Introduction to the Rosgen Stream Classification System

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Rosgen Stream Classification Technique—Supplemental Materials

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Cover photo: The Rosgen stream classification system uses morphometric data to characterize streams.

Advisory Note

Techniques and approaches contained in this handbook are not all-inclusive, nor universally applicable. Designing stream restorations requires appropriate training and experience, especially to identify conditions where various approaches, tools, and techniques are most applicable, as well as their limitations for design. Note also that product names are included only to show type and availability and do not constitute endorsement for their specific use.

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Purpose

Rivers are complex natural systems. A classification system is often used to stratify river reaches into groups that share common physical characteristics. A stream classification system provides better communication among those studying river systems and promotes a better understanding of river processes. The river classification system presented in this technical supplement is based on measurable physical parameters.

The stream classification presented in this technical supplement is condensed from the more detailed version by Rosgen (1994). It is intended for planning purposes, but is not sufficient for design. Appropriate data for use in river classification systems can be obtained from simple measurements and estimates.

The objectives of the Rosgen stream classification are to:

- assimilate a relatively complex mix of mathematical relationships that describes a type of river and simplifies it into a system that can be understood
- provide a consistent and reproducible frame of reference for those working with river systems and communicating stream morphology among a variety of disciplines and interested parties and enable people to talk in common terms about streams
- predict a river's behavior from its appearance and better understand cause and effect relationships (the specific measured stages in channel evolution models)
- provide a mechanism to extrapolate site-specific data to stream reaches having similar characteristics
- encourage thinking about stream processes relative to channel evolutionary changes and trends
- provide a tool to define a target such as the stable reference reach or desired form to aid in departure analysis and for setting objectives for restoration or rehabilitation

Data requirements

The Rosgen stream classification can be met through a hierarchical assessment of channel morphology measured based on bankfull dimensions. In order, the hierarchical attributes are:

- single-threaded or multiple-threaded channels
- entrenchment ratio
- width-to-depth ratio
- sinuosity
- slope
- material size D_{50} median particle size bed material

Stream reach

The classification applies to segments or reaches of the stream as defined by the user. However, any given stream reach should be comparatively uniform in its physical and biological characteristics.

Stream reaches can be defined from U.S. Geological Survey (USGS) 7.5-minute quadrangles, aerial photographs of appropriate resolution, and confirmed by field reconnaissance. Soil and geologic maps may also provide helpful information for delineating stream reaches.

Plan view (planform) type and level I classification

Level I classification is related to basin relief, landform, and valley morphology. This broadest characterization level is used only where general classification is required. The dimensions, patterns, and profiles are based on information from topographic and/or landform maps and aerial photography. The intent of level I classification is for a broad characterization that integrates landform and fluvial features of valley morphology with channel relief pattern, shape, and dimension (table TS3E–1).

A geomorphic characterization describing A through G stream types completes the level I classification. The stream type is based upon the measures of the stream in plan view from topographical or ortho-digital maps (fig. TS3E–1 (Rosgen 1996)). The plan view is classified as straight, sinuous (meandering), sinuous with active point bars, or braided (numerous intertwining channels separated by longitudinal and/or transverse bars). Some reaches may have actively eroding banks, anastomosing (multiple narrow and deep channels with extensive well-vegetated bars and flood plains), tortuous (extremely contorted meanders), or highly sinuous low width-to-depth bankfull channels.

Aerial photographs of sufficient resolution to show the plan view of the channel bed are good tools depending on the channel size and age of air photos. Judgments should be verified by field reconnaissance, since channels are dynamic and can change their plan view character over time. Photographs and field observations are best obtained at times of low flow and optimum visibility. Flood stages or vegetation can mask important features from observation and could result in misidentification of the plan view type.

A general longitudinal profile, which can be inferred from topographic maps, serves as the basis for breaking the stream reaches into broad slope categories that reflect profile morphology.

The shape of the cross section indicating a narrow and deep stream or a wide and shallow stream can be inferred at the broad level I characterization. The manner in which the channel is incised into the valley can be also be deduced at this level. For example, A and G stream types are narrow, deep, confined, and entrenched. F stream types are wide and shallow and are entrenched. Stream types D and C are wider and shallow with well-developed flood plains. E stream types are narrow and deep with well-developed flood plains. B stream types typically have moderately developed flood-prone areas in narrower but steeper valleys than D, C, and E types. Table TS3E–2 includes aerial and ground photos of the eight major stream types, A through G.

Valley types

Stream type, width-to-depth ratio, sinuosity, entrenchment, and other morphological features are dependent upon the valley development. For an initial broad level association of stream types, valley types are invaluable to level I classification and as a general indication of morphological pattern. Table TS3E–3 provides more detailed description of the 11 valley types used in the Rosgen stream classification system.

Channel slope—level I

Over substantial distances, elevations, and channel lengths can sometimes be determined from a combination of USGS 7.5-minute quadrangles and aerial photos. Aerial photographs can be used to calculate sinuosity. Thus, slope can often be calculated by first multiplying sinuosity times stream length from the quad maps, then second, by dividing the difference in elevation by the total sinuous stream length.

Table TS3E–1 Plan view characteristics of Rosgen stream type

Stream type	Plan view
Aa+, A	Relatively straight
B	Slightly sinuous
F, G	Moderately sinuous, F or Bs may have active point bars
C	Sinuous with active point bars
D	Multiple thread, braided
DA	Multiple thread, anastomosed
E	Tortuous and/or highly sinuous

Figure TS3E–1 Major stream types

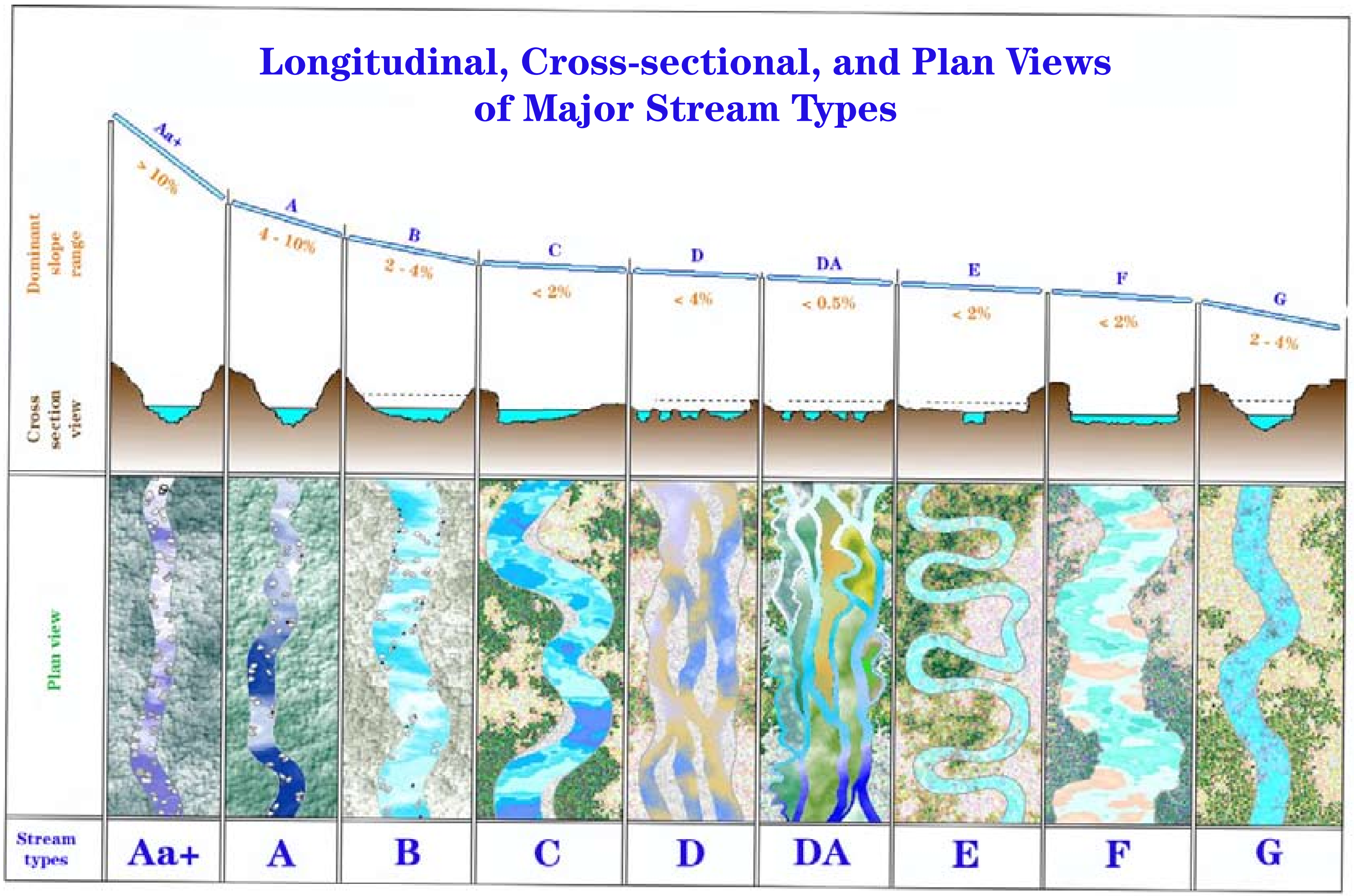


Table TS3E–2 Aerial and surface views of major stream types

Stream type and bedforms	Aerial view	Surface view
A **Step-pool and/or cascade and/or chute bed**		

Stream type and bedforms	Aerial view	Surface view
B **Step-pool and/or plane-bed and/or pool-riffle**		

Table TS3E–2 Aerial and surface views of major stream types—Continued

Stream type and bedforms	Aerial view	Surface view
C **Pool-riffle and/or plane-bed and/or ripple-dune**		

Stream type and bedforms	Aerial view	Surface view
D **Braided** **Some pool-riffles develop on patterns of convergence and divergence**		

Table TS3E–2 Aerial and surface views of major stream types—Continued

Stream type and bedforms	Aerial view	Surface view
DA **Anastomose** **Braided pool-riffle or ripple-dune**		

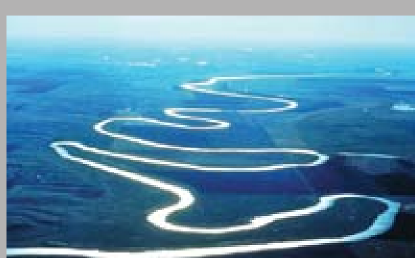
Stream type and bedforms	Aerial view	Surface view
E **Pool-riffle or ripple-dune** **Depositonal bars sometimes not present**		

Table TS3E–2 Aerial and surface views of major stream types—Continued

Stream type and bedforms	Aerial view	Surface view
F **Pool-riffle or ripple-dune** **Depositonal bars sometimes not present**		

Stream type and bedforms	Aerial view	Surface view
G **Step-pool with some instances of plane-bed forms**		

Table TS3E–3 Valley type, morphological description, and stream type association

Valley type	Description	Stream type association
I	Steep V-shaped confined, highly dissected fluvial slopes greater than 2 percent	A and Aa+
II	Moderate relief gentle sloping side slopes with a parabolic valley bottom form often in colluvial valleys	B
III	Primarily depositional, usually steep, greater than 2 percent valley slope with debris-colluvium or alluvial fan landform	A, B, G, and D
IV	Gentle gradient canyons, gorges and confined alluvial valleys such as the Grand Canyon. Valley floors are typically less than 2 percent	F
V	U-shaped glacial-fluvial troughs with slopes generally less than 4 percent. Landforms typically include lateral or terminal moraines, alluvial terraces and flood plains. Trough is typically the result of glacial scouring process	C, D, G
VI	Fault control valleys, structurally controlled and dominated by colluvial slope building processes. Moderately steep with slopes less than 4 percent. G stream types observed under fault disequilibrium	Mostly B with C and F; some G
VII	Steep highly dissected fluvial slopes typically in either colluvium, alluvium or in residual soil. Active lateral and vertical accretion (Badlands of SD)	A and G
VIII	Mature wide gently valley slopes with well developed flood plain features adjacent to river terraces. Alluvial terraces and flood plains are predominate landforms. Depending on local streambed and riparian conditions D, F, and G stream types can be found. Gentle slopes with the alluvial valley fills	C and E D, F, and G
IX	Glacial outwash and/or eolian sand dunes. Moderate to gentle slopes. High sediment supply either single- or multiple-threaded channels	C and D
X	Very broad and very gentle slopes with extensive flood plain development. Often associated with lacustrine and gentle alluvial slopes. G and F streams are common when local base grades have been changed	E or C and DA, G, and F
XI	Large river deltas and tidal flats constructed of fine alluvial materials originating from riverine and estuarine depositional processes. Extremely gentle slopes with base grade controlled by sea or lake levels. Most often distributary channels, wave, or tide dominated	DA C and E

Morphological description (level II classification)

The level II classification process provides a more detailed morphological description of the stream based on field collected data. It includes assessments of channel entrenchment, dimensions, patterns, profiles, and bed materials. It uses a more finely resolved hierarchal criterion to stratify types and address general characteristics such as sediment supply, stream sensitivity to disturbance, potential for natural recovery, channel responses to flow regime change, and fish habitat potential. The morphological description level requires the computation of the entrenchment ratio, width-to-depth ratio, sinuosity, slope, and D_{50} or dominant particle size determination (fig. TS3E–2 (Rosgen 1996)).

Channel slope—level II

The channel slope should be determined for each stream reach being classified. It consists of the difference in elevation of the water surface or bed through the reach divided by the length of the channel reach. The elevations are usually obtained at the upper and lower ends of each bed feature. When water surface slope is field measured it is preferable to measure through at least two meander wavelengths. For example, the average slope is calculated from the top of the riffle to the top of the next downstream riffle (fig. TS3E–3). The channel length used in the calculation is the centerline length of the channel between the two points used for elevations.

In practice, the average low-flow water surface slope is the same as the average bankfull stage slope and is an accurate representation of slope needed for classification. The average slope of the water surface is generally measured through 20 to 30 channel widths. The higher water surface profile can be obtained from standard hydraulic methods.

Bankfull discharge validations

Dimensions measured and characterized in Rosgen's geomorphic stream classification system are based on bankfull discharge. A complete description of bankfull discharge is provided in NEH654.05. It is advised that a field validation of bankfull discharge and associated return intervals be completed at USGS or similar gages. This validation is used to develop and/or check regional curves for specific hydro-physiographic areas.

Although a bankfull discharge of 1.5Q is generally considered to be the typical return interval (Williams 1978), it is not at all uncommon to find ranges between 1.1 to 2.0 or higher. Data show that a return interval difference from a 1.1- to a 1.5-year event can have as much as 68 percent more flow (Southerland 2003). The bankfull dimensions associated with this difference in flow can likely lead to incorrect and/or inconsistent classification.

Entrenchment

Entrenchment is a measure of the extent of vertical containment of a channel relative to its adjacent flood plain. Entrenchment is defined as the ratio of the width of the flood-prone area to the bankfull width of the channel (fig. TS3E–4). The flood-prone width is measured at an elevation of two times the maximum depth at the bankfull stage. In figure TS3E–4, the flood-prone width is 305 feet, and the bankfull width is 25 feet. The entrenchment ratio is 12.2.

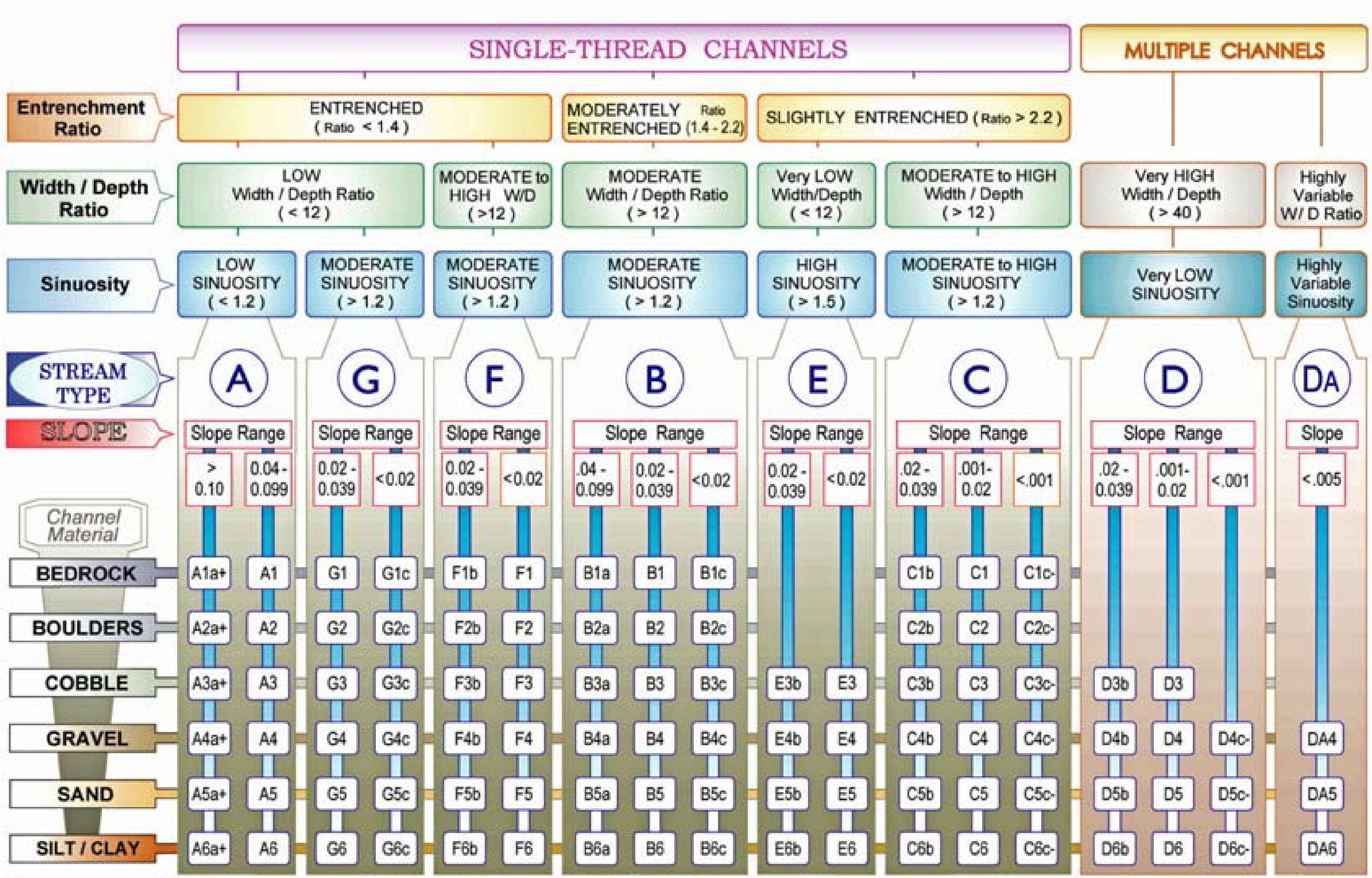
The top of banks does not always indicate bankfull stage. In deeply entrenched channels, the flood-prone area may be contained entirely within the banks. Entrenchment ratios for various stream types are shown on figure TS3E–5 (Rosgen 1996). The flood-prone area is measured at the riffle facet of the profile at level II classification. The entrenchment ratio may vary by 0.2 units without necessarily changing the classification.

Usually, field measurements will be necessary. In some cases, widths of flood-prone areas and bankfull stages can be made from aerial photos and topographic maps at the level I characterization. It is recommended that a typical cross section of each stream reach and its associated flood plain be obtained.

Channel material

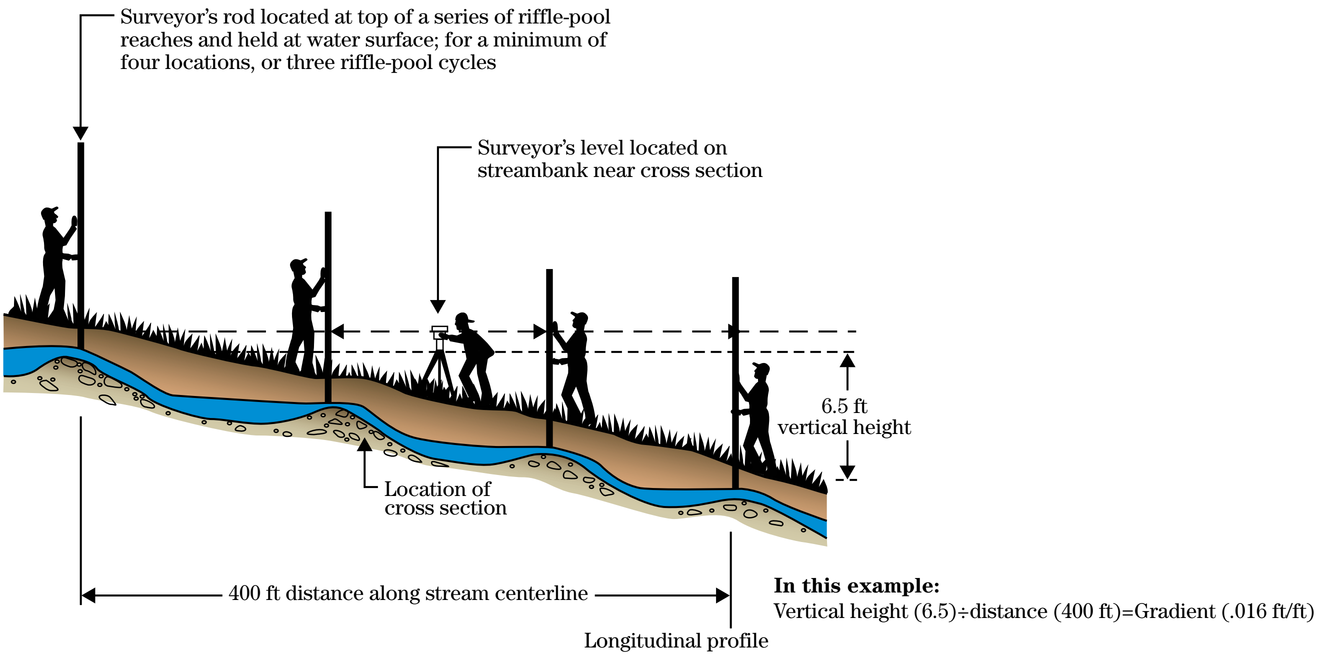
The channel material consists of the soil, rock, and vegetation that occur in the bed and banks of the channel. For classification, the dominant bed material is of primary interest. This consists of the sediment or rock

Figure TS3E–2 Hierarchical level II key



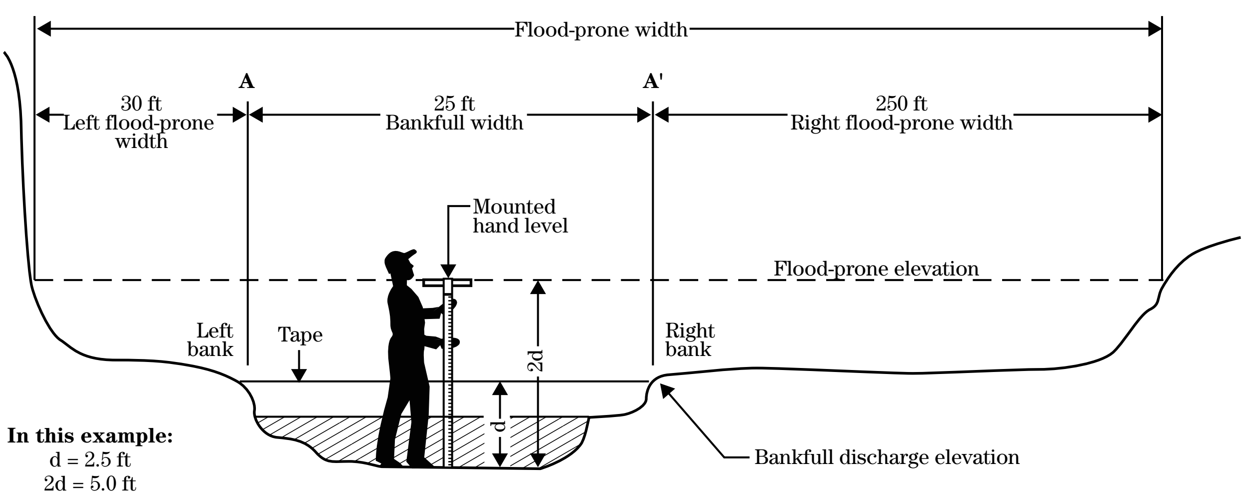
KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the *"continuum of physical variables"* within stream reaches, values of ***Entrenchment*** and ***Sinuosity*** ratios can vary by +/- 0.2 units; while values for ***Width / Depth*** ratios can vary by +/- 2.0 units.

Figure TS3E–3 Measuring stream gradient



Note: Riffle to riffle gradient approximates the average water surface slope

Figure TS3E–4 Field measurement of entrenchment ratio



Cross sections

Figures are not to scale

exposed in the bed and on about the lowermost third of the banks of the stream reach. The measure used is the median grain size, or D_{50}, of the bed material. Several sampling traverses may be necessary to represent the channel material in a given stream reach (fig. TS3E–6). Plant material, leaves, and so forth are not counted as bed-load material. When organic material is found, bed load at the particle size sampling interval (usually 1-ft intervals) should be pulled from beneath. If the debris is too large for bed load extrication below it, consistently draw particles at the same 1-foot interval from the side of the woody debris, while remaining on the same path. A detailed description of sediment sampling is provided in NEH654 TS13A.

Based on the D_{50} size, the channel material is classified into one of six particle size categories:

1 – bedrock (>2048 mm)

2 – boulder (256 mm to 2047.9 mm)

3 – cobble (64 mm to 255.9 mm)

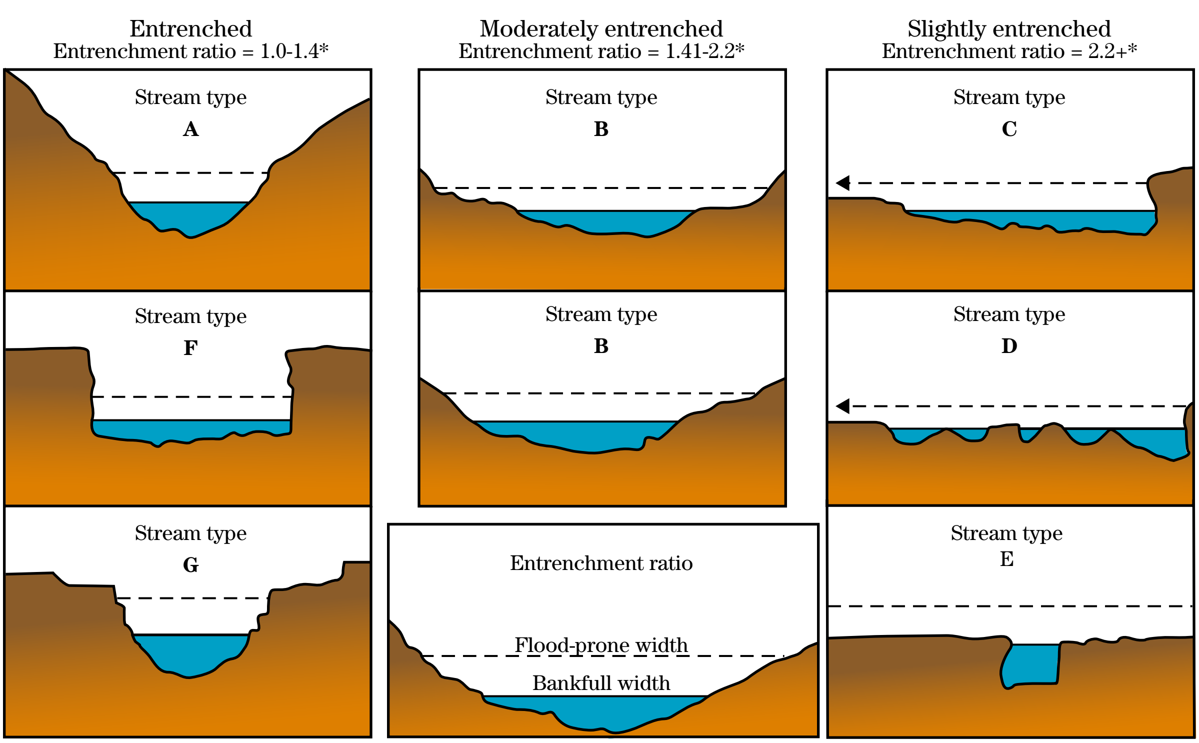
4 – gravel (2 mm to 63.9 mm)

5 – sand (0.062 mm to 1.99 mm)

6 – silt/clay (<0.062 mm)

Plot material sizes showing cumulative and percent distributions on log normal scaled paper. Estimate D_{50}. In figure TS3E–7, D_{50} is 34 millimeters (gravel size).

Figure TS3E–5 Entrenchment ratios of major stream types

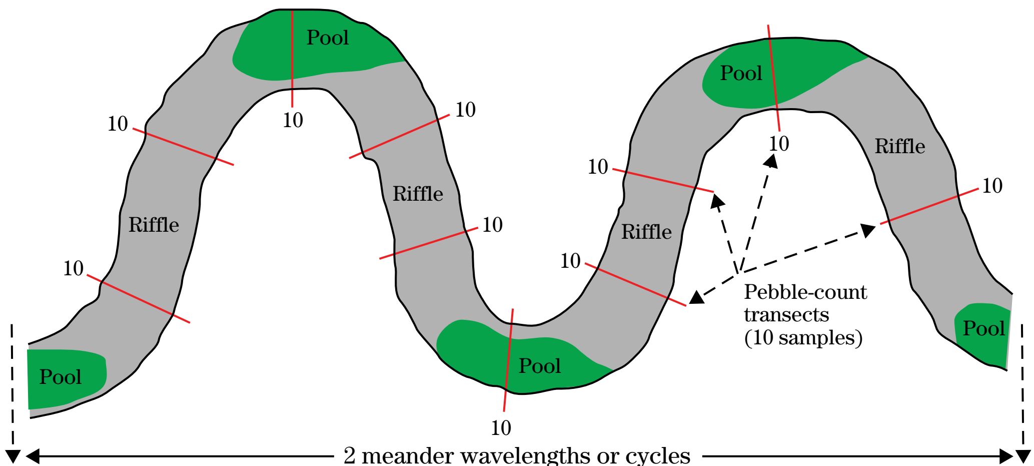


Entrenchment ratio = $\frac{\text{Flood-prone width}}{\text{Bankfull width}}$

*Entrenchment ratio may vary by ± 0.2 units

Flood-prone width = water level @ 2 × max/ depth

Figure TS3E–6 Pebble count

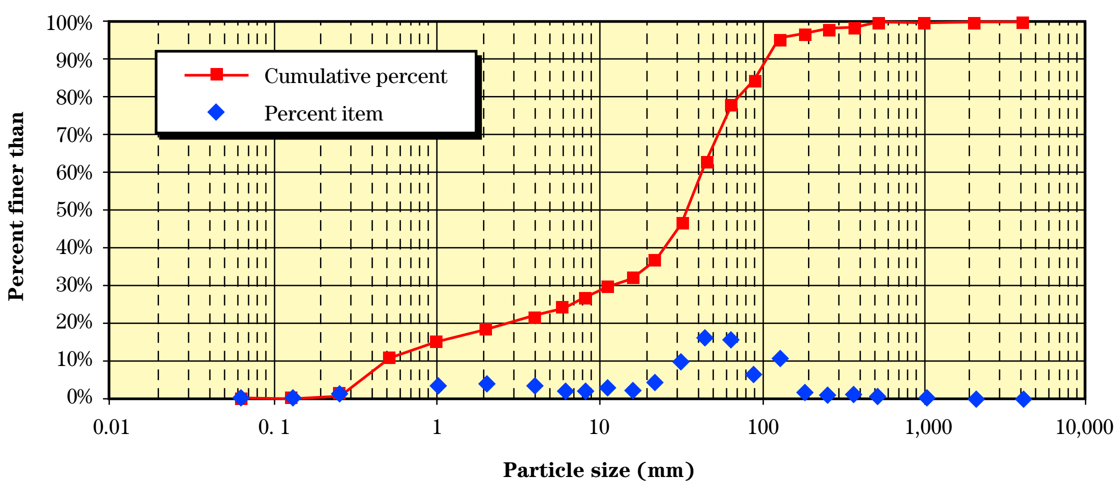


This reach is approximately 24 channel widths in length.

Example: Reach configured as:

	Pool	Riffle	
	75 ft	175 ft	Total length: ± 250 ft
Percentage:	30%	70%	Samples for pebble count: 30% in pools, 70% in riffles

Figure TS3E–7 Plotted particle size distribution



Width-to-depth ratio

This consists of the ratio of the top width of the channel at bankfull stage to the average depth at bankfull. The average depth is computed by dividing the cross-sectional area of the channel by the width. The width divided by the depth (width-to-depth ratio) is typically the most sensitive indicator in level II classification. However, the width-to-depth ratio can vary by 2.0 units without necessarily changing the classification (Rosgen 1996).

It is recommended that a typical cross section of each stream reach be surveyed and appropriate measurements obtained from a graphical plot of the cross section. The bankfull stage can be estimated from field evidence or predicted using standard hydrologic techniques.

Sinuosity

This measure indicates the degree of meandering and channel migration within a valley that the channel exhibits in plan view. It consists of the ratio of channel length to valley length. The channel length of the stream reach is measured along the thalweg of the channel. The valley length is the length of the reach measured along a line paralleling the local trend of the stream valley.

Aerial photographs of appropriate resolution, soil maps, geologic maps, and USGS 7.5 quadrangles provide convenient means for measuring sinuosity.

Procedure

The simplified version of Rosgen's stream classification is implemented by applying the following procedure to each stream reach of interest.

Identify a reach of at least 20 bankfull widths. Define drainage area and use relative USGS gage data, if available.

Step 1 Identify plan view type and determine whether the channel type is multiple-threaded (three or more channels) at bankfull.

Step 2 Determine the entrenchment ratio.

Step 3 Find the width and average depth of bankfull event, and compute the width-to-depth ratio.

Step 4 Determine the channel slope (water surface).

Step 5 Using the data from steps 1 and 2, figure TS3E–1, and table TS3E–1, assign a capital letter designation representing stream type. If results are ambiguous, give more weight to plan view type than channel slope or entrenchment. This corresponds to the level I classification of Rosgen (1994).

Step 6 Determine D_{50} size of the dominant bed material, and classify in terms of size (sand, gravel).

Step 7 Assign a number from 1 to 6, depending on results of step 6. This corresponds to the level II classification of Rosgen (1994).

Step 8 Determine the channel and valley lengths of the stream reach and compute sinuosity.

Step 9 Check the values of channel slope, entrenchment ratio, width-to-depth ratio, and sinuosity against typical ranges for those values associated with the channel type (refer to fig. TS3E–2).

Step 10 If steps 4 and 9 are completed with satisfactory results, proceed with interpretations.

Step 11 If the stream reach fails to fit into a category in step 4 or if one or more values in step 9 lie outside the indicated ranges, additional studies are necessary. Anthropogenic alterations to some streams are so recent that the form may be in a transitory state and difficult to classify. However, with additional analysis a classification trend possibly may be identified. Table TS3E–4 (Harrelson, Rawlins, and Potyondy 1994) provides both the stream morphometry and landform features of the major stream types. Information such as this may aid in this further analysis

Interpretations and uses of the Rosgen stream classification system

The Rosgen stream classification system is intended as an evaluation tool. It conveys important information about the stability of the stream reach and about the degree of compatibility that certain types of stream

Table TS3E–4 Stream morphometry and landform

Stream type	General description	Entrench ratio	Width-to-depth ratio	Sinuosity	Slope	Landform/soils/features
Aa+	Very steep, deeply entrenched, debris transport streams	<1.4	<12	1.0 – 1.2	>.10	Very high relief. Erosional, bedrock, boulder, or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls
A	Steep, entrenched, cascading, step-pool streams. High energy/debris transport with depositional soils. Very stable if bedrock or boulder-dominated channel	<1.4	<12	1.0 – 1.2	.04–.10	High relief. Erosional bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool bed morphology
B	Moderately entrenched, moderate gradient dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks	1.4 – 2.2	>12	>1.2	.02–.039	Moderate relief, colluvial riffle deposition, and/or residual soils. Moderate entrenchment and width-to-depth ratio. Narrow, moderately sloping valleys. Rapids predominate with occasional pools
C	Low gradient, meandering point-bar, riffle-pool, alluvial channels with broad, well-defined flood plains	>2.2	>12	>1.4	<.02	Broad valleys w/terraces, in association with flood plains, alluvial soils. Slightly entrenched with well-defined meandering channel. Riffle-pool bed morphology
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks	N/a	>40	N/A	<.04	Broad valleys with alluvial and colluvial fans. Glacial debris and depositional features. Active lateral adjustment with abundance of sediment supply
DA	Anastomosing (multiple channels) narrow and deep with expansive well-vegetated flood plain and associated wetlands. Very gentle relief with highly variable sinuosity's, stable streambanks	>4.0	<40	Variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition with well-vegetated bars that are laterally stable with broad wetland flood plains. Stream type common in estuaries
E	Low gradient, meandering riffle-pool stream with low width-to-depth ratio and little deposition. Very efficient and stable. High meander width ratio	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with flood plain and/or lacustrine soil. Highly sinuous with stable well-vegetated banks. Riffle-pool morphology with very low width-to-depth ratio
F	Entrenched meandering riffle-pool channel on low gradients with high width-to-depth ratio	<1.4	>12	>1.4	<.04	Entrenched in highly weathered material. Gentle gradients usually less than .02 ft/ft, but may range up to .04 ft/ft with a high width-to-depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle-pool morphology.
G	Entrenched gully step-pool and low width-to-depth ratio on moderate gradients	<1.4	<12	>1.2	.02–.039	Gully, step-pool morphology with moderate slopes and low width-to-depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials (fans or deltas). Unstable with grade control problems and high bank erosion rates

management measures will have with the channel. The following section on stream management presents a few examples of how the classification can be used in stream assessment and restoration work.

Stream management

Each of the stream types delineated by level II classification has certain characteristics that indicate its sensitivity to changes. Table TS3E–5 (Rosgen 1996) summarizes the expected degree of sensitivity each stream type exhibits.

For example, type C streams have a meandering plan view with active point bars (fig. TS3E–1). A type C2 (table TS3E–5) exhibits low sensitivities to disturbance and erosion because of the coarse, boulder channel material. Type C5, however, is extremely sensitive to disturbance and erosion (table TS3E–5, col. 2 and 5) because the sandy channel materials are extremely susceptible to erosion. Column 6 indicates vegetation exerts a very high level of controlling influence on stability of C5 channels.

Channel evolution

If a stable channel is subjected to significant changes in its alignment, bank vegetation, or watershed land use, it is likely to become unstable. The channel system readjusts to a new level of equilibrium. The sequence of changes can be documented by applying the stream classification presented previously. In some cases, the type and magnitude of the changes can be predicted and management measures planned to prevent adverse responses. The sequence of changes may occur rapidly over a few years or more slowly, depending on the sensitivity of the stream and the magnitude of the imposed changes.

For example, figure TS3E–8 illustrates the sequence of changes in a particular stream (Rosgen 1996). Initially, the stream reach was a stable type E4. Extensive land use changes reduced the bank vegetation and increased the supply of sediment from the watershed. The channel responded to the imposed changes by increasing its width and gradient and decreasing sinuosity to form a C4 channel. As the gradient increased, the stream was able to attack its bed with more energy, eventually initiating a gully in the streambed (type G4). As the slope decreased within the tall confining banks, the channel migrated laterally which led to a degraded F4 type entrenched well below its original flood plain. The channel eventually reestablished a sinuous course at the lower elevation, returning to its initial E4 geomorphic stream type.

Planning stream restoration measures

Certain stream reaches have undesirable characteristics from an ecological point of view. These characteristics were often initiated by past land use and stream management practices. To restore the stream reach to a more desirable condition, it is necessary to know what suite of characteristics will be compatible with its new condition. The stream classification approach provides useful insight into this matter. If structural approaches to restoration are considered to be a viable alternative, understanding past, current, and future stream types will aid the user in developing the appropriate stable stream form and its respective bankfull dimensions.

Communication

Streams and rivers are complicated systems which are governed by complex and interdependent energy, form, and shape relationships. Classifying things into groups is a mechanism for creating order out of chaos (Goodwin 1999). The Rosgen stream classification provides such a needed communication tool for the existing condition of a stream. At level II, it stratifies data for the pattern, dimension, profile, bed materials, and entrenchment of the stream. It provides a shorthand description of morphological variables which are influenced or influence the energy use, behavior, and sensitivity of a stream. Channel classification and channel typing is particularly of use when stratifying data to develop hydraulic geometry relations and in the selection of a hydraulic geometry relations.

Prediction

The Rosgen stream classification at level II classifies the form of the stream. This classification system by itself only provides information about the existing pattern, dimension, profile, and bed materials. However, if it can be assumed that streams with the same general form also tend to have the same geomorphic processes, the classification can be used to predict typical

Table TS3E–5 Summary of delineative criteria for broad level classification

Stream type	Sensitivity to disturbance 1/	Recovery potential 2/	Sediment supply 3/	Streambank erosion potential influence 4/	Vegetation controlling
A1	Very low	Excellent	Very low	Very low	Negligible
A2	Very low	Excellent	Very low	Very low	Negligible
A3	Very high	Very poor	Very high	High	Negligible
A4	Extreme	Very poor	Very high	Very high	Negligible
A5	Extreme	Very poor	Very high	Very high	Negligible
A6	High	Poor	High	High	Negligible
B1	Very low	Excellent	Very low	Very low	Negligible
B2	Very low	Excellent	Very low	Very low	Negligible
B3	Low	Excellent	Low	Low	Moderate
B4	Moderate	Excellent	Moderate	Low	Moderate
B5	Moderate	Excellent	Moderate	Moderate	Moderate
B6	Moderate	Excellent	Moderate	Low	Moderate
C1	Low	Very good	Very low	Low	Moderate
C2	Low	Very good	Low	Low	Moderate
C3	Moderate	Good	Moderate	Moderate	Very high
C4	Very high	Good	High	Very high	Very high
C5	Very high	Fair	Very high	Very high	Very high
C6	Very high	Good	High	High	Very high
D3	Very high	Poor	Very high	Very high	Moderate
D4	Very high	Poor	Very high	Very high	Moderate
D5	Very high	Poor	Very high	Very high	Moderate
D6	High	Poor	High	High	Moderate
DA4	Moderate	Good	Very low	Low	Very high
DA5	Moderate	Good	Low	Low	Very high
DA6	Moderate	Good	Very low	Very low	Very high
E3	High	Good	Low	Moderate	Very high
E4	Very high	Good	Moderate	High	Very high
E5	Very high	Good	Moderate	High	Very high
E6	Very high	Good	Low	Moderate	Very high
F1	Low	Fair	Low	Moderate	Low
F2	Low	Fair	Moderate	Moderate	Low
F3	Moderate	Poor	Very high	Very high	Moderate
F4	Extreme	Poor	Very high	Very high	Moderate
F5	Very high	Poor	Very high	Very high	Moderate
F6	Very high	Fair	High	Very high	Moderate
G1	Low	Good	Low	Low	Low
G2	Moderate	Fair	Moderate	Moderate	Low
G3	Very high	Poor	Very high	Very high	High
G4	Extreme	Very poor	Very high	Very high	High
G5	Extreme	Very poor	Very high	Very high	High
G6	Very high	Poor	High	High	High

1/ Includes increases in streamflow magnitude and timing and/or sediment increases
2/ Assumes natural recovery once cause of instability is corrected
3/ Includes suspended and bed load from channel derived sources and/or from stream adjacent slopes
4/ Vegetation that influences width-to-depth ratio stability

stream processes, sensitivity, and behavior. However, this sort of assessment needs to be made within the context of the topographic setting, as well as the channel evolution and watershed history.

The Rosgen stream classification system, as with many classification systems, describes a static condition that is not necessarily related to a specific process or change and, therefore, does not provide a direct mechanism for predicting a new stable channel form in disturbed watersheds (Gillian 1996, Cherry, Wilcock, and Wolman 1996). In addition, due to the dependence of the classification upon the present morphological characteristics, the approach does not have the ability to take into account previous or anticipated hydrologic changes. The classification of a stream to a particular type does not, by itself, imply that a stream is stable or unstable. It only indicates that the stream pattern, dimension, profile, and bed material are within the specified limits and variances of the classification system.

Trends and dominant processes

The Rosgen stream classification can be used to assess general trends in stream behavior and also to provide a guide to the dominant processes that a stream system can experience. Table TS3E–6 summarizes the characteristics of the Rosgen stream types by watershed conditions.

It is important to recognize that the science of fluvial geomorphology is based primarily on observation. As a result, predicted trends and changes tend to represent average conditions. Assessment and design for a specific project area requires the use of physically based calculations (Goodwin 1999).

Figure TS3E–8 Evolutionary stages of channel adjustment

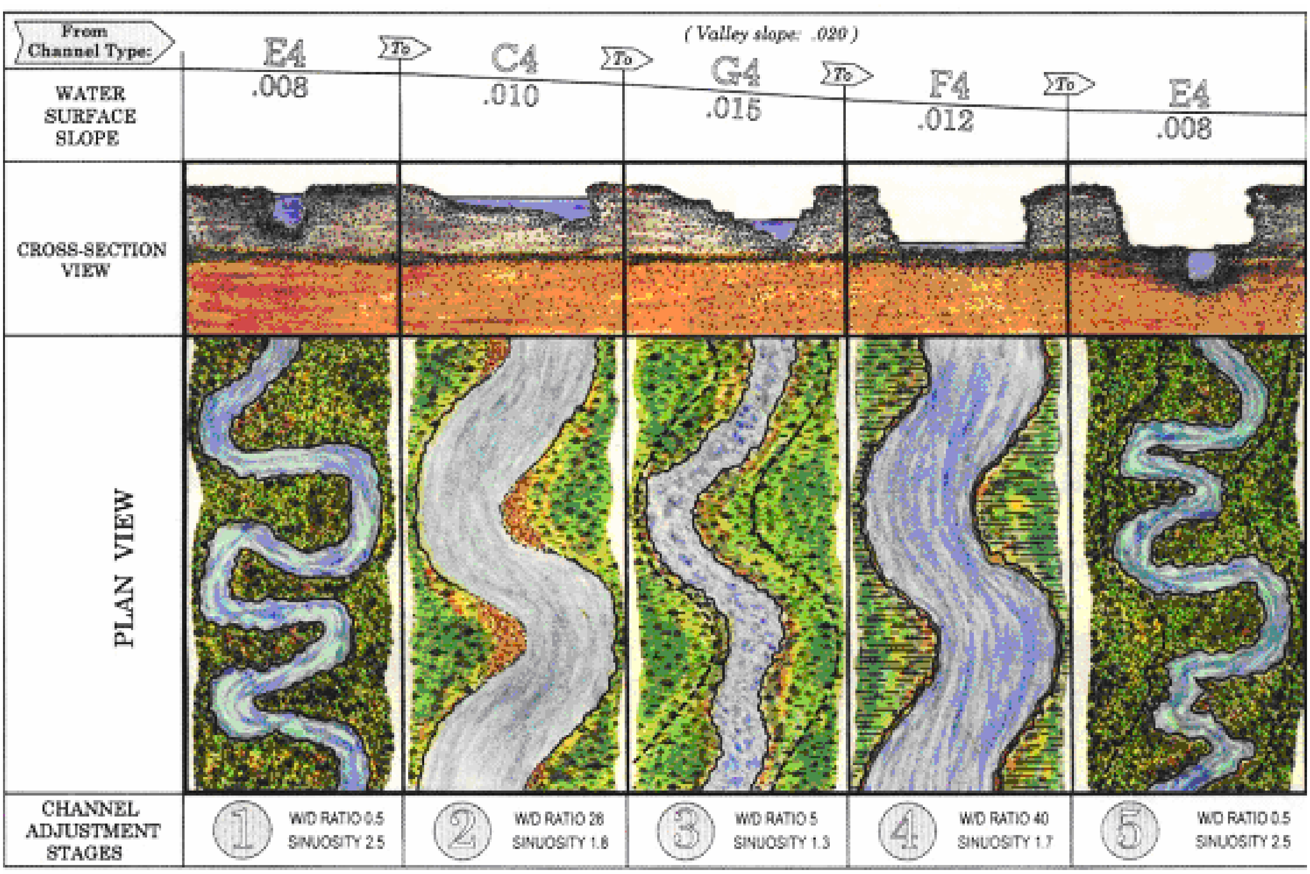


Table TS3E–6 Summary of characteristics of Rosgen stream types by watershed conditions

Rosgen stream type	Watershed type	Sediment load	Energy of stream	Energy dissipation in stream is typically by:	May be appropriate for design in:
A	Typically associated with steep, narrow mountain valleys. Bank vegetation is typically a low component of stability	High	High	Step pool	• Upper order urban streams (A2 and A3) • Grade control (A2)
B	Associated with narrow, gently sloping valleys. Bank vegetation is a moderate component of stability	Low to moderate	High	On banks and bed materials	• Urban streams (B2 and B3) • Grade control (B2 and B3) • Transition from flood plain to incised streams (B2, B3, B2c, and B3c) • Limited flood plain width (B and Bc) • Bottom incised streams (B and Bc)
C	Associated with broad, valleys with terraces and alluvial soils. Bank vegetation will typically have a high component of stability	High	Moderate	Through meanders, bedforms, and vegetation	Rural and urban streams with broad flood plains. However, these typically require bank protection and grade control during establishment of vegetation
D	Associated with broad valleys, glacial debris, and alluvial fans. Active lateral adjustment with abundant sediment supply. Vegetation will typically have limited influence on stability	High	Low to moderate	Banks and sediment	Normally not recommended
E	Often associated with broad valley meadows and well vegetated flood plains. Vegetation is typically a high component of stability	Very efficient at carrying sediment	Low	Through meanders, bedforms, and vegetation	Rural and urban streams with broad flood plains. However, these types may be difficult to construct due to low width-to-depth ratio and need for vegetation for stability especially on larger streams
F	Associated with modified channels and unstable channels	Low to very high	Low to moderate	Banks, vegetation, and sediment	Normally not recommended. These stream types can be laterally unstable with high bank erosion rates
G	Associated with narrow valleys or deeply incised in alluvial or colluvial materials such as fans or deltas	Low to very high	Moderate to high	Banks, vegetation, and sediment	Normally not recommended. These stream types can be laterally unstable with grade control problems and high bank erosion rates

Conclusion

Fluvial geomorphology techniques provide insight relative to general responses of a river system to a variety of imposed changes. These techniques are useful in analyzing the stability of the existing stream system and in identifying the source of instabilities.

The Rosgen stream classification system is based on the systematic collection and organization of field data by measuring combinations of morphological features. This system requires multiple measurements and calculations related to the pattern, dimension, profile, bed material, and entrenchment of a stream. It requires the assessment and characterization of valley types.

Some of the advantages of the Rosgen stream classification system (Rosgen 1996) are:

- communication—provides a common language for describing streams and their attributes
- standardization—encourages practitioners to measure things in a standard manner
- encourages thinking about stream processes
- provides a basis for generalizing and extrapolating data, knowledge, treatment strategies, and testing hypotheses about stream systems
- prediction—used to predict a river's behavior from its dimension, pattern and profile
- extrapolation—used to extrapolate data from a few sites or channels to a much larger number of channels over a broader geographic area
- defining a target—used to define the stable or desired form and to set targets or objectives for restoration or rehabilitation
- defining the scope of a problem—provides a means for quantifying the size of the problem and the type and size of the responses needed to address the major issues

While not all of these advantages are universally applicable or accepted by all practitioners, the Rosgen stream classification has been used as a tool to help understand how the stream form and processes are related, and it can be used to assist with stream evaluation, management, and design.

As stated by Craig Goodwin in Fluvial Classification: Neanderthal Necessity or Needless Normalcy (Goodwin 1999):

> *Classification should be considered only one part of a much larger scientific puzzle that also incorporates observation, laws, hypothesis, theories, and models.*

Since every stream system is unique, trends should only be considered to be general guidelines and a designer should note that there will always be exceptions.