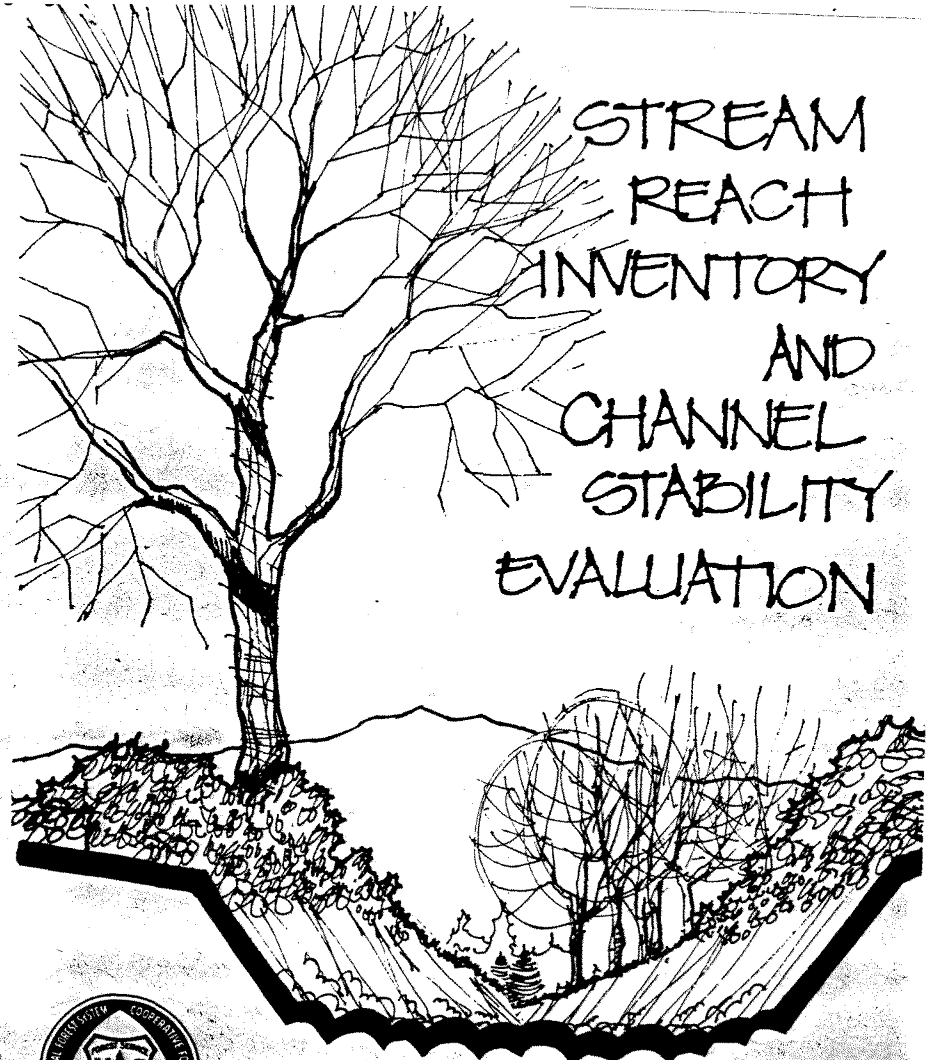
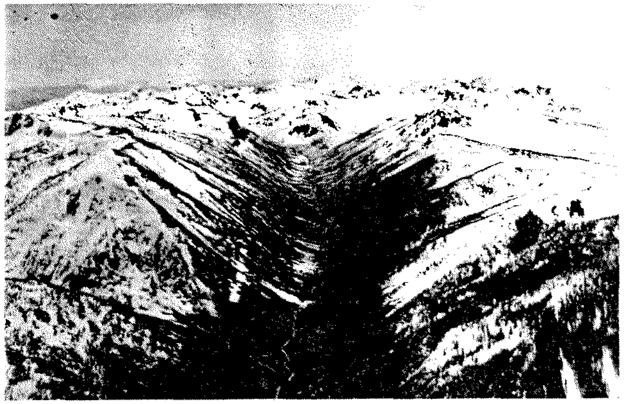
STREAM REACH INVENTORY AND CHANNEL STABILITY EVALUATION



A Watershed Management Procedure

U.S. Department of Agriculture
Forest Service/Northern Region

ACKNOWLEDGEMENTS



Playfair's Law: "Every river appears to consist of a main trunk, fed from a variety of branches, each running in a valley proportioned to its size, and all of them together forming a system of valleys connecting with one another, and having such a nice adjustment of their declivities that none of them join the principal valley either on too high or too low a level; a circumstance which would be infinitely improbable if each of these valleys were not the work of the stream which flows in it."

John Playfair, 1802

Others have built on John Playfair's observations. So it is with this work. Dr. Walter Megahan's original efforts at stream channel characterization in Utah a decade ago served as the stimulus. From that beginning the present system has evolved as a team effort. It has been my pleasure to shephard this work and contribute from my personal experience and observations. My Northern Region colleagues, past and present, have contributed so much in the way of suggestions and critique that it is impossible now to say "this is his and this is mine". My thanks and appreciation go especially to Dave Rosgen and Lee Silvey who labored through several revisions of the field form with me. Now the ball passes to you. Take it and run!

Dale J. Pfankuch, Forester
Lolo National Forest
Missoula, MT
March 17, 1975

STREAM REACH INVENTORY AND CHANNEL STABILITY EVALUATION

Channel evaluations are best made during periods of low flow.

Purpose: These procedures were developed to systemize measurements and evaluations of the resistive capacity of mountain stream channels to the detachment of bed and bank materials and to provide information about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production.

Uses: The information may be gathered at a "point" for projects such as bridge sites, campground, etc., or in complete channel analyses for fisheries, timber management water balance or multiple use inventories and planning. Stream reaches may be stratified by order and geologic type and sampled to an intensity that meets survey requirements. "Point" as used here always means a reach of sufficient length to provide the observer with a range of information on which to base a sound selection from available alternatives.

Instructions: The card format of R-1 Form 2500-5A and this pocket field guidebook are designed to be used together - in the field. Use a separate rating card for each length of stream that appears similar. Identify the reach on Card Form 2500-5A, on maps and/or photos in sufficient detail so others can locate the same reach at some future time.

The inventory items are completed using maps, aerial photos and field observations and measurements. Circle all estimated data items that could be measured but weren't. The precision of measurements will be dictated by the requirements of the particular inventory. These standards should be clearly in mind when the work begins.

The evaluation portion of the inventory requires judgement based on experience and the criteria outlined in this booklet. The condition descriptions, briefly explained on the tally form, are amplified in more detail in the pages that follow. As you begin the evaluation phase of the inventory, a few words of caution are in order. Avoid keying in on a single indicator or a small group of indicators in making ratings. Since the indicators are interrelated, don't dwell on any one item for long. If all are used without bias, the maximum diagnostic value can be obtained. Do the best you can. Experience has shown that over and underratings tend to balance out. Total rating scores made by inexperienced persons are often numerically close to the scores of those with more experience.

Keep in mind that each item directly or indirectly is designed to answer three basic questions:

1. What are the magnitudes of the hydraulic forces at work to detach and transport the various organic and inorganic bank and channel components?

2. How resistent are these components to the recent stream flow forces exerted on them?

3. What is the capacity of the stream to adjust and recover from potential changes in flow volume and/or increases in sediment production?

The channel and adjacent flood plain banks are subjectively rated, item by item, following an on-the-ground inspection. Circle only one of the numbers in parentheses for each item rated. If actual conditions fall somewhere between the conditions as described, cross out the number given and below it write in an intermediate value which better expresses the situation as you see it.

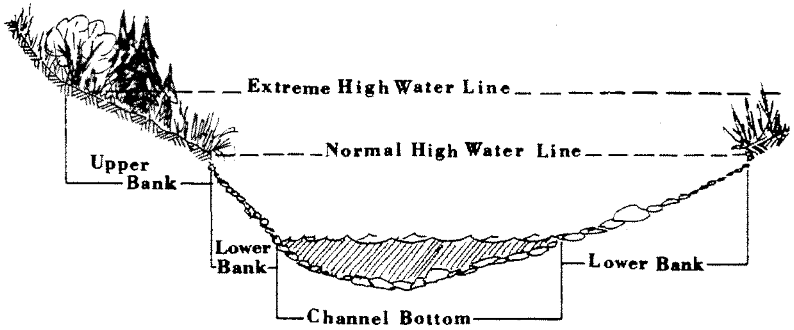
NOTE: Channels cut to bedrock are always rated Excellent.

DEFINITION OF TERMS AND ILLUSTRATIONS

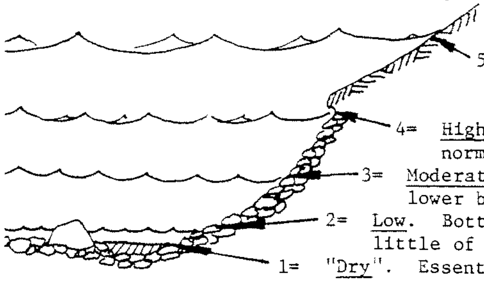
Upper Bank - That portion of the topographic cross section from the break in the general slope of the surrounding land to the normal high water line. Terrestrial plants and animals normally inhabit this area.

Lower Banks - The intermittently submerged portion of the channel cross section from the normal high water line to the water's edge during the summer low flow period.

Channel Bottom - The submerged portion of the channel cross section which is totally an aquatic environment.



Stream Stage - The height of water in the channel at the time of rating is recorded, using numbers 1 through 5. These numbers, as shown below, relate to the surface water elevation relative to the normal high water line. A decimal division should be used to more precisely define conditions, i.e., 3.5 means 3/4ths of the channel banks are under water at the time of rating.



5= Flooding. The flood plain is completely covered.

4= High. Channel full to the normal high water line.

3= Moderate. Bottom and 1/2 of lower banks wetted.

2= Low. Bottom covered but very little of the lower banks wet.

1= "Dry". Essentially no flow. Water may stand in bottom depressions.

KEY CARD FOR FIELD FORM 2500-5A

KEY NUMBER ON FIELD CARDS

	Item Rated	
Upper Banks	Landform Slope	1
	Mass Wasting or Failure (existing or potential)	2
	Debris Jam Potential (Floatable Objects)	3
	Vegetative Bank Protection	4
Lower Banks	Channel Capacity	5
	Bank Rock Content	6
	Obstructions Flow Deflectors Sediment Traps	7
	Cutting	8
	Deposition	9
Bottom	Rock Angularity	10
	Brightness	11
	Consolidation or Particle Packing	12
	Bottom Size Distribution and Percent Stable Materials	13
	Scouring and Deposition	14
	Clinging Aquatic Vegetation (Moss and Algae)	15

R-1 STREAM REACH INVENTORY and CHANNEL STABILITY EVALUATION

REACH LOCATION: Survey Date 8-12-75 Time 1430 Obs. D.R. - L.S. - D.P.

Forest Brightwater Rgr. Dist. Purity

Stream Fern Creek P.W.I. W/S No. 16-02-00-04-23-05-01-01

Reach Description & Other Identification Road crossing Sec 3 to 1/4 mi. upstream Aerial Photo #274-191

	Key #	Stability Indicators by Classes EXCELLENT		GOOD (Fair and Poor on reverse side)	
Upper Banks	1	Bank slope gradient <30%.	(2)	Bank slope gradient 30-40%.	(4)
	2	No evidence of past or any potential for future mass wasting into channel.	3	Infrequent and/or very small. Mostly healed over. Low future potential.	(6)
	3	Essentially absent from immediate channel area.	(2)	Present but mostly small twigs and limbs.	4
	4	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	(6)
Lower Banks	5	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	(1)	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	2
	6	65%+ with large, angular boulders 12"+ numerous.	(2)	40 to 65%, mostly small boulders to cobbles 6-12".	4
	7	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	2	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	(4)
	8	Little or none evident. Infrequent raw banks less than 6" high generally.	(4)	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	~~(6)~~ 6
	9	Little or no enlargement of channel or point bars.	4	Some new increase in bar formation, mostly from coarse gravels.	(8)
Bottom	10	Sharp edges and corners, plane surfaces roughened.	(1)	Rounded corners and edges, surfaces smooth and flat.	2
	11	Surfaces dull, darkened, or stained. Gen. not "bright".	(1)	Mostly dull, but may have up to 35% bright surfaces.	2
	12	Assorted sizes tightly packed and/or overlapping.	2	Moderately packed with some overlapping.	(4)
	13	No change in sizes evident. Stable materials 80-100%.	4	Distribution shift slight. Stable materials 50-80%.	(8)
	14	Less than 5% of the bottom affected by scouring and deposition.	6	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	(12)
	15	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.	(1)	Common. Algal forms in low velocity & pool areas. Moss here too and swifter waters.	2
		EXCELLENT COLUMN TOTAL →	24	GOOD COLUMN TOTAL →	22

Add values in each column and record in spaces below. Add column scores.

E. 24 + C. 22 + F. 6 + P. 0 = 52 Total Reach Score.

Adjective ratings: <38=Excellent, 39-76=Good, 77-114=Fair, 115+=Poor*

*(Scores above may be locally adjusted by Forest Hydrologist)

R1-Form 2500-5A Rev.1-75 Side 1.

INVENTORY DATA: (observed or measured on this date) Side 2

Stream Width 6 ft.X Ave.Depth 0.5 ft.X Ave.Velocity 1.2 /s= 3.6 Flow cfs
Reach Gradient 4 %, Stream Order 3 , Turbidity Level Low , Stream Stage Low (2.3) Sinuosity Ratio 1.2 .
Temperature °F or °C of: Air 86 Water 52 , Others pH 7.2, Conductance 45 µMhos
Water Quality Sample Bottle # 34

	Key #	Stability Indicators by Classes: FAIR		POOR	
Upper Banks	1	Bank slope gradient 40-60%.	(6)	Bank slope gradient 60%+.	(8)
	2	Moderate frequency & size, with some raw spots eroded by water during high flows.	(9)	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	(12)
	3	Present, volume and size are both increasing.	(6)	Moderate to heavy amounts, predominantly larger sizes.	(8)
	4	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	(9)	<50% density plus fewer species & less vigor indicate poor, discontinuous, and shallow root mass.	(12)
Lower Banks	5	Barely contains present peaks. Occassional overbank floods. W/D ratio 15 to 25.	(3)	Inadequate. Overbank flows common. W/D ratio > 25.	(4)
	6	20 to 40%, with most in the 3-6" diameter class.	(6)	< 20% rock fragments of gravel sizes, 1-3" or less.	(8)
	7	Moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling of pools.	(6)	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	(8)
	8	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.	(12)	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	(16)
	9	Moderate deposition of new gravel & coarse sand on old and some new bars.	(12)	Extensive deposits of predominantly fine particles. Accelerated bar development.	(16)
Bottom	10	Corners & edges well rounded in two dimensions.	(3)	Well rounded in all dimensions, surfaces smooth.	(4)
	11	Mixture, 50-50% dull and bright, ± 15% ie. 35-65%.	(3)	Predominantely bright, 65%+, exposed or scoured surfaces.	(4)
	12	Mostly a loose assortment with no apparent overlap.	(6)	No packing evident. Loose assortment, easily moved.	(8)
	13	Moderate change in sizes. Stable materials 20-50%.	(12)	Marked distribution change. Stable materials 0-20%.	(16)
	14	30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	(18)	More than 50% of the bottom in a state of flux or change nearly yearlong.	(24)
	15	Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	(3)	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	(4)
		FAIR COLUMN TOTAL →	6	POOR COLUMN TOTAL →	0

Size Composition of Bottom Materials (Total to 100%)

1. Exposed bedrock........... 0 %
2. Large boulders, 3'+ Dia.... 5 %
3. Small boulders, 1-3'....... 10 %
4. Large rubble, 6"-12"....... 10 %
5. Small rubble, 3"-6"..... 30 %
6. Coarse gravel, 1"-3".... 25 %
7. Fine gravel, 0.1-1"..... 20 %
8. Sand, silt, clay, muck.. T %

Amplification of the Stream Channel Evaluation Items

General

Space on the field form permits only the very briefest description of the various components. This field booklet provides, in the text which follows, some of the basic rationale in support of these brief "kernels" or core thoughts. These explanations are arranged in the same order as they appear on the field form.

The channel cross section is subdivided into three components, to focus your attention on the various indicators to be subjectively evaluated. Once again, you are cautioned not to "key in" on any one item or group of items. All that have been included are interralated and all must be used in an unbiased way to achieve consistent evaluations of the current situation.

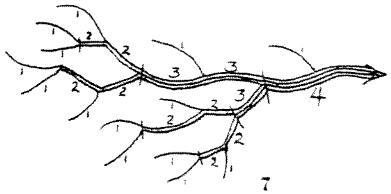
Stream channel ratings should not be attempted without the preparation provided by this Field Guide. The language of the text has been kept rather general to avoid limiting its use as a management tool to a small geographic area. These general descriptions, coupled with your local experience, will stimulate mental images of indicator conditions which, when shared with fellow workers, will lead to consistent, reproducible ratings.

Illustrations in the text should be considered general in nature and not specific for all situations. It is suggested that local conditions be photographed and the pictures added to this Field Guide to achieve local uniformity.

A word of additional caution: Keep the scale of the reach being evaluated in context with the scale of dimensions given in the text and on the inventory form. Rating items were taylored for and best fit the 2nd to 4th order stream reaches. Very small, unbranched, first order segments will require a scaling down of sizes while the larger stream and river reaches will require some mental enlargement of the criteria given to fit the situation.

STREAM ORDER CLASSIFICATION

First order streams are unbranched reaches found usually but not exclusively at the head of drainage basins. Second order reaches are formed when two or more first order reaches come together and so on as illustrated below.



I. Upper Channel Banks

The land area immediately adjacent to the stream channel is normally and typically a terrestrial environment. Landforms vary from wide, flat, alluvial flood plains to the narrow, steep termini of mountain slopes. Intermittently this dry land flood plain becomes a part of the water course. Forces of velocity and turbulence tear at the vegetation and land. These hydrologic forces, while relatively short lived, have great potential for producing onsite enlargements of the stream channel and downstream sedimentation damage. Resistance of the component elements on and in the bank are highly variable. This section is designed to aid in rating this relative resistence to detachment and transport by floods.

A. Landform Slope: The steepness of the land adjacent to the stream channel determines the lateral extent and ease to which banks can be eroded and the potential volume of slough which can enter the water. All other factors being equal, the steeper the land adjacent to the stream, the greater the potential volume of slough materials.

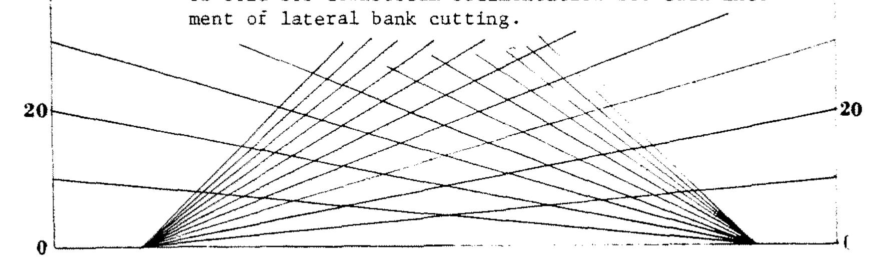
The 60% limit for poor was selected as a conservative gravitational repose angle for unconsolidated soil materials. Slopes steeper than this are rated poor because they would erode into the stream by gravity alone, if denuded of their protecting vegetation. The other ratings built on this limit and are arbitrarily set as follows:

1. Excellent: Side slopes to the channel are generally less than 30 percent on both banks.

2. Good: Side slopes up to 40% on one or occasionally both banks.

3. Fair: Side slopes to 60% common on one or both banks.

4. Poor: Steep slopes, over 60%, provide larger volumes of soil for downstream sedimentation for each increment of lateral bank cutting.



PERCENT SLOPE SCALE

Hold this page at arms length..match the slope of the topography with the percent slope lines on the scale above.

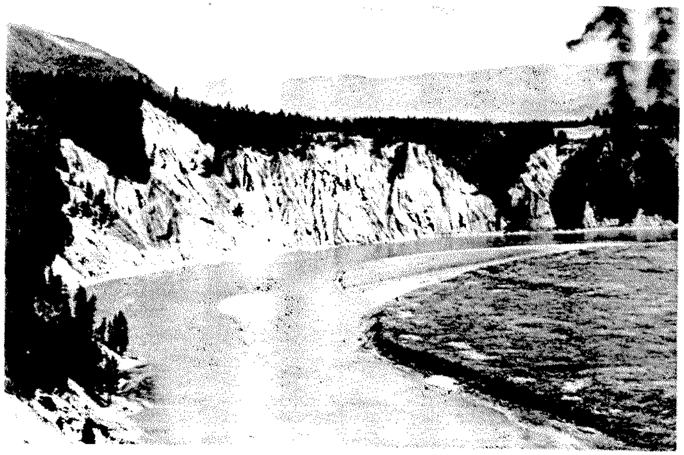
B. Mass Wasting Hazard This rating involves existing or potential detachment from the soil mantle and downslope movement into waterways of relatively large pieces of ground. Mass movement of banks by slumping or sliding introduces large volumes of soil and debris into the channel suddenly, causing constrictions or complete damming followed by increased stream flow velocities, cutting power and sedimentation rates. Conditions deteriorate in this element with proximity, frequency and size of the mass wasting areas and with progressively poorer internal drainage and steeper terrain:

1. Excellent: There is no evidence of mass wasting that has or could reach the stream channel.

2. Good: There is evidence of infrequent and/or very small slumps. Those that exist may occasionally be "raw" but predominately the areas are revegetated and relatively stable.

3. Fair: Frequency and/or magnitude of the mass wasting situation increases to the point where normal high water aggrevates the problem of channel changes and subsequent undercutting of unstable areas with increased sedimentation.

4. Poor: Mass wasting is not difficult to detect because of the frequency and/or size of existing problem areas or the proximity of banks are so close to potential sides that any increases in the flow would cut the toe and trigger slides of significant size to cause downstream water quality problems for a number of years.



Mass wasting of slopes directly into the stream channel.

C. Debris Jam Potential Floatable objects are deposited on stream banks by man and as a natural process of forest ecology. By far, the bulk of this debris is natural in origin. Tree trunks, limbs, twigs, and leaves reaching the channel form the bulk of the obstructions, flow deflectors, and sediment traps to be rated below. This inventory item assess the potential for increasing these impediments to the natural direction and force of flow where they now lay. It also includes the possibility of creating new debris jams under certain flow conditions.

1. Excellent: Debris may be present on the banks, but is so situated or is of such a size, that the stream is not able to push or float it into the channel and, therefore, for all intents and purposes, it is absent. In truth, there may be none physically present. Both situations are rated the same.

2. Good: The debris present offers some bank protection for a while but is small enough to be floated away in time. Only small jams could be formed with this material alone.

3. Fair: There is a noticeable accumulation of all sizes and the stream is large enough to float it away, at certain times, thus decreasing the bank protection and adding to the debris jam potential downstream.

4. Poor: Moderate to heavy accumulations are present due to fires, insect attack, disease mortality, windthrow, or logging slash. High flows will float some debris away and the remainder will cause channel changes.

A series of debris jams of small size materials like the one shown in the center of this photo cause this item to be rated "Poor".

D. Vegetative Bank Protection: The soil in banks is held in place largely by plant roots. Riparian plants have almost unlimited water for both crown and root development. Their root mats generally increase in density with proximity to the open channel. Trees and shrubs generally have deeper root systems than grasses and forbs. Roots seldom extend far into the water table, however, and near the shore of lakes and streams they may be comparatively shallow rooted. Some species are, therefore, subject to windthrow.

In addition to the benefits of the root mat in stabilizing the banks, the stems help to reduce the velocity of flood flows. Turbulence is generated by stems in what may have been laminar flow. The seriousness of this energy release depends on the density of both overstory and understory vegetation. The greater the density of both, the more resistence displayed. Damage from turbulence is greatest at the periphery and diminishes with distance from the normal channel. Other factors to consider, in addition to the density of stems, are the varieties of vegetation, the vigor of growth and the reproduction processes. Vegetal variety is more desirable than a monotypic plant community. Young plants, growing and reproducing vigorously, are better than old, decadent stands.

1. Excellent: Trees, shrubs, grass and forbs combined cover more than 90 percent of the ground. Openings in this nearly complete cover are small and evenly dispersed. A variety of species and age classes are represented. Growth is vigorous and reproduction of species in both the under- and over-story is proceeding at a rate to insure continued ground cover conditions. A deep, dense root mat is inferred.
2. Good: Plants cover 70 to 90 percent of the ground. Shrub species are more prevalent than trees. Openings in the tree canopy are larger than the space resulting from the loss of a single mature individual. While the growth vigor is generally good for all species, advanced reproduction may be sparse or lacking entirely. A deep root mat is not continuous and more serious erosive incursions are possible in the openings.
3. Fair: Plant cover ranges from 50 to 70 percent. Lack of vigor is evident in some individuals and/or species. Seedling reproduction is nil. This condition ranked fair, based mostly on the percent of the area not covered by vegetation with a deep root mat potential and less on the kind of plants that make up the overstory.
4. Poor: Less than 50 percent of the ground is covered. Trees are essentially absent. Shrubs largely exist in scattered clumps. Growth and reproduction vigor is generally poor. Root mats discontinuous and shallow.

II. Lower Channel Banks

The channel zone is located between the normal high water and low water lines. Both aquatic and terrestrial plants may grow here but normally their density is sparse.

The lower channel banks define the present stream width. Stability of these channel banks is indicated under a given flow regimen by minor and almost imperceptable changes in channel width from year to year. In other words, encroachment of the water environment into the land environment is nil.

Under conditions of increasing channel flow, the banks may weaken and both cutting (bank encroachment) and deposition (bank extension) begin, usually at bends and points of constriction. Cutting is evidenced by steepening of the lower banks. Eventually the banks are undercut, followed by cracking and slumping. Deposition behind rocks or bank protrusions increase in length and depth.

As the channel is widened, it may also be deepened to accomodate the increased volume of flow. For convenience only, changes of channel bottoms are observed separately and last in this evaluation scheme.

A. Channel Capacity: Channel width, depth, gradient, and roughness determine the volume of water which can be transmitted. Over time channel capacity has adjusted to the size of watershed above the reach rated, to climate, and to changes of vegetation. Some indicators of change are widening and/or deepening of the channel which affects the ratio of width to depth. When the capacity is exceeded, deposits of soil are found on the banks and organic debris may be found hung up in the bank vegetation. These are expressions of the most recent flood event. Indicators of conditions as recent as a year or two ago may be difficult or impossible to find, but do your best to estimate what normal peak flows are and whether the present cross section is adequate to handle the load without bank deterioration.

1. Excellent: Cross sectional area is ample for present peak volumes plus some additional, if needed. Overbank floods are rare. Width to depth ratio less than 7; i.e., (36' wide ÷ 6' deep = 6).

2. Good: Adequate cross sectional area contains most peak flows. Width to depth ratio 8 to 15.

3. Fair: Channel barely contains the peak runoff in average years or less. Width to depth ratios range from 15 to 25.

4. Poor: Channel capacity generally inadequate. Overbank floods quite common as indicated by kind and condition of the bank plants and the position and accumulation of debris. Width to depth ratio 25 or more.

B. Bank Rock Content: Examination of the materials that make up the channel bank will reveal the relative resistence of this component to detachment by flow forces. Since the banks are perennially and intermittently both aquatic and terrestrial environments, these sites are harsh for most plants that make up both types. Vegetation is, therefore, generally lacking and it is the volume, size and shape of the rock component which primarily determine the resistence to flow forces.

A soil pit need not be dug. Surface rock and exposed cut banks will enable you to categorize this item as listed by percentage ranges on the field form.

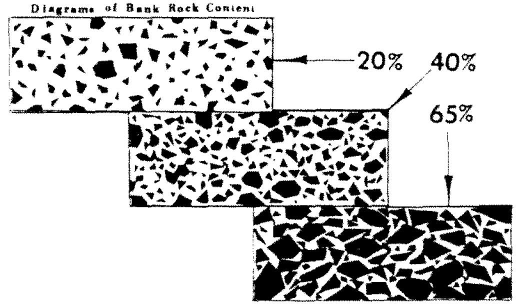
1. Excellent: Rock makes up 65% or more of the volume of the banks. Within this rock matrix large, angular boulders 12" (on their largest axis) are numerous.

2. Good: Banks 40-65% rock which are mostly small boulders and cobble ranging in size from 6-12" mean diameter. Some may be rounded while others are angular.

3. Fair: 20-40% of bank volume rock. While some big rock may be present, most fall into the 3-6" diameter class.

4. Poor: Less than 20% rock fragments, mostly of gravel sizes 1-3" in diameter.

Diagrams of Bank Rock Content



C. Obstructions and Flow Deflectors: Objects within the stream channel, like large rocks, embedded logs, bridge pilings, etc., change the direction of flow and sometimes the velocity as well. Obstructions may produce adverse stability effects when they increase the velocity and deflect the flow into unstable and unprotected banks and across unstable bottom materials. They also may produce favorable impacts when velocity is decreased by turbulence and pools are formed.

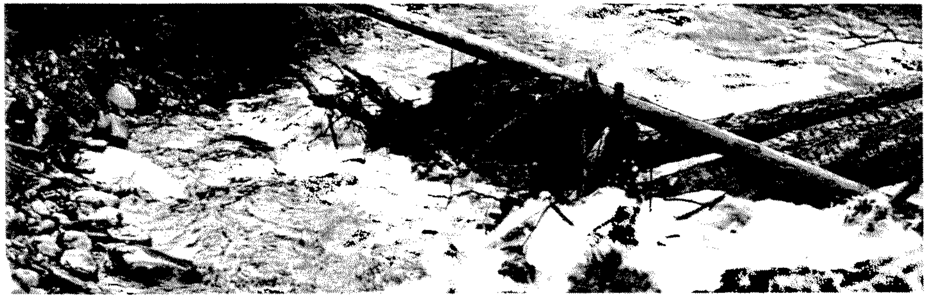
Sediment Traps: Channel obstructions which dam the flow partly or wholly form pools or slack water areas. The pools lower the channel gradient. With this loss of energy the sediment transport power is greately reduced. Coarse particles drop out first at the head of the pool. Some or all of the fine suspended particles may carry on through.

Embedded logs and large boulders can produce very stable natural dams which do not add to channel instability. Some debris dams and beaver dams, however, are quite unstable and only serve to increase the severity of channel damage when they break up.

The effectiveness of these sediment traps depends on pool length relative to entrance velocity. The swifter the current, the longer the pool needed to reach zero velocity. Turbulence caused by a falls at the head of the pool shortens the length required to reach zero velocity.

How long these traps are effective depends on depth and width as well as pool length and, of course, the rate of sediment accretion.

Items of vegetation growing in the water, like alders, willows, cattails, reeds, and sedges are also effective traps in some locations and reduce flow velocity and sediment carrying power.



Overturned shoreline trees become obstructions and flow deflectors as shown here. If frequent in the reach, rate this item "Poor".

C. Obstructions and Flow Deflectors (Continued)

1. Excellent: Logs, rocks, and other obstructions to flow are firmly embedded and produce a pattern of flow which does not erode the banks and bottom or cause sediment buildups. Poolriffle relationship stable.

2. Good: Obstructions to flow and sediment traps are present, causing cross currents which create some minor bank and bottom erosion. Some of the obstructions are newer, not firmly embedded and move to new locations during high flows. Some sediment is trapped in pools decreasing their capacity.

3. Fair: Moderately frequent and quite often unstable obstructions, cause noticeable seasonal erosion of the channel. Considerable sediment accumulates behind obstructions.

4. Poor: Obstructions and traps so frequent they are intervisible, often unstable to movement and cause a continual shift of sediments at all seasons. Since traps are filled as soon as formed, the channel migrates and widens.

Same location as shown on page 14, but looking upstream. Obstruction like this could become the nucleus of a debris jam.

Cutting and Deposition are concommittent processes. You can't have one without the other. However, it is possible for each to be taking place in different reaches of the same stream at the same time, and hence the separation for classification purposes which follows.

D. Cutting: One of the first signs of channel degradation would be a loss of aquatic vegetation by scouring or uprooting. Some channels are naturally devoid of aquatic plants and here the first stages would be an increase in the steepness of the channel banks. Beginning near the top, and later extending in serious cases to the total depth, the lower channel bank becomes a near vertical wall.

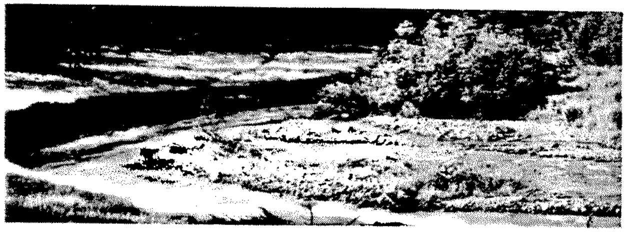
If plant roots bind the surface horizon of the adjacent upper bank into a cohesive mass, undercutting will follow. This process continues until the weight of overhang causes the sod to crack and subsequently slump into the channel. Differential horizontal compaction and texture could also result in undercut banks even with an absence of vegetative cover. There are some loosely consolidated banks that with or without vegetation are literally nibbled away, never developing much, if any, overhang.

1. Excellent: Very little or no cutting is evident. Raw, eroding banks are infrequent, short and predominately less than 6" high.

2. Good: Some intermittent cutting along channel outcurves and at prominent constrictions. Eroded areas are equivalent in length to one channel width or less and the vertical cuts are predominately less than 12".

3. Fair: Significant bank cutting occurs frequently in the reach. Raw vertical banks 12" to 24" high are prevalent as are root mat overhangs and sloughing.

4. Poor: Nearly continuous bank cutting. Some reaches have vertical cut faces over 2 feet high. Undercutting, sod-root overhangs and vertical side failures may also be frequent in the rated reach.



Poor bank conditions at this bend are evident.

E. Deposition: Lower bank channel areas are generally the steeper portions of the wetted perimeter and may be rather narrow strips of land that offer slight opportunity for deposition. Exceptions to this statement abound since deposition is often noted on the lea side of large rocks and log deflectors which form natural jetties. However, these deposits tend to be short and narrow. On the less steep, lower banks, deposition during recession from peak flows can be quite large. The appearance of sand and gravel bars where they did not previously exist may be one of the first signs of upstream erosion. These bars tend to grow, primarily in depth and length, with continued watershed disturbance(s). Width changes are in a shoreward direction as overflow deposition takes place on the upper banks. Dimensional deposition "growth" is limited by the size and orientation of the obstructions to flow along the channel banks, flow velocity and a continuing upstream sediment supply.

Deposition may also occur on the inside radii of bends, particularly if active cutting is taking place on the opposite shore. Also, deposits are found below constrictions or where there is a sudden flattening of stream gradient as occurs upstream above geologic nic points.

1. Excellent: Very little or no deposition of fresh silt, sand or gravel in channel bars in straight reaches or point bars on the inside banks of curved reaches.

2. Good: Some fresh deposits on bars and behind obstructions. Sizes tend to be predominately from the larger size classes - coarse gravels.

3. Fair: Deposits of fresh, coarse sands and gravels observed with moderate frequency. Bars are enlarging and pools are filling so riffle areas predominate.

4. Poor: Extensive deposits of predominately fresh, fine sands, some silts, and small gravels. Accelerated bar development common. Storage areas are now full and sediments are moving even during low flow periods.

Poor conditions are illustrated here.

III. Channel Bottom

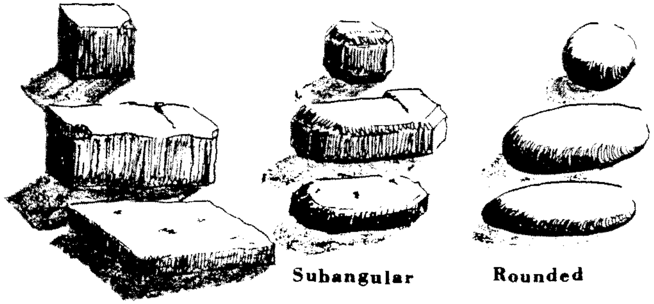
Water flows over the channel bottom nearly all of the time in perennial streams. It is, therefore, almost totally an aquatic environment, composed of inorganic rock constituents found in an infinite variety of kinds, shapes, and sizes. It is also a complex biological community of plant and animal life. This latter component is more difficult to discern and may in fact, at times and places, be totally lacking.

Both components, by their appearance alone and in combination, offer clues to the stability of the stream bottom. They are arbitrarily separated and individually rated for convenience and emphasis during the evaluation process. Because of the high reliance on the visual sense, inventory work is best accomplished during the low flow season and when the water is free of suspended or dissolved substances. If ratings must be made in high flow periods, sounds of movement may be the only clue as to the state of flux on the bottom.

A. Angularity: Rocks from stratified, metamorphic formations break out and work their way into channels as angular fragments that resist tumbling. Their sharp corners and edges wear and are rounded in time, but they resist the tumbling motion. These angular rocks pack together well and may orient themselves like shingles (imbricated). In this configuration they are resistant to detachment.

In contrast, igneous rocks often produce fragments that round up quickly, pack poorly and are easily detached and moved downstream.

Excellent to Poor ratings relate to the amount of rounding exhibited and, secondarily, the smoothness or polish the surfaces have achieved. Some rocks never do smooth up in the natural environment, but most round up in time. Both conditions, of course, are relative within the inherent capability of the respective rock types.



Angular **Subangular** **Rounded**

B. Brightness: Rocks in motion "gather no moss", algae or stain either. They become polished by frequent tumbling and, as a general rule, appear brighter in their chroma values than similar rocks which have remained stationary. The degree of staining and vegetative growths relate also to water temperature, seasons, nutrient levels, etc. In some areas a "bright" rock will be "dulled" in a matter of weeks or months. In another it may take years to achieve the same results. Nevertheless, even slight changes during the spring runoff should be detectable during the next summer's survey. Look first for changes in the sands and gravels.

1. Excellent: Less than 5% of the total bottom should be bright, newly polished and exposed surfaces. Most will be covered by growths or a film of organic stain. Stains may also be from minerals dissolved in the water.

2. Good: 5 to 35% of the bottom appears brighter, some of which may be on the larger rock sizes.

3. Fair: About a 50-50 mixture of bright and dull with a 15% leeway in either direction (i.e., a range of from 35 to 65% bright materials).

4. Poor: Bright, freshly exposed rock surfaces predominate with two-thirds or more of the bottom materials in motion recently.

Dull

Mostly Bright

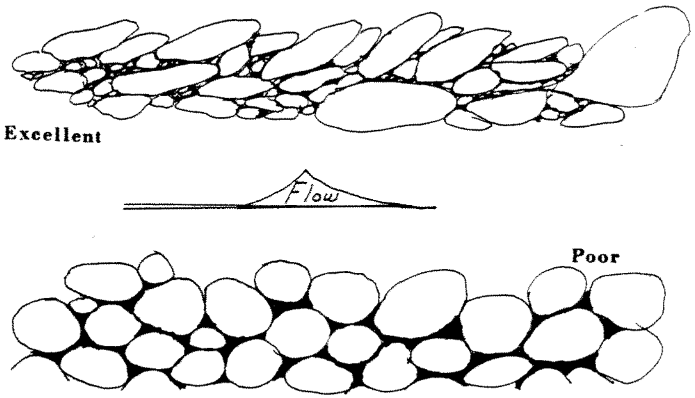
C. Consolidation (Particle Packing): Under stable conditions, the array of rock and soil particle sizes pack together. Voids are filled. Larger components tend to overlap like shingles (imbricate). So arranged, the bottom is quite resistent to even exceptional flow forces. Some rock types (granitics) are less amenable to this packing process and never reach the stable state of others like the Belt Series rocks.

1. Excellent: An array of sizes are tightly packed and wedged with much overlapping which makes it difficult to dislodge by kicking.

2. Good: Moderately tight packing of particles with fast water parts of the cross section protected by overlapping rocks. These might be dislodged by higher than average flow conditions, however.

3. Fair: Moderately loose without any pattern of overlapping. Most elements might be moved by average high flow conditions.

4. Poor: Rocks in loose array, moved easily by less than high flow conditions and move underfoot while walking across the bottom. The shape of these rocks tends to be predominantly round and sorted so that most are of similar size.



Side Views of Substrate

D. Bottom Size Distribution and Percent Stable Materials:

Rocks remaining on a stream's bottom reflect the geologic sources within the basin and the flow forces of the past. Normally, there is an array of sizes that you expect to see in any given local. After a little experience, you begin to "sense" abnormal situations. Generally, in the mature topography typical of the Northern Region of the Forest Service and much of the other western Regions as well, the flow in the small, steep upper stream reaches is sufficient to wash the soil separates and some of the gravels away. What remains is a gravelly, cobbly stream bottom. In the lower reaches where the gradient is less and flow is often slower, deposition of the "fines" eroded above begin to drop out. The separates of sand, silt, and some clay begin to cover the coarser elements. Except where trapped in still water areas, these fines tend to be in constant motion to ever lower elevations.

Two elements of bottom stability are rated in this item: (1) Changes or shifts from the natural variation of component size classes and (2) the percentage of all components which are judged to be stable materials. Bedrock, large boulders, and cobble stones ranging in size from one to three feet or more in diameter are considered "stable" elements in the average situation. Obviously, smaller rocks in smaller channels might also be classed as stable. The sizes are given only to guide thought. Bedrock as a major component of bottom and banks, no matter what size the channel or how the other elements rate, always results in an excellent classification of that reach.

1. Excellent: There is no noticeable change in size distribution. The rock mixture appears to be normal for the kind of geologic sources in the basin and the flow forces of streams of this size and location in the watershed.

   If a shift or change has taken place so there are greater percentages of large rock in the small streams and smaller sizes in large streams, the condition class most appropriate should be checked. It is a matter of degree as follows:

   (Stable Materials 80-100%).

2. Good: Slight shift in either direction.

   (Stable Materials 50-80%).

3. Fair: Moderate shift in size classes.

   (Stable Materials 20-50%).

4. Poor: Marked, a pronounced shift.

   (Stable Materials less than 20%).

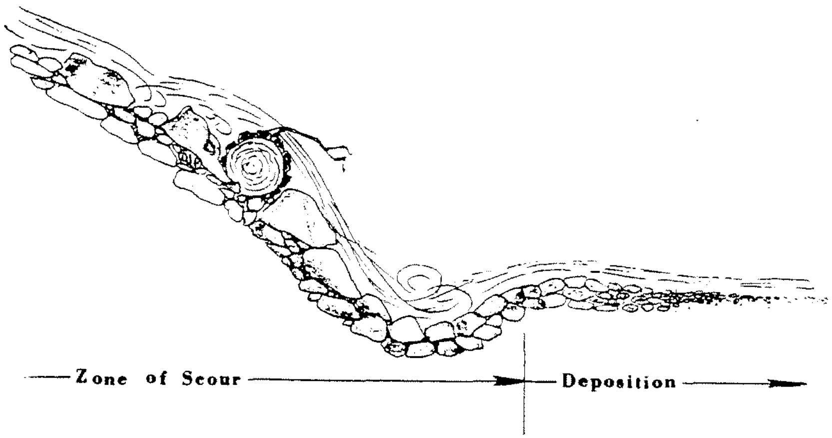
E. Scouring and/or Deposition: Items of size, angularity and brightness already rated above should lead you to some conclusions as to the amount of scouring and/or deposition that is taking place along the channel bottom.

1. Excellent: Neither scouring or deposition is much in evidence. Up to 5% of either or a combination of both may be present along the length of the reach; i.e., 0-5 feet in 100 feet of channel length.

2. Good: Affected length ranges from 5 to 30%. Cuts are found mostly at channel constrictions or where the gradient steepens. Deposition is in pools and backwater areas. Sediment in pools tends to move on through so pools change only slightly in depth but greatly in composition of their size classes.

3. Fair: Moderate changes are occurring. 30 to 50% of the bottom is in a state of flux. Cutting is taking place below obstructions, at constrictions and on steep grades. Deposits in pools now tend to fill the pool and decrease their size.

4. Poor: Both cutting and deposition are common; 50% plus of the bottom is moving not only during high flow periods but at most seasons of the year.



F. Aquatic Vegetation: When some measure of stabilization of the soil-rock components is achieved, the channel bottom becomes fit habitat for plant and animal life. This process begins in the slack water areas and eventually may include the swift water portions of the stream cross section. With a change in volume of flow and/or sedimentation rates, there may also be a temporary loss of the living elements in the aquatic environment. This last item attempts to assess the one macro-aquatic biomass indicator found to best express a change in channel stability.

Clinging Moss and Algae: These lower plant forms do not have roots but cling to the substrate. They are low growing and may first appear as a green to yellow-green slick spot on the bottom rocks. Moss plants continue with slight variation in color but no great change in mass form season to season. Algae by contrast have a peak of growth activity and then die off in great numbers. The slippery conditions they produce persist after death, however.

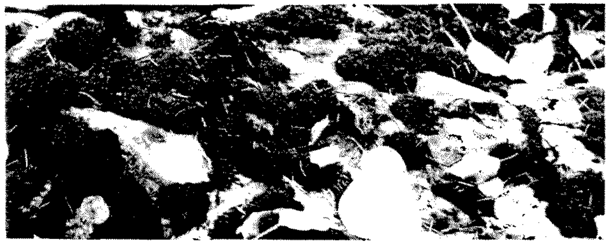
Both algae and moss inhabit the swift water areas as well as the quiet pools and backwater portions of the stream bottom.

1. Excellent: Clinging plants are abundant throughout the reach from bank to bank. A continuous mat of vegetation is not required but moss and/or algae are readily seen in all directions across the stream.

2. Good: Plants are quite common in the slower portions of the reach but thin out or are absent in the swift flowing portions of the stream.

3. Fair: Plants are found but their occurrence is spotty. They are almost totally absent from rocks in the swifter portions of the reach and may also be absent in some of the slow and still water areas.

4. Poor: Clinging plants are rarely found anywhere in the reach. (This is an unusual situation but could happen under a combination of adverse environmental conditions).



Channels with this much moss are rated "Excellent"

Management Implications

After beating the brush, getting your feet wet and fighting insects, you have established a series of channel ratings. You may now ask, "What do these numbers mean and how are they used in making a management decision?".

By now you know this subject is complicated and precludes indepth answers here. The following brief answers may satsify you of they may raise more questions. When this happens, it's time to consult your Forest hydrologist for detailed, specific answers.

The numbers and the adjective ratings they relate to mean what they say. A stream channel reach that rates "poor" has a combination of attributes that will require more judicious upstream management of the tributary watershed lands than one rated "excellent". This rating procedure was not designed to fix blame for poor land and water management or to reward good management, although, in time, it could be used for this purpose. Before passing judgment, be aware that natural, undistrubed watersheds may exhibit poor hydologic conditions. Conversely, a highly developed and used watershed may have a drainage network in good hydologic shape. The rating system will therefore have the most value to land managers who have definite water management goals, who can relate these to impacts of other resource uses and activities, who understand natural limitations, and are willing and able to use the system to define the risks they are willing to take to maintain or alter the status quo.

One use of this rating system is to assess conditions and define impacts along short reaches of stream. Channel conditions can be evaluated in terms of stream stability and potential for damaging water quality at culvert and bridge sites, at campgrounds and administrative sites or wherever livestock and wildlife concentrate near or across a water course. A channel rated "poor" at a culvert site, for example, cannot withstand as much constriction or gradient change as one rated "good". Armed with this additional knowledge, the decision could be to change locations, redesign the intallation or select a different type of structure to protect the aquatic habitat.

The primary use of this system is to assess entire channel systems within a watershed and to use the results in conjunction with other hydrologic analyses to augment silvicultural prescriptions. Rapid changes in the density and areal extent of vegetation on a watershed can increase stream discharges. Channel systems rated "excellent"

can withstand these increases with less damage than systems rated "poor". "Poor" systems can withstand gradual changes better than abrupt changes in the discharge regimen.

To calculate an overall rating for a stream system, (1) multiply the length of each reach by its numeric rating, (2) add the weighted products of all reaches in the system and (3) divide by the total length of the system.

For example:

Reach A	:	3.2 miles x 80 (fair)	= 256
Reach B	:	0.5 miles x 100 (poor)	= 50
Reach C	:	2.0 miles x 40 (good)	= 80
Total	:	5.7 miles	386

Stream system average: 386 ÷ 5.7 = 68 (Good)

Land and water should not be managed on the basis of averages. In the above example, the stream system is composed of three reaches which rate "good" on the average, but a "weak link" has been identified. Reach B is in "poor" condition. One of the obvious uses of this system is to identify "weak links" and to discover what, if any, opportunity exists to correct the condition. It matters little if the damaged area is natural or man-caused. The discovery of "weak links" should reasonably alter upstream land management to the extent necessary to achieve stated land and water management objectives.

The procedures should ultimately serve as a check and a measure of management success. The net effects of each new increment of change within the watershed management unit will ultimately be expressed in the condition of the stream channel responding to a new hydraulic regimen. Prudent managers will seek these trend data by periodic reappraisal of channel conditions and respond to adverse changes before impacts to the water resource become unacceptable and unalterable.

This large stream channel reach would be rated "excellent" overall.

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