesda, Maryland, USA. 24 p.
- Boldt, Charles D., Daniel W. Uresk, and Keith E. Severson. 1978. Riparian woodlands in jeopardy on Northern High Plains. In: Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, Technical Coordinators). USDA Forest Service General Technical Report WO-12. Washington, DC, USA. pp. 184-189.
- Cooperrider, Allen Y., Raymond J. Boyd, and Hanson R. Stuart. 1986. Inventory and monitoring of wildlife habitat. USDI Bureau of Land Management, Denver Service Center, Denver Colorado, USA. 858 p.
- Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deep water habitats of the United States. USDI Fish and Wildlife Service, Office of Biological Services, Washington, DC, USA. Publication Number FWS/OBS-79/31. 107 p.
- Cows and Fish. 2001. Invasive Weed and Disturbance-caused Herbaceous Species List For Use in Riparian Health Assessment and Inventory in Alberta -- draft. Alberta Riparian Habitat Management Program. Lethbridge, Alberta, Canada.
- Federal Interagency Committee for Wetland Delineation. 1989. Federal manual for identifying and delineating jurisdictional wetlands. US Army Corps of Engineers, US Environmental Protection Agency, USDI Fish and Wildlife Service, and USDA Soil Conservation Service Cooperative Technical Publication, Washington, DC, USA. 76 p.
- Fitch, L., B.W. Adams and G. Hale, Eds. 2001. Riparian Health Assessment for Streams and Small Rivers - Field Workbook. Lethbridge, Alberta: Cows and Fish Program. (adapted from Riparian and Wetland Research Program, School of Forestry. 2001. Lotic health assessments: Riparian Health Assessment for Streams and Small Rivers [Survey] User Guide. University of Montana, Missoula, Montana, USA. January 2001.) 75 p.
- Fitch, L. and N. Ambrose. 2003. Riparian areas: A user's guide to health. Lethbridge, Alberta: Cows and Fish Program. ISBN No. 0-7785-2305-5. 46 p.
- Hansen, Paul L., Robert D. Pfister, Keith Boggs, Bradley J. Cook, John Joy, and Dan K., Hinckley. 1995. Classification and management of Montana's riparian and wetland sites. Miscellaneous Publication No 54. Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula, Montana, USA. 646 p.
- Huel, Denis. 1998. Streambank stewardship, your guide to caring for riparian areas in Saskatchewan. ISBN No. 1-896793-20-7. Saskatchewan Wetland Conservation Corporation. Regina, Saskatchewan, Canada. 43 p.
- Huel, Denis. 2000. Managing Saskatchewan Wetlands—a landowner's guide. ISBN No. 1-896793-26-6. Saskatchewan Wetland Conservation Corporation. Regina, Saskatchewan, Canada. 68 p.
- Johnson, R. R., and S. W. Carothers. 1980. Riparian habitats and recreation: interrelationships and impacts in the Rocky Mountain region. Produced under agreement 53-82 FT-0-125 of the Eisenhower Consortium for Western Environmental Forestry Research, Fort Collins, Colorado, USA. 109 p.
- Kent, Donald M. 1994. Applied wetlands science and technology. Donald M. Kent, editor. CRC Press, Inc., Lewis Publishers, Boca Raton, Florida, USA. 436 p.

- Kovalchik, Bernard L. 1987. Riparian zone associations: Deschutes, Ochoco, Fremont, and Winema National Forests. USDA Forest Service Region 6 Ecology Technical Paper 279-87. Pacific Northwest Region, Portland, Oregon, USA. 171 p.
- Mitsch, William J., and James G. Gosselink. 1993. Wetlands. Second Edition. Van Nostrand Reinhold, Publishers, New York, New York, USA. 722 p.
- Padgett, Wayne G., Andrew P. Youngblood, and Alma H. Winward. 1989. Riparian community type classification of Utah and southeastern Idaho. USDA Forest Service Region 4 Ecology 89-01. Intermountain Research Station, Ogden, Utah, USA. 191 p.
- Platts, W. S., C. Armour, G. D. Booth, M. Bryant, J. L. Bufford, P. Cuplin, S. Jensen, G. W. Lienkaemper, G. W. Minshall, S. B. Monsen, R. L. Nelson, J. R. Sedell, and J. S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. USDA Forest Service General Technical Report INT-221. Intermountain Research Station, Ogden, Utah, USA. 187 p.
- Reed, Porter B., Jr. 1988. National list of plant species that occur in wetlands: Northwest (Region 9). US Fish and Wildlife Service Biological Report 88 (26.9). USDI Fish and Wildlife Service, Research and Development, Washington, DC, USA. 89 p.
- Rosgen, D. L. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, Colorado, USA. 246 p.
- Rosgen, Dave. 2006. Watershed assessment of river stability and sediment supply (WARSSS). Wildland Hydrology. Pagosa Springs, Colorado, USA. 628 p.
- Shaw, S. P., and C. G. Fredine. 1956. Wetlands of the United States: Their extent and their value for waterfowl and other wildlife. USDI Fish and Wildlife Service, Circular 39. Washington, DC, USA. 67 p.
- Stewart, R. E., and H. A. Kantrud. 1972. Classification of natural ponds and lakes in the glaciated prairie region. USDI Fish and Wildlife Service, Research Publication 92. 57 p.
- Thompson, William H. and Paul L. Hansen. 2001. Classification and management of riparian and wetland sites of the Saskatchewan prairie ecozone and parts of adjacent subregions. Saskatchewan Wetland Conservation Corporation. Regina, Saskatchewan, Canada. 298 p.
- Thompson, William H. and Paul L. Hansen. 2002. Classification and management of riparian and wetland sites of the Alberta Grassland Natural Region and adjacent subregions. Bitterroot Restoration, Inc. Prepared for the Alberta Riparian Habitat Management Program-Cows and Fish, Lethbridge, Alberta, Canada. 416 p.
- Thompson, William H. and Paul L. Hansen. 2003. Classification and management of riparian and wetland sites of Alberta's Parkland Natural Region and Dry Mixedwood Natural Subregion. Bitterroot Restoration, Inc. Prepared for the Alberta Riparian Habitat Management Program-Cows and Fish, Lethbridge, Alberta, Canada. 340 p.
- Windell, John T., Beatrice E. Willard, David J. Cooper, Susan Q. Foster, Christopher F. Knud-Hansen, Lauranne P. Rink, and George N. Kiladis. 1986. An ecological characterization of Rocky Mountain montane and subalpine wetlands. USDI Fish and Wildlife Service Biological Report 86(11). National Ecology Center, Division of Wildlife and Contaminant Research, Fish and Wildlife Service, US Department of the Interior, Washington, DC, USA. 298 p.