Technical Supplement 3C

Streambank Inventory and Evaluation

Issued August 2007

Cover photo: Techniques for collecting data for design range from simple field measurements to complex modeling.

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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Streambank Inventory and Evaluation

Contents

Figures

Technical Supplement 3C

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Abstract

Inventory and evaluation of stream stability requires an understanding of the cause of the perceived problems. Sometimes, causes of instability are visible onsite, but many times it is necessary to consider activities in other reaches of the stream or in the overall watershed. Also, the problem may not be anthropogenic at all, but rather a naturally occurring process that is incompatible with the existing riparian land use. This technical supplement introduces the concepts of stream stability and equilibrium along with a channel evolution model (CEM) as background material. It then presents a detailed procedure for data collection and analysis to facilitate the understanding of the dynamics of a subject stream. Published data and field-collected measurements are analyzed and compared; when all valid data match closely, the level of confidence in the analysis is high, and an assessment of the situation can proceed. The suggested procedure relies heavily on a spreadsheet tool developed by Illinois NRCS to collect and compare all available relevant data, but the same analysis can be successfully accomplished without this specific tool.

Problem identification and trend analysis

Causes of channel and bank instability can be broadly grouped into four areas of common causes: downstream, upstream, watershedwide factors, and local factors. Downstream factors involve lowering of the downstream base level, which can significantly impact upstream reaches. Upstream factors alter the incoming discharge of water and/or sediment by installation of features such as dams and diversion channels. Watershedwide factors are the result of major land use changes such as urbanization. Local factors result from geotechnical failures, sparse riparian vegetation, and unstable planform. These local causes may be exacerbated by upstream, downstream, or watershedwide factors or they may be the primary cause.

One common misconception often found is the assumption that a stable stream should not erode its banks. The fact is that stable streams are not static; they typically migrate more slowly than one that has been destabilized by anthropogenic forces. The difference between stable and unstable is not always a clear distinction as streams in dynamic equilibrium will continually migrate slowly across their flood plains. The distinction is in the rate of lateral migration being slow enough in stable streams that the riparian zone remains essentially intact through the entire process. Stable streams should, however, remain essentially static in relation to their overall profile; that is, they will not exhibit any large scale degradation or aggradation.

Watershedwide problems

Hundreds of years of human activity on the landscape have made significant changes in the major elements controlling stream balance. People have:

- cleared the timber
- plowed the prairie
- drained the wetlands
- straightened the streams
- levied the flood plains
- built cities with large areas of concrete, asphalt, and rooftops

Results of such activity on stream dynamics have generally had the effect of increasing runoff and stream slope and reducing flood plain width. In many watersheds, the land use changes are a significant factor in increased runoff. In rural areas, this may be due to more intense agricultural activities replacing woodland and grass land with cultivated land. In urban areas, the increase of impermeable surfaces within the watershed results in an increased volume of water. Additionally, the urban development of a watershed typically results in permanent land cover, either in impermeable surfaces or lawns, which produces little sediment to be delivered to the system.

Lane's Balance (fig. TS3C–1) is a tool for understanding the relationship between factors affecting channel configuration (Federal Interagency Stream Restoration Working Group (FISRWG) 1998). Stability is represented when the scale is balanced and the system has achieved an equilibrium condition. Both the increased runoff from impervious areas and the reduced sediment loads will tend to tip Lane's Balance to channel degradation in the stream system, as illustrated with the arrow in figure TS3C–1. Increased runoff represents higher energy in the streamflow, and reduced sediment load means there is less work for that energy to do. The excess streamflow energy is dissipated by eroding the streambanks or scouring out the bed of the channel (degradation), providing more sediment and bringing the system to a new equilibrium.

Another aid in identifying the processes at work in a stream is the CEM (fig. TS3C–2 (Simon 1989)). This model describes a predictable series of changes that a channel may transition through following some disturbance. The CEM is addressed in more detail in NEH654.03.

Channel problems

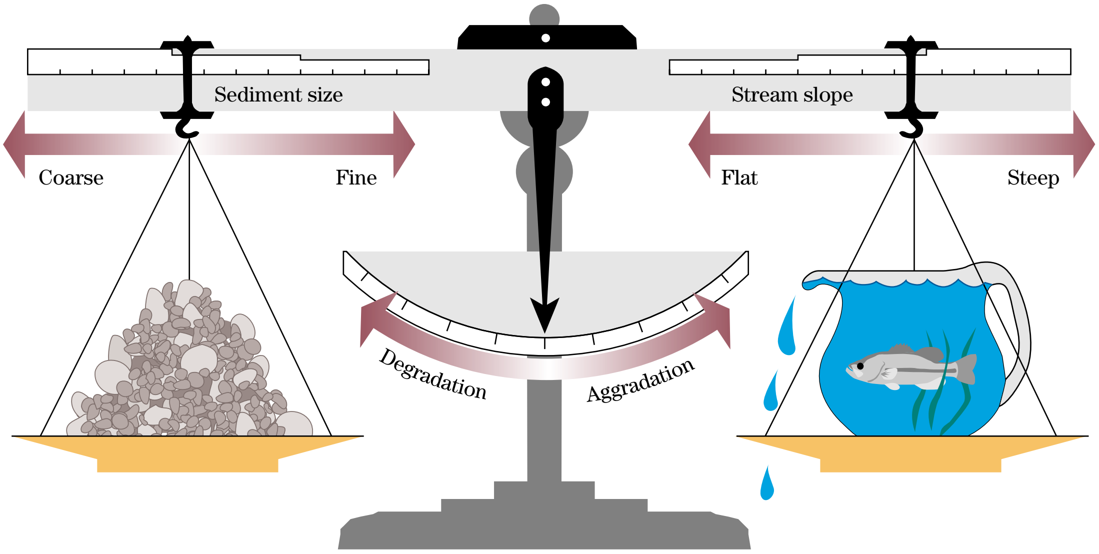
Channel modifications nearly always contribute to channel instability at some point. Some of the more obvious modifications are channelization, dam construction, and levees. Some less obvious, but still significant changes, include clearing and snagging, gravel mining, and channel lining or paving. The changes induced by these channel modifications can be dramatic, but more typically, they appear rather insignificant to the casual observer, especially in the short term. Time then becomes a significant element to consider in the problem identification phase, as the lag time between channel or watershed changes and the full effects of those changes can be decades. Because the impacts of channel modifications are cumulative over time, it is often difficult to identify a single modification that is responsible for an adverse condition.

The designer's most important task is to be aware of the overall condition of the stream and identify trends toward or away from the equilibrium or balanced condition. Only then can alternatives be considered.

Procedures for streambank investigations and analysis

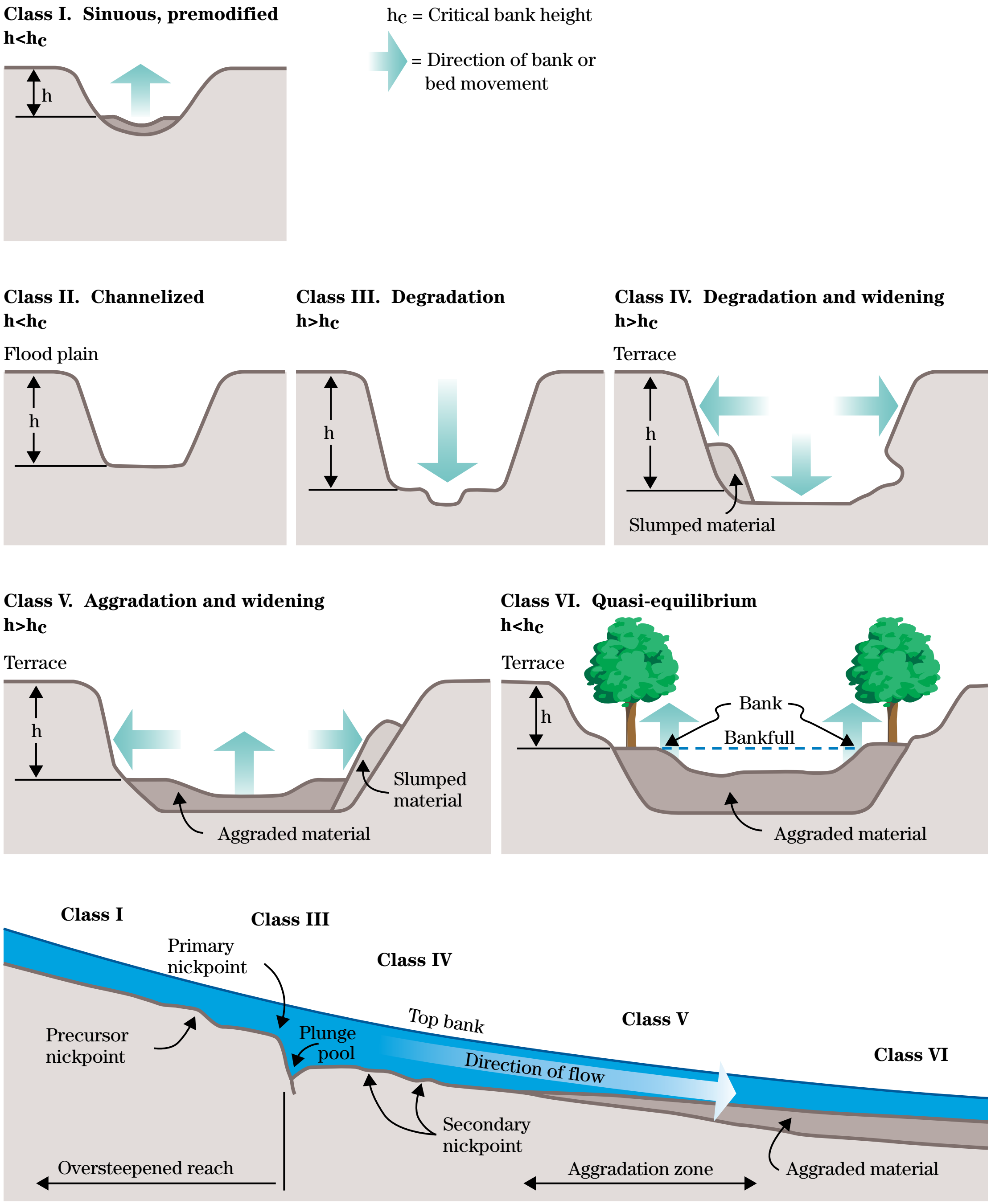
The underlying assumption to the designer's investigation and analysis is that every stream has a stable dimension, slope, and planform to safely carry the water and sediment generated from its watershed under the current climate and land use. That is not to

Figure TS3C–1 Lane's Balance for determining the effect of human activity on streams



$$Q_s \bullet D_{50} \propto Q_w \bullet S$$

Figure TS3C–2 Channel evolution model (CEM) (Simon 1989)



Class I. Sinuous, premodified
h<hc

Class II. Channelized
h<hc

Class III. Degradation
h>hc

Class IV. Degradation and widening
h>hc

Class V. Aggradation and widening
h>hc

Class VI. Quasi-equilibrium
h<hc

say that the stream is in a static condition, but rather that a stable stream maintains the same dimensions, slope, and planform while moving slowly within its flood plain position. The investigative procedure is a process of determining what the stable conditions of each unique stream segment should be and what the current conditions are, comparing the two conditions, and then attempting to understand the reasons for any differences. Only then can the designer analyze the condition of the stream and recommend action to improve an unsatisfactory condition and move the stream toward a stable state or, at a very minimum, prevent action that would further destabilize the stream.

The Illinois NRCS spreadsheet program, designed to assist in gathering and analyzing the data required for inventory and evaluation (I&E) of an Illinois stream segment, will be presented as a part of the suggested investigative procedure. Some of the data and analysis are very specific to Illinois, particularly gage data and regression curves. If the spreadsheet is used outside of Illinois, the reference stream gage section and the U.S. Geological Survey (USGS) flood-peak discharge prediction section will not apply. The collection form and its accompanying subroutines appear later in this supplement. The spreadsheet program can be found in its most current form on the Illinois NRCS Web site: *http://www.il.nrcs.usda.gov/technical/engineer/engsprdshts.html.*

Geomorphic values

There is a natural variability to hydraulic geometry relationships. It is important to recognize that this variability represents a valid range of stable channel dimensions due to such variables as geology, vegetation, land use, sediment load, sediment grain size, and runoff characteristics. The values suggested in the following procedure for bankfull discharge, width-to-depth ratio, sinuosity, radius of curvature-to-bankfull width ratio, and entrenchment ratio are based on measured observations from streams in Illinois, as well as published ranges from various research done elsewhere. Values for these relationships should not be assumed to be more accurate or precise than intended. These relationships can be used as a preliminary guide to stability in stream reaches, but other techniques and local data should be considered.

Background data collection (prior to field visit)

The first step in the investigation phase is to gather existing data for the project area. The information gathered will make the initial field visit much more productive and allow for some preliminary analysis to be done with less field time.

Step 1 On the I&E spreadsheet, enter the location and identification information including county, legal description, stream name, name(s) of decisionmakers or landowners, and UTM coordinates (if desired). These appear at the top of the spreadsheet I&E form.

Step 2 Aerial photography is the first data set to acquire. Using the most recent aerial photography available, compare with older aerial photos to determine:

- Channel alignment changes (straightening and shortening of the channel length)—Calculate channel sinuosity (old and new).
- Lateral migration rates—By measuring from discernible features such as known points, roads, and section lines, and determining the total migration rate for several years, a reasonable estimate can be made of average annual migration.
- Changes in the channel width over time—Has the channel top width gotten larger? Widening could be a sign of past downcutting, or excessive bed load causing aggradation.
- Changes in the bed features such as central bars and size of point bars—Increased bar size could be a sign of excessive bed load.
- Scour patterns in the flood plain
- Locations of any existing levees

Step 3 From USGS topographic maps (or other suitable maps), determine the watershed boundaries of the stream reach. Calculate drainage area (if available, nearby gage data can be used to help determine the drainage area), and enter in square miles on the spreadsheet.

Step 4 Regional curve bankfull dimensions are supplied by the spreadsheet program based on drainage area, based on work by Dunne and Leopold (1978) (fig. TS3C–3 (FISRWG 1998)). The data are based on typical relationships and may not be applicable to a specific watershed or area. For example, curve B bankfull widths and depths correlate reasonably well with observations of several hundred rural streams in Illinois ,but should be used cautiously (if at all) in an urban setting. Development of regional curve bankfull dimensions for streams in the subject hydro-physiographic area should be pursued for best results.

Step 5 Look for reference streamflow gaging data. USGS and some state and local governments may own or operate gaging equipment on the stream you are investigating. If not, look for the nearest gage data available in a watershed with similar soils, climate, and land use to the one you are investigating.

a. Gage data are available online at *http://www.usgs.org* for USGS-operated gages.

b. The Illinois NRCS stream stabilization spreadsheet has a pull-down menu of USGS gage data in and near the selected county. The 2-year return interval maximum discharge, Q2, calculated from the actual gage data will be displayed for the selected gage along with the station number and its drainage area. Results of the USGS regression analysis (USGS 1987) are also displayed, if available; they are not available for urban streams in Northeastern Illinois as the regression analysis does not represent urban hydrology. This feature is applicable only to Illinois streams. Further information on stream gage analysis is provided in NEH654.05.

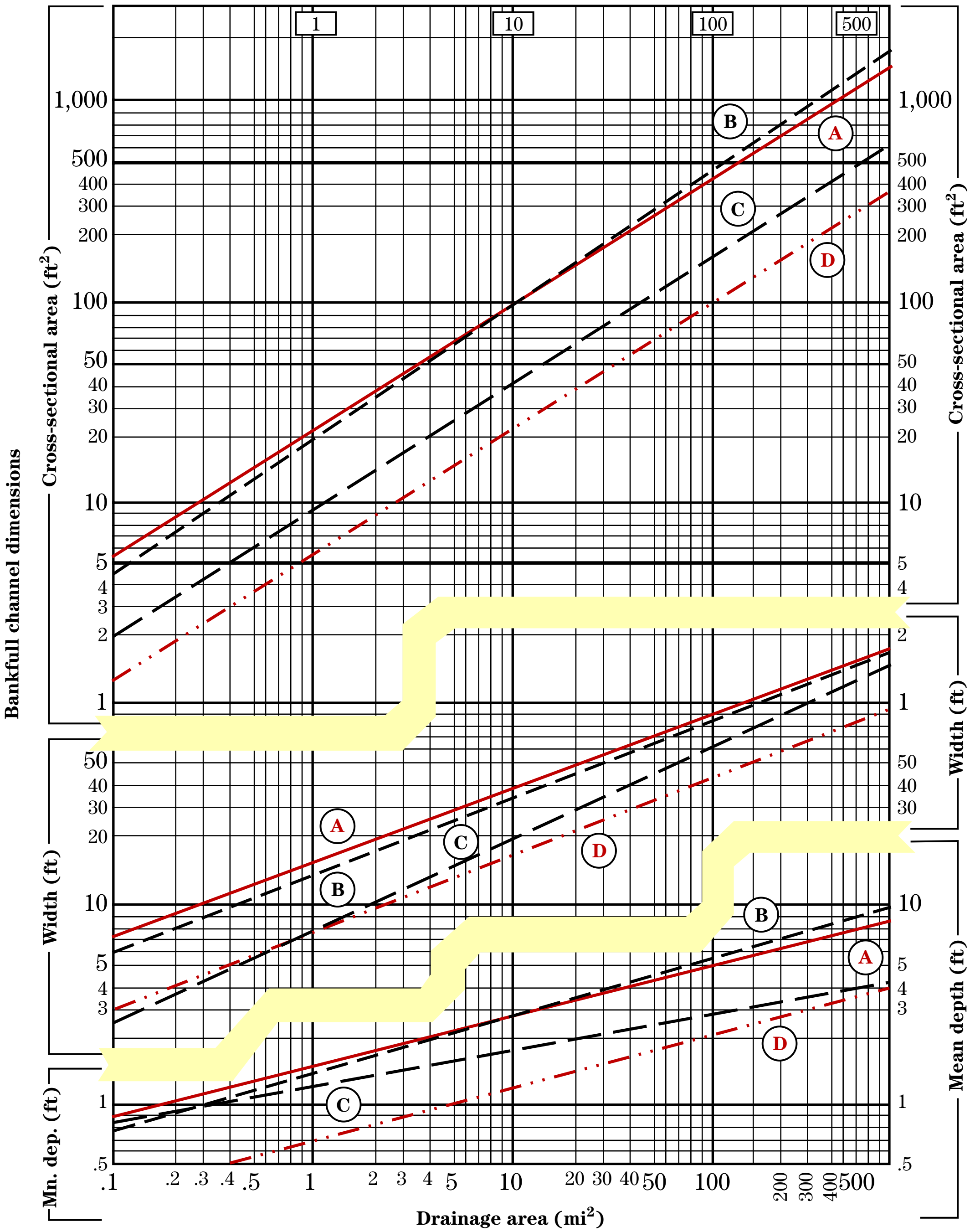
Step 6 To determine the USGS flood-peak discharge predictions for the subject stream, the spreadsheet needs a value for valley slope (USGS 1987). Rainfall and regional factor are automatically supplied based on the county selection, and the predicted Q2 discharge from the regression equation will be displayed. It will always display the typical range for bankfull, which is 40 percent to 80 percent of the Q2 discharge, corresponding to the approximate 1 to 1.5-year return interval storm event commonly representing bankfull flow in Illinois. If the subject stream is not in Illinois, use other data if available.

a. For the regression analysis, valley slope is defined as “the difference of elevations divided by distance between points 10 percent and 85 percent of the total distance measured along the low-water channel of the stream from the site to the basin divide” (USGS 1987). Divide the difference in elevation by total flowline distance between points, using the topographic map with delineated drainage area determined previously.

b. If desired, the spreadsheet valley slope subroutine (fig. TS3C–4) may be used. The subroutine prompts entries of topographic contour elevations and corresponding distances along the flow line of the channel. It automatically determines elevations at the critical points using linear interpolation and plots a profile of the channel to provide a visual model of the process.

Step 7 The sinuosity of the local stream site is best determined from a recent aerial photo. Identify the points where contour lines immediately upstream and downstream of the project site cross the stream channel. Measure the stream length along the channel between the two points, along with the valley length (a straight line measurement) between the same two points. Enter these distances on the spreadsheet, along with the contour interval, and the resulting sinuosity will automatically be determined.

Figure TS3C–3 Regional curves showing bankfull dimensions by drainage area



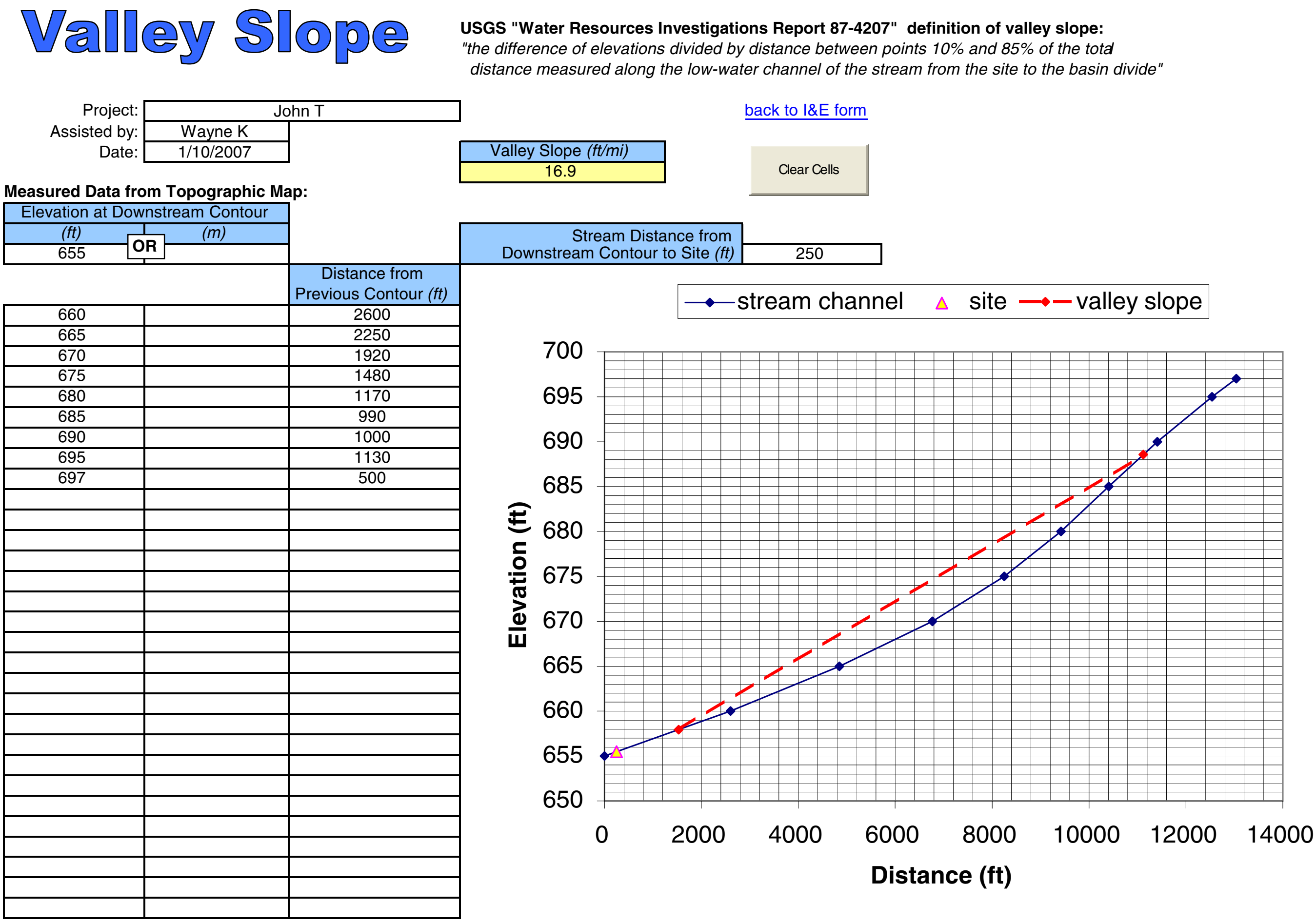
Ⓐ San Francisco Bay region
at 30 inches annual precipitation

Ⓑ Eastern United States

Ⓒ Upper Green River, Wyoming

Ⓓ Upper Salmon River, Idaho (Emmett 1975)

Figure TS3C–4 Valley slope subroutine from stream stabilization spreadsheet



Valley Slope

USGS "Water Resources Investigations Report 87-4207" definition of valley slope:
"the difference of elevations divided by distance between points 10% and 85% of the total distance measured along the low-water channel of the stream from the site to the basin divide"

Project: John T
Assisted by: Wayne K
Date: 1/10/2007

back to I&E form

Valley Slope *(ft/mi)*: 16.9

Clear Cells

Stream Distance from Downstream Contour to Site *(ft)*: 250

Measured Data from Topographic Map:

Elevation at Downstream Contour *(ft)*	OR *(m)*	Distance from Previous Contour *(ft)*
655		
660		2600
665		2250
670		1920
675		1480
680		1170
685		990
690		1000
695		1130
697		500

Field data collection

With the background data gathered and an understanding of the perceived problems and risks, the designer is ready to make a field visit to the site. Actual field measurements from the subject site are used to customize the analysis. The local stream morphology section of the spreadsheet is a way to record and interpret field observations of the bankfull condition.

Step 1 Observe the roughness of the channel, which is affected by vegetation, obstructions, irregularities in cross section, and meandering. Select a value for Manning's *n* from the pull-down menu on the I&E spreadsheet, based on channel description.

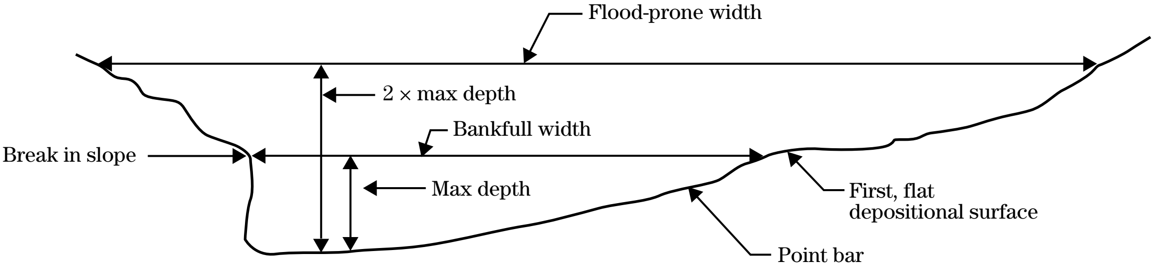
Step 2 During the field visit, walk at least two meander lengths of the stream channel, identifying bankfull indicators. Mark the elevations of indicators with flags, and use a hand level or other survey instrument to determine the height above existing flowline. Best indicators are the first flat depositional surface, top of washed root zone, and a break in slope angle on the streambank.

Refer to figure TS3C–5 (Steffen, Roseboom, and Kinney 2000) for guidance on locating bankfull indicators. The regional curve predictions for channel dimensions (fig. TS3C–3) are mean depths. Bankfull indicators identified in the field will be measured at maximum bankfull depth, and maximum depth may be 0.5 to 2.0 times the mean bankfull depth predicted by the regional curve data. Therefore, during the field investigation, do not expect bankfull indicators to be found at the mean depth predictions unless the channel cross section is a flat bottomed rectangle. A further description on the identification of bankfull indicators is provided in NEH654.05.

Step 3 After measuring several bankfull indicator elevations, look for converging evidence to support your selection of indicators. When selected indicators are zeroed in to within a few tenths of a foot, take an average, and use the result as your field identified bankfull stage. Also, at a riffle location, measure the distance across the channel at the bankfull elevation. Note: If the channel is undergoing active downcutting (CEM stage 3 or 4 (fig. TS3C–2)), there will not be any reliable bankfull indicators.

Figure TS3C–5 Bankfull indicators used for field identification

Bankfull stage (approximate 1.5 year or 67 percent chance)



Typical bankfull indicators may be:

- First, flat depositional surface
- Top of washed root zones
- Top of point bar or other deposits
- Change in size of substrate materials
- Lowest extent of woody vegetation
- Topographic break in slope
- Change in nature and amount of debris deposits
- Zone of washed rock

Step 4 Survey a cross section at the nearest riffle (fig. TS3C–6), extending out on each side at least to the flood plain elevation. The survey data will be used to calculate the cross-sectional area at the field identified bankfull stage. To determine a representative channel slope, survey at least several hundred feet along the streamflow line, at riffle locations. Since channel slopes are often quite flat, it is critical to take accurate measurements at a minimum of three or more riffles to determine channel slope.

Step 5 Measure the radius of curvature, Rc, (fig. TS3C–7 (FISRWG 1998)) of the channel bend(s) in the project area. Alternatively, this can be done using a recent aerial photo, if desired.

Step 6 During the field visit, measure the characteristics of the bed load. Larger cobbles indicate higher velocity flow. Sieve a bed load sample and do a pebble count, or estimate the D_{90} bed-load size (the size mesh through which 90 percent of the bed load would pass). Do the same for the D_{50} bed-load size. More information on sediment sampling is provided in NEH654 TS13A.

Data analysis and assessment

Analysis of the field data involves first determining the value of several standard parameters used to describe stream morphology: width-to-depth ratio, entrenchment ratio, sinuosity, and the ratio of radius of curvature to bankfull width. These parameters will be used to assess the condition of the stream and the potential for stabilization. Bankfull discharge and flow velocity are determined in several ways from the field data. The ultimate goal is to develop confidence in the analysis by matching discharge and velocity measurements from as many sources as possible.

Step 1 Plot the riffle cross section on the cross-sectional spreadsheet subroutine (fig. TS3C–6) and enter a flow depth equal to the maximum bankfull depth as determined from the field bankfull indicators. Cross-sectional area, velocity, discharge, and hydraulic radius will be computed using Manning's equation and displayed on the subroutine page. If the actual channel slope data is absent on the I&E sheet, the cross-sectional subroutine will use a slope estimate based on entries from the sinuosity determination.

Step 2 Width-to-depth ratio is determined from the bankfull width and the mean bankfull depth.

Step 3 Bankfull width can be entered directly from the field measurement, or measured from the plotted cross section.

Step 4 Mean bankfull depth can be determined by dividing the cross-sectional area at the field-determined maximum bankfull elevation by the stream width at the maximum bankfull elevation.

Step 5 The entrenchment ratio compares the bankfull width to the width of flow when the stream reaches twice the maximum bankfull depth for the bankfull discharge. On the I&E spreadsheet, enter maximum bankfull depth (from the cross section taken at the riffle) and the width of the channel or flood plain at twice the depth; the entrenchment ratio will be automatically determined.

Step 6 Enter the measured radius of curvature; its ratio to bankfull width is automatically calculated by the spreadsheet.

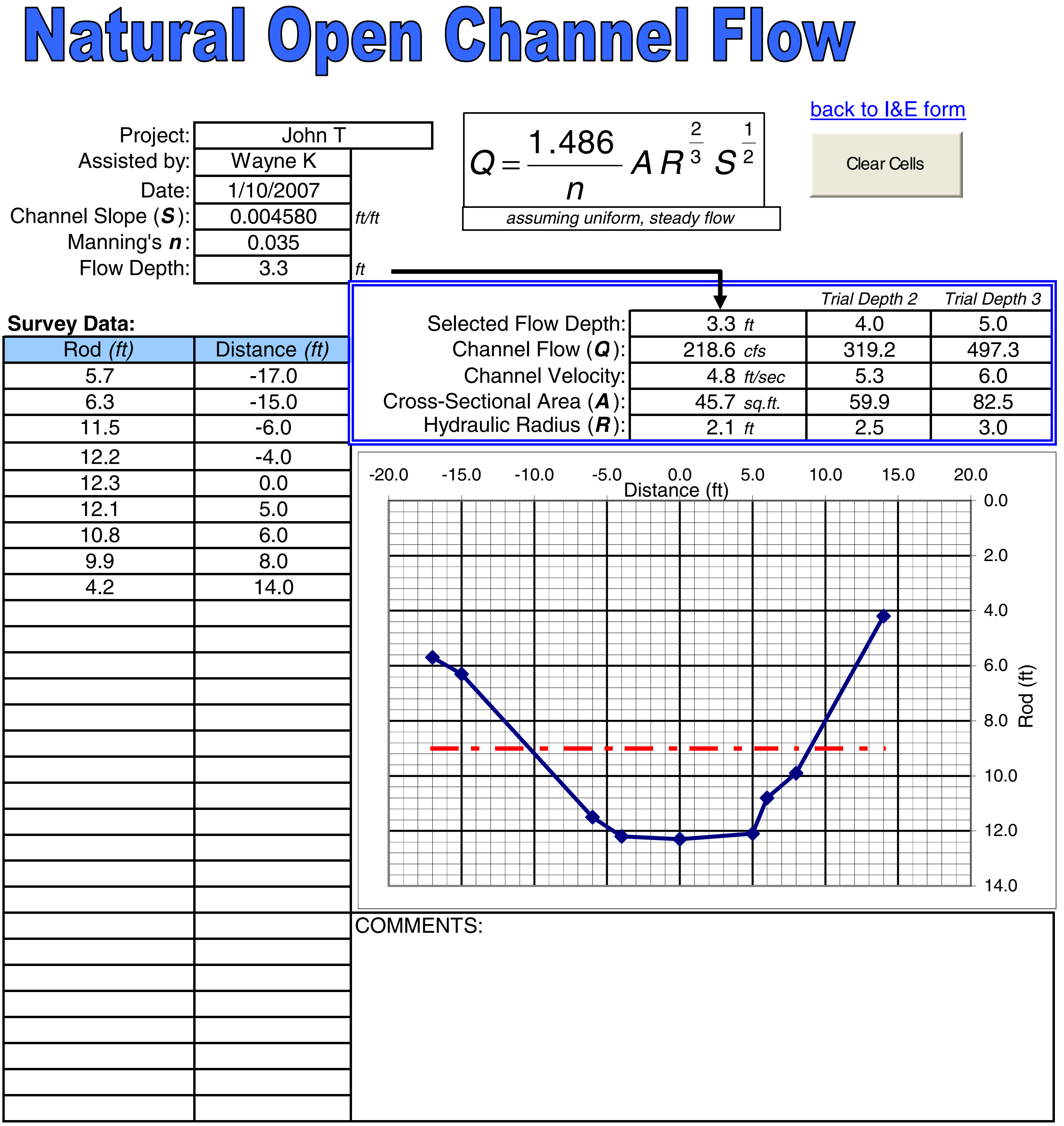
Step 7 Enter the discharge calculated by the cross-sectional subroutine at maximum bankfull depth as the selected Q on the I&E spreadsheet, or select your own best estimation of bankfull discharge based on all of the foregoing data (including the regression analysis and other background investigation).

Step 8 Enter the field-determined bed-load sizes on the spreadsheet.

Step 9 The spreadsheet will display a series of four bankfull velocity checks:

- velocity required to move D_{90} bed load
- velocity from cross-sectional subroutine (using Manning's equation on actual surveyed cross section and slope)
- velocity calculated from basic field data (using a modified Manning's equation with mean depth in place of hydraulic radius)
- velocity from the selected Q entry, using $V=Q/A$ and a cross-sectional area determined from the basic field data section

Figure TS3C–6 Cross-sectional subroutine from stream stabilization spreadsheet



Natural Open Channel Flow

back to I&E form

Clear Cells

$$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

assuming uniform, steady flow

Project:	John T
Assisted by:	Wayne K
Date:	1/10/2007
Channel Slope (***S***):	0.004580 *ft/ft*
Manning's ***n***:	0.035
Flow Depth:	3.3 *ft*

		Trial Depth 2	*Trial Depth 3*
Selected Flow Depth:	3.3 *ft*	4.0	5.0
Channel Flow (***Q***):	218.6 *cfs*	319.2	497.3
Channel Velocity:	4.8 *ft/sec*	5.3	6.0
Cross-Sectional Area (***A***):	45.7 *sq.ft.*	59.9	82.5
Hydraulic Radius (***R***):	2.1 *ft*	2.5	3.0

Survey Data:

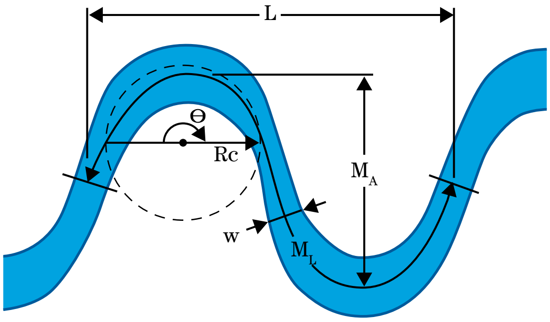
Rod *(ft)*	Distance *(ft)*
5.7	-17.0
6.3	-15.0
11.5	-6.0
12.2	-4.0
12.3	0.0
12.1	5.0
10.8	6.0
9.9	8.0
4.2	14.0

COMMENTS:

Step 10 Velocities from all four calculations should be very close and should be sufficient to move the D_{90} bed load. If more than 1.0 feet per second difference is observed between these four values, review to see if there is a mistake in data entry. If not, the bankfull indicators may be in error and need to be rechecked.

Step 11 After all the velocities compare well, compare the bankfull dimensions with those predicted by the regional curves, and compare the selected Q with the discharge predicted by the gage data and/or the regression equation. Modify entries as needed to develop confidence that the stream condition is understood. The field indicators should be the main guide, not the regional curve data or the regression equation predictions, as the field indicators are specific to the stream being investigated. Also, if the stream segment is in channel evolution stage 3 or 4, there will be no reliable bankfull indicators, and the designer will be forced to rely on flow relationships developed from other similar watersheds and experience gained from previous comparisons.

Figure TS3C–7 Typical stream morphology illustrating radius of curvature



L	Meander wavelength
M_L	Meander arc length
w	Average width at bankfull discharge
M_A	Meander amplitude
Rc	Radius of curvature
Θ	Arc angle

Departure analysis

Now that the designer has determined the bankfull or channel forming discharge in the stream segment, some analysis of the stream condition compared to stable streams can begin.

Condition 1: Is the flood plain elevation at or near the elevation of maximum bankfull depth?

Yes. The channel is connected to the flood plain. Discharges larger than bankfull begin to spread out over the flood plain, slowing velocities and dissipating energy. The channel has not experienced significant downcutting. CEM stage 1 or 6 would apply: a stable configuration. The entrenchment ratio (width at twice maximum bankfull depth/ bankfull width) will be greater than 2.5.

No. The channel is not connected to the flood plain. Discharges larger than bankfull will remain inside the channel with little or no opportunity to spread out onto the flood plain. This is evidence of current or past downcutting. The channel evolution process is active and its morphology is adjusting to regain equilibrium with flow characteristics. Incised channels such as this are likely to continue to erode laterally to build a flood plain. CEM stage could be 2, 3, 4, or 5. The entrenchment ratio will be less than 2.5. Entrenchment ratio will be smallest in stage 2 or 3 channels and then increase to about 2.5 or more as channel nears a new equilibrium in stage 6. The exception to this condition will be low-gradient, channelized streams with insufficient energy to erode the channel boundary, even when entrenched.

Condition 2: Is the channel bed in riffle locations comprised of bed-load material or is it residual (hard) silt, clay, or bedrock?

Bed-load material. The channel is probably not actively downcutting. Bed-load material is not being swept away by streamflow. If the entrenchment ratio is low (less than 2.5), the channel is most likely in the widening phase of the CEM, stage 4 or 5.

Residual (hard) silt, clay, or bedrock. Bed-load material is being swept out of this reach of channel, leaving the residual material exposed at the riffle locations. The channel is actively downcutting (CEM stage 3). If the streambed is not stabilized, this reach of stream will go through all six CEM stages and the degradation will advance upstream until it meets resistance in the form of bedrock, bridge floor, and culvert. Channels can be downcutting even when the entrenchment ratio is over 2.5. Streams are not considered entrenched until they degrade to twice the maximum bankfull depth, but degradation begins as soon as the bottom begins to be eroded.

Condition 3: Is the width-to-depth ratio less than 10 with an entrenchment ratio less than 1.4 (a deep, narrow channel)?

Yes. Width-to-depth ratios can be small (less than 10) in low gradient, fine-grained, or sinuous channels. However, these channel types are always connected to the flood plain in stable situations. Therefore, width-to-depth ratios less than 10, combined with entrenchment, are good indicators that downcutting has occurred in the past or is actively occurring at present (CEM stage 2, 3, 4 or 5). If, in addition, the sinuosity is low (less than 1.2), it is likely that the stream has been channelized to create the entrenched condition.

No. If width-to-depth is greater than 20, suspect an overwidened stream segment and sediment transport problems (CEM stage 5). This condition could indicate an aggrading stream segment.

Condition 4: Is the velocity calculated from the cross-sectional subroutine of the I&E spreadsheet much faster or much slower than that required to move the D_{90} bed-load material?

Much faster—Excessive velocities indicate that bed-load material is too small to resist existing velocities. Therefore, downcutting is probably occurring (CEM stage 3). Check the status of condition 2. Streams with only very fine-grained bed-load material will have excessive velocities compared to D_{90} material size. Vertical stability of these streams cannot be assessed using bed-load material size estimates.

Much slower—Slow velocity could indicate an aggrading system where the heavy bed load generated upstream cannot be transported through the system. These conditions often occur in delta areas above impoundments or at confluences with larger streams. They also occur when channel velocities change due to slope changes (at the downstream end of a channelized reach), when width-to-depth ratios increase dramatically or when there is an exceptionally large contribution of bed load just upstream.

Condition 5: Is the radius of curvature-to-bankfull width (Rc/W) ratio less than 1.8?

Yes. The situation is outside of the normal range of planform stability. It may be necessary to realign the channel or walk away from the project. Natural, stable channel radius of curvature-to-bankfull width ratios vary widely, but most commonly range from 2.3 to 2.7 or higher. With a radius of curvature-to-bankfull width ratio less than 1.8, the possibility of a channel cutoff at this point increases dramatically.

I&E spreadsheet details

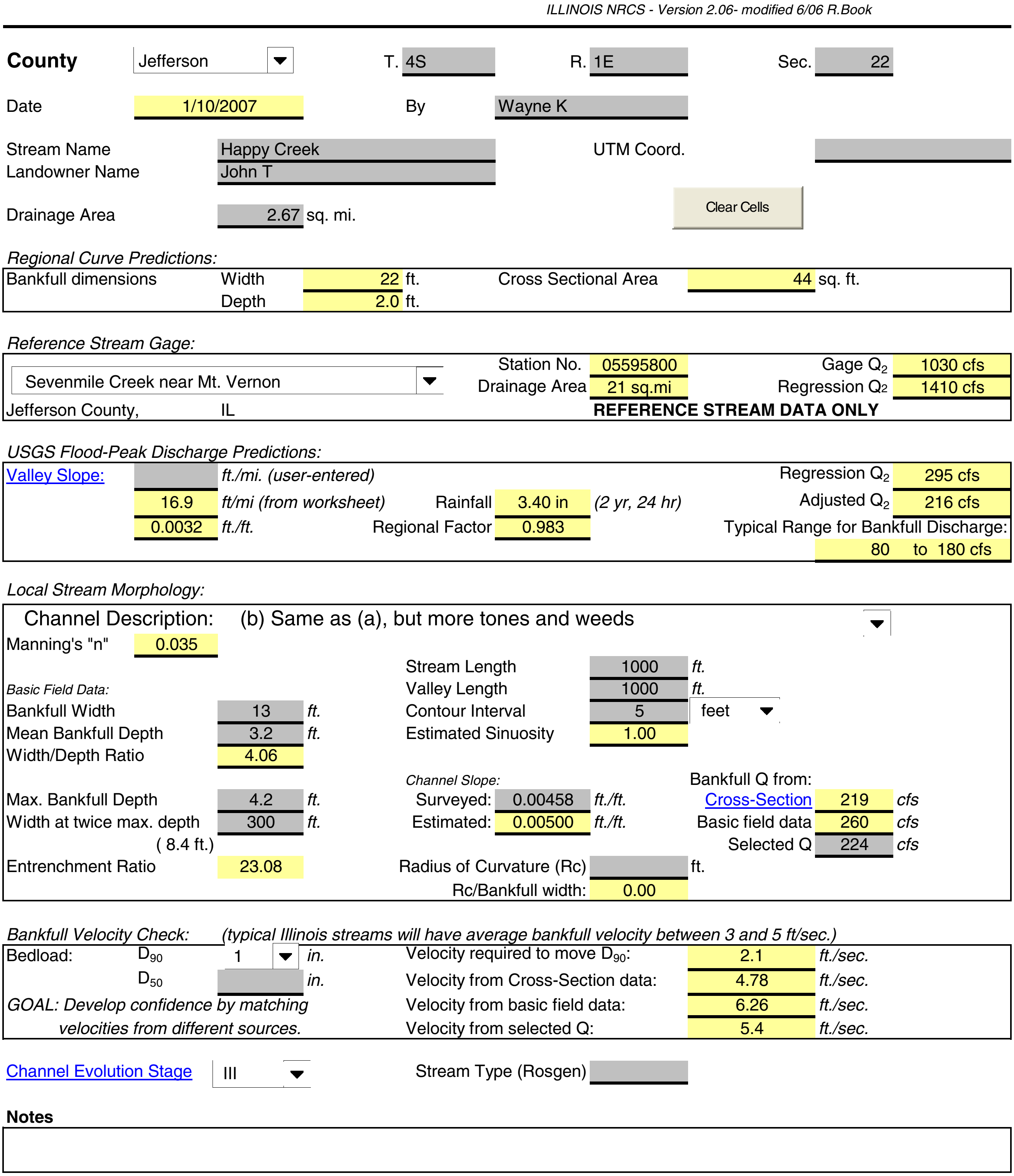
The inventory and evaluation function of the stream I&E spreadsheet includes the following introduced in the discussion of suggested I&E procedure (figs. TS3C–4, TS3C–6, and TS3C–8) in this technical supplement:

- streambank I&E form
- cross-sectional subroutine
- valley slope subroutine

In addition to the above, the spreadsheet also includes design sheets to determine dimensions and material quantities for certain standard stream stabilization practices, and automatically fills out the applicable Illinois standard drawings:

- rock riffles
- stone toe protection
- stream barbs

Figure TS3C–8 Stream stabilization I&E form from spreadsheet



ILLINOIS NRCS - Version 2.06- modified 6/06 R.Book

County Jefferson T. 4S R. 1E Sec. 22

Date 1/10/2007 By Wayne K

Stream Name Happy Creek UTM Coord.
Landowner Name John T

Drainage Area 2.67 sq. mi.

Regional Curve Predictions:

Bankfull dimensions	Width	22 ft.	Cross Sectional Area	44 sq. ft.
	Depth	2.0 ft.		

Reference Stream Gage:

Sevenmile Creek near Mt. Vernon
Jefferson County, IL

Station No.	05595800	Gage Q_2	1030 cfs
Drainage Area	21 sq.mi	Regression Q_2	1410 cfs

REFERENCE STREAM DATA ONLY

USGS Flood-Peak Discharge Predictions:

Valley Slope: ft./mi. *(user-entered)*
16.9 *ft/mi (from worksheet)* Rainfall 3.40 in *(2 yr, 24 hr)*
0.0032 *ft./ft.* Regional Factor 0.983

Regression Q_2 295 cfs
Adjusted Q_2 216 cfs
Typical Range for Bankfull Discharge: 80 to 180 cfs

Local Stream Morphology:

Channel Description: (b) Same as (a), but more tones and weeds
Manning's "n" 0.035

		Stream Length	1000	*ft.*
Basic Field Data:		Valley Length	1000	*ft.*
Bankfull Width	13 *ft.*	Contour Interval	5	feet
Mean Bankfull Depth	3.2 *ft.*	Estimated Sinuosity	1.00	
Width/Depth Ratio	4.06			

Channel Slope:
Surveyed: 0.00458 *ft./ft.*
Estimated: 0.00500 *ft./ft.*

Bankfull Q from:
Cross-Section 219 *cfs*
Basic field data 260 *cfs*
Selected Q 224 *cfs*

Max. Bankfull Depth 4.2 *ft.*
Width at twice max. depth 300 *ft.*
(8.4 ft.)
Entrenchment Ratio 23.08

Radius of Curvature (Rc) ft.
Rc/Bankfull width: 0.00

Bankfull Velocity Check: *(typical Illinois streams will have average bankfull velocity between 3 and 5 ft/sec.)*

Bedload: D_{90}	1 *in.*	Velocity required to move D_{90}:	2.1	*ft./sec.*
D_{50}	*in.*	Velocity from Cross-Section data:	4.78	*ft./sec.*
GOAL: Develop confidence by matching		Velocity from basic field data:	6.26	*ft./sec.*
velocities from different sources.		Velocity from selected Q:	5.4	*ft./sec.*

Channel Evolution Stage III Stream Type (Rosgen)

Notes