Development, Verification, and Application of a Simplified Method to Estimate Total-Streambed Scour at Bridge Sites in Illinois

By Robert R. Holmes, Jr. and Chad J.Dunn

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CONVERSION FACTORS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
feet per feet (ft/ft)	1.00	meter per meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
square mile (mi^2)	2.590	square kilometer
square mile (mi^2)	259.0	hectare

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Abstract

A simplified method to estimate total-streambed scour was developed for application to bridges in the State of Illinois. Scour envelope curves, developed as empirical relations between calculated total scour and bridge-site characteristics for 213 State highway bridges in Illinois, are used in the method to estimate the 500-year flood scour. These 213 bridges, geographically distributed throughout Illinois, had been previously evaluated for streambed scour with the application of conventional hydraulic and scour-analysis methods recommended by the Federal Highway Administration. The bridge characteristics necessary for application of the simplified bridge scour-analysis method can be obtained from an office review of bridge plans, examination of topographic maps, and reconnaissance-level site inspection. The estimates computed with the simplified method generally resulted in a larger value of 500-year flood total-streambed scour than with the more detailed conventional method. The simplified method was successfully verified with a separate data set of 106 State highway bridges, which are geographically distributed throughout Illinois, and 15 county highway bridges.

INTRODUCTION

Bridge failures are most commonly caused by the scouring of the streambed from around bridge foundations during floods (Richardson and others, 1993). All bridges over waterways in the United States must be evaluated for the risk of failure because of streambed scour (Thomas O. Willett, United States Department of Transportation, Federal Highway Administration, written commun., 1991). Each bridge must be rated on the basis of Item 113 of the National Bridge Inspection Standards (Code of Federal Regulations, 1992). The Item 113 rating is assigned by determining the stability of the bridge structure when the streambed is subjected to scour resulting from a flood of either 500-year recurrence or 1.7 times the 100-year recurrence interval (1.7 times the 100-year flood discharge is recommended in Federal Highway Administration (FHWA) Hydraulic Engineering Circular Number 18 (HEC-18) as a reasonable approximation to the 500-year flood peak discharge), either case will be referred to as the 500-year flood in this report. For Illinois streams, the 500-year flood discharge regression relation determined by Curtis (1987) essentially ranges from 1.25 to 1.3 times the 100-year flood discharge, which indicates that 1.7 times the 100-year flood discharge is more conservative than the method outlined in Curtis (1987). The 500-year flood scour has typically been estimated conventionally from equations contained in the HEC-18 manual (Richardson and others, 1993). The hydraulic information needed in the HEC-18 equations is determined by simulating the bridge-site hydraulic conditions using computer models for estimating the lateral water depths and velocity distributions for each cross section in one or two dimensions.

The conventional hydraulic and scour-analysis method is time consuming and expensive, requiring field surveying and extensive office time to complete the necessary computations. The Illinois Department of Transportation is analyzing all State highway bridges by applying conventional hydraulic and scour-analysis methods (more than 500 analyses have been completed to date (1995)). However, complete hydraulic and scour analysis of the more than 10,000 local agency bridges (those bridges not owned and maintained by the State of Illinois) is not possible because of financial and personnel constraints. The U. S. Geological Survey (USGS), in cooperation with the Illinois Department of Transportation (IDOT), developed a simplified method to estimate the total-streambed scour at local agency bridges to assist in addressing the FHWA mandate. Total-streambed-scour envelope curves are utilized in the method. These curves relate total-streambed scour with easily obtainable bridge-site characteristics. In this report, total-streambed scour is the sum of the local and contraction scour only. Very little hydraulic information is required in the method and the analysis can be completed in less time than the conventional method. The method offers local agencies an economical tool to analyze bridge sites for total-streambed scour. The tradeoff in time saved is that the estimates from the simplified method may be significantly more conservative than scour estimates from the conventional method.

This report describes the development, verification, and application of a simplified method to estimate total-streambed scour at bridge sites in Illinois. The method was developed from 213 bridge sites for which conventional total-streambed bridge-scour analyses had been done by IDOT and verified from 106 and 15 bridge sites for which conventional total streambed bridge-scour analyses had been done by IDOT and county highway departments, respectively. The method was applied to two county highway bridges in central Illinois, which are included as examples in this report.

SIMPLIFIED METHOD TO ESTIMATE TOTAL-STREAMBED SCOUR

Development of the Method

In developing the simplified method, the main objective was to relate some combination of easily obtainable bridge-site characteristics to an estimate of the total-streambed scour resulting from the 500-year flood discharge. A further constraint, at the request of IDOT, was that no hydraulic computations would be necessary to use the simplified method. The bridge-site characteristics would be obtained from a reconnaissance-level bridge-site visit, 7.5-minute topographical maps, and bridge plans. The method to estimate streambed scour was initially envisioned in the form of a multiple regression equation or envelope curves of total-streambed scour.

More than 500 State highway bridges that had been analyzed by IDOT personnel using conventional methods were screened based on the following criteria:

1. Sufficient site-characteristic data were available in the bridge-site file.
2. The bridge was not part of a dual system of bridges (being either the upstream or downstream bridge) because the hydraulics of dual bridges would be dissimilar to those of single bridges. Most local agency bridges are single-span bridges.

IDOT is organized into nine geographical districts. To attain a good spatial distribution of data, an attempt was made to select an equal number of bridges from each district (approximately 30–35 per district). On the basis of the above criteria, 319 bridges (fig. 1) were selected for developing the method. These data are contained in a computer file listed in appendix 1.

For each of the 319 bridges, characteristics of the bridge site, easily calculated or measured from either the bridge plans, topographical maps, or a field visit, were determined and compiled in a data base along with the estimated total-streambed scour resulting from the 500-year flood. Of the 319 bridges, 213 were used to develop and calibrate the simplified method to estimate total-streambed scour. The 213 bridge site data sets were divided into multi-span and single-span categories (124 multi-span and 89 single-span). The remaining 106 bridges in the data set were utilized to verify the applicability of the simplified method.

At the beginning of the development of the method, several attempts were made to develop a valid multiple linear regression (MLR) model to estimate the total-streambed scour resulting from the 500-year flood discharge. After 40 MLR model trials, the model calibrations for both multi- and single-span bridges resulted in correlation coefficients less than 0.6 and a model fit through the center of the data, which would mean underestimating scour calculated

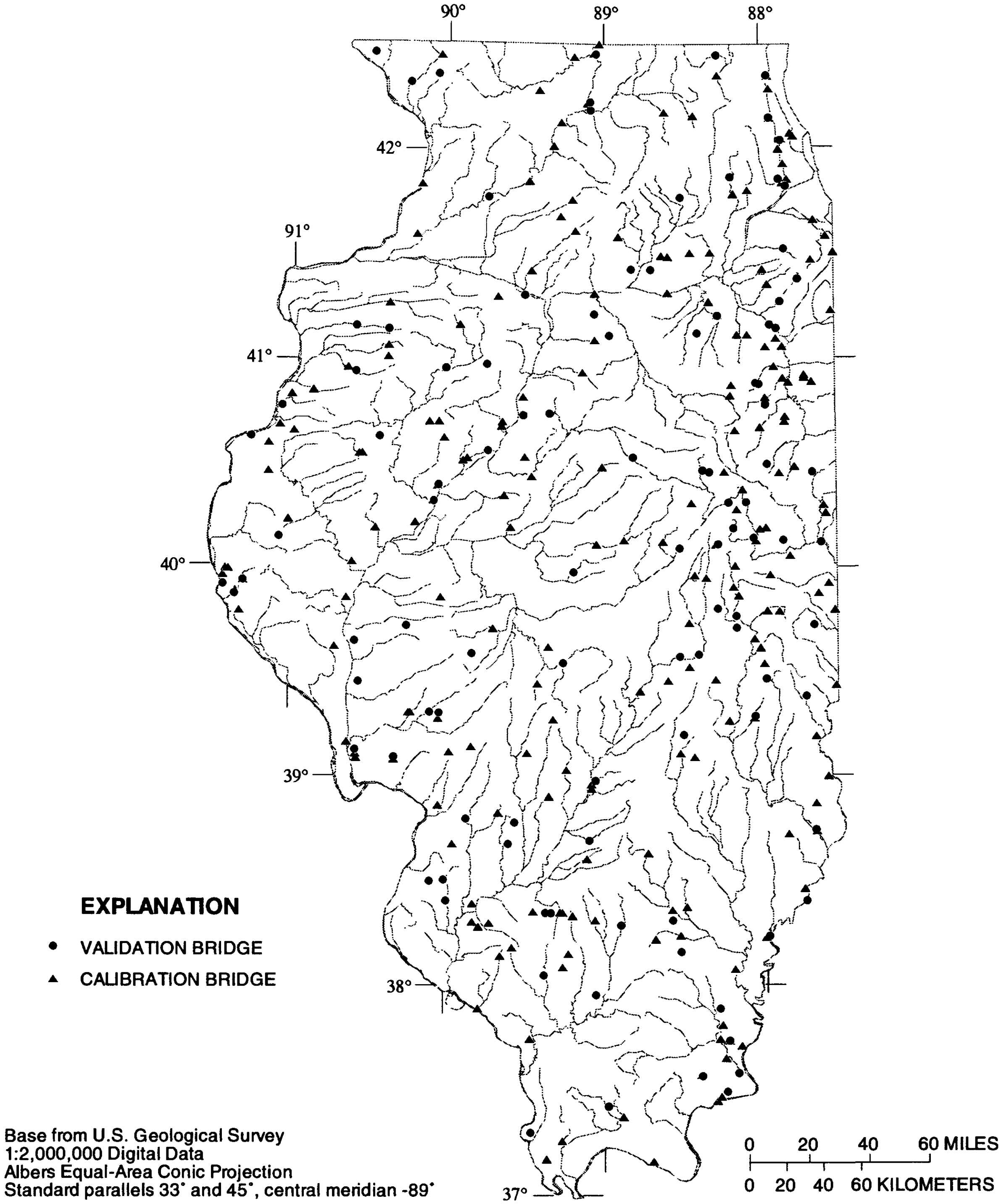


Figure 1. Location of bridges used in calibration and verification of the simplified method to estimate total-streambed scour in Illinois.

with the conventional method on many of the bridges, which is an unacceptable method to estimate scour.

Many of the bridge-site characteristics were plotted with the total 500-year flood scour that was estimated with the conventional method. No relation was found between any single bridge-site characteristic and total-streambed scour. A representative example illustrating no relation among specific bridge-site characteristics and the conventionally estimated total-streambed scour is shown in figure 2.

By trying to represent quasi-hydraulic properties (because actual hydraulic computations can not be made) with combinations of various bridge-site characteristics to serve as a surrogate hydraulic property, it was thought that relations between these surrogate hydraulic properties and the estimated 500-year total scour may be obtained. For example, a hydraulic property such as the flow Reynolds number, which is the flow velocity times a characteristic depth divided by the kinematic viscosity, could possibly be represented by a surrogate measure of velocity, estimated as the 100-year flood discharge divided by the bridge length times the low steel to bed distance, and a surrogate characteristic depth, such as the low steel to channel bed distance. Starting with combinations of characteristics for both multi-span and single-span bridges that represent the bridge site hydraulic properties of constriction ratio, flow Reynolds number, and Froude number, the total scour and these hydraulic properties were plotted as a means to envelop the data points to provide a curve whereby scour could be estimated. These physically meaningful prediction variables provided no basis to envelop the data in such a way as to not be overly conservative in the estimation of total-streambed scour. For example, a plot of the surrogate Reynolds number for multi-span bridge and total-streambed scour is shown in figure 3. An enveloping curve will result in very conservative estimates of total-streambed scour. The plots of the other "pure" surrogate variable of constriction ratio and Froude number were very similar in appearance to figure 3 for both single- and multi-span bridges, and as such did not provide a useful relation. Therefore, a trial-and-error scheme was used to add various characteristics and adjust exponents to optimize the enveloping of the data points for each of the six curves. After seven iterations using the verification data set, two curves each for single-span and multi-span bridges are used in the final simplified method (figs. 4–7). Some of the 213 bridge sites are not plotted in figures 4–7, as some of the bridge characteristic values required in the predictor variable were missing from the data files. As can be seen in the four envelope curve (figs. 4–7), the physical significance of the predictor variable has been lost in the trial-and-error process. The bridge characteristics utilized in the envelope curves (figs. 4–7) will be defined later and shown on example bridge site drawings in figures 8 and 9.

Different envelope curves are utilized in the simplified method depending on the type of bridge (single- or multi-span). For single-span bridges, two envelope curves are utilized in the method, and similarly, for multi-span bridges, two envelope curves are also utilized. To estimate the total scour for a single- or multi-span bridge, the predictor variable for each envelope curve must first be computed. The predictor variable varies for each envelope curve and consists of an equation combining some of the bridge-site characteristics from table 1. Once the predictor variable is known, the total-scour estimate is determined from the envelope curve. The final total-scour estimate from the simplified method is determined as the minimum of the two envelope curves for multi-span bridges, or the minimum of the two curves for single-span bridges. For example, if the predictor variable for multi-span envelope curve 1 in figure 5 is computed to be 1 and the predictor variable for multi-span envelope curve 2 in figure 6 is computed to be 200, then the total-scour estimate from envelope curve 1 would be 15 ft and the total-scour estimate from envelope curve 2 would be 9 ft. Therefore, the final total-scour estimate would be the minimum of 9 ft and 15 ft, or 9 ft.

One curve per type of bridge was intended to be needed; however, multiple curves were found to be necessary to make the simplified method as robust as possible. If only one curve per type of bridge (single- or multi-span) had been used, the total-scour estimate at some bridge sites would have been highly overestimated because of potential anomalies in the combinations of the bridge characteristics. By utilizing multiple curves and taking the minimum, the number of anomalous total-scour estimates was decreased.

Verification of the Method

The 106 State highway bridges not utilized in the development and calibration of the simplified method were used, along with 15 county highway

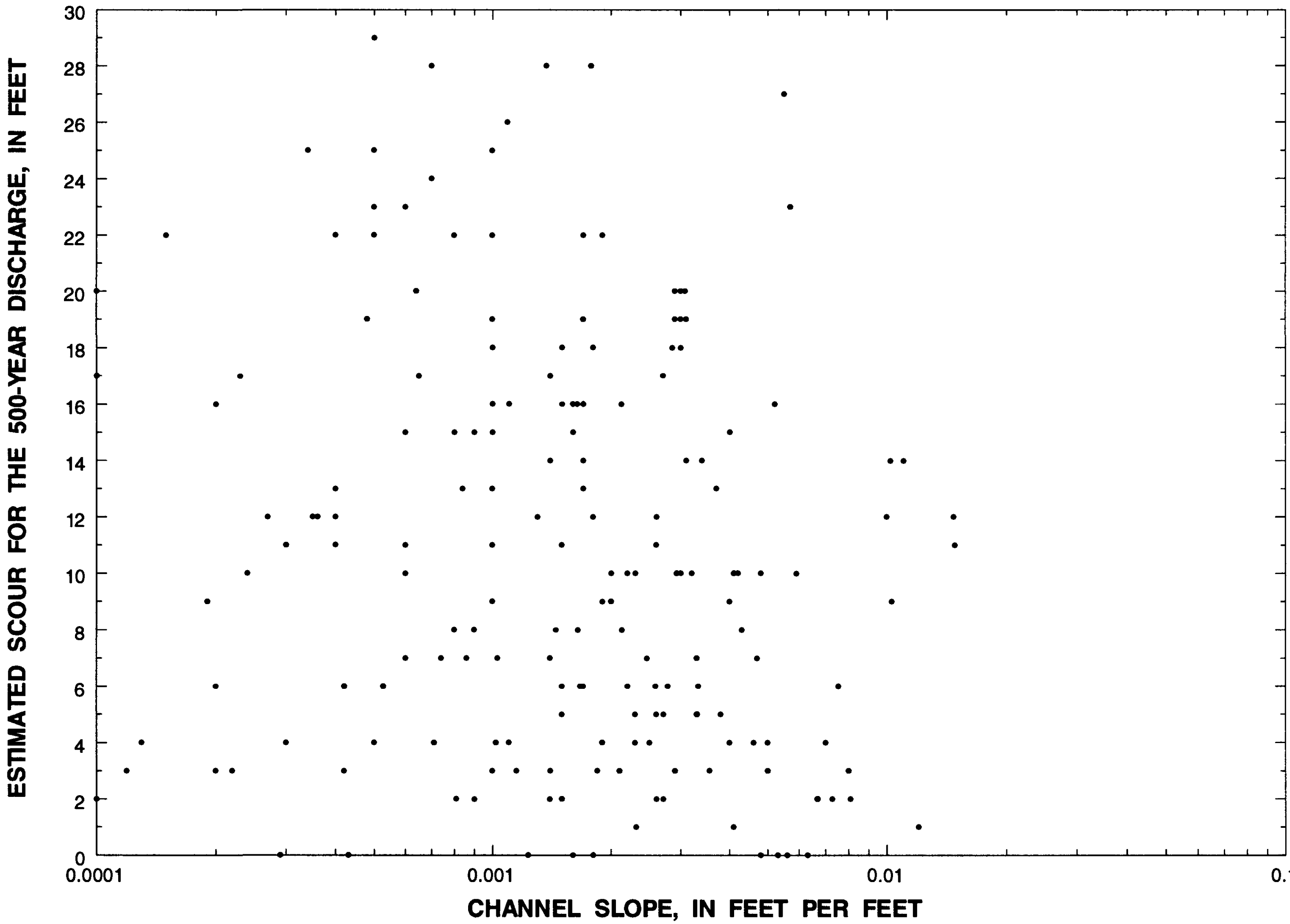


Figure 2. Channel slope near the bridge and estimated scour determined with conventional methods for a 500-year flood for bridge sites in Illinois.

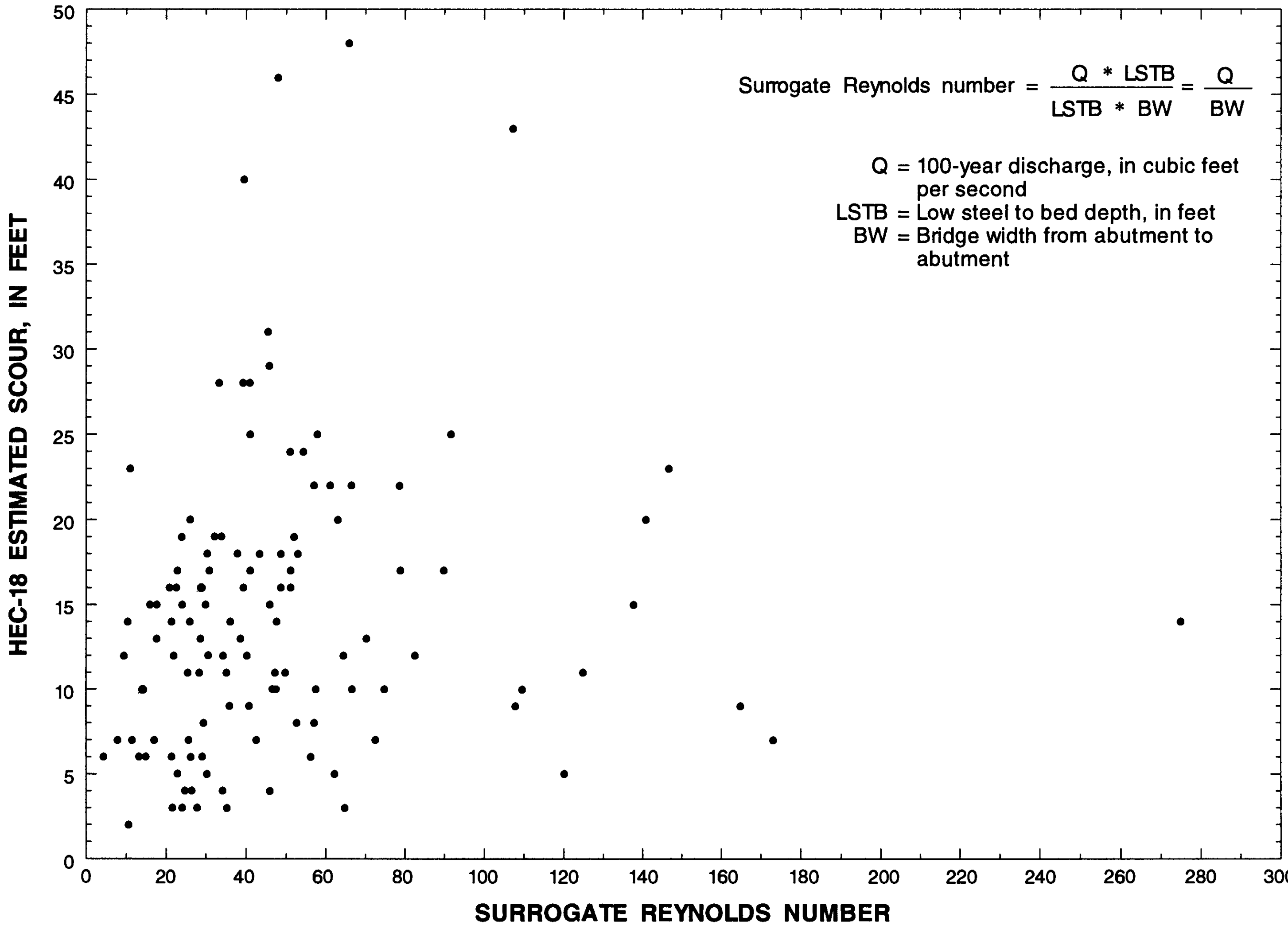


Figure 3. Surrogate Reynolds number and total scour estimated with the conventional method for multi-span bridges in Illinois.

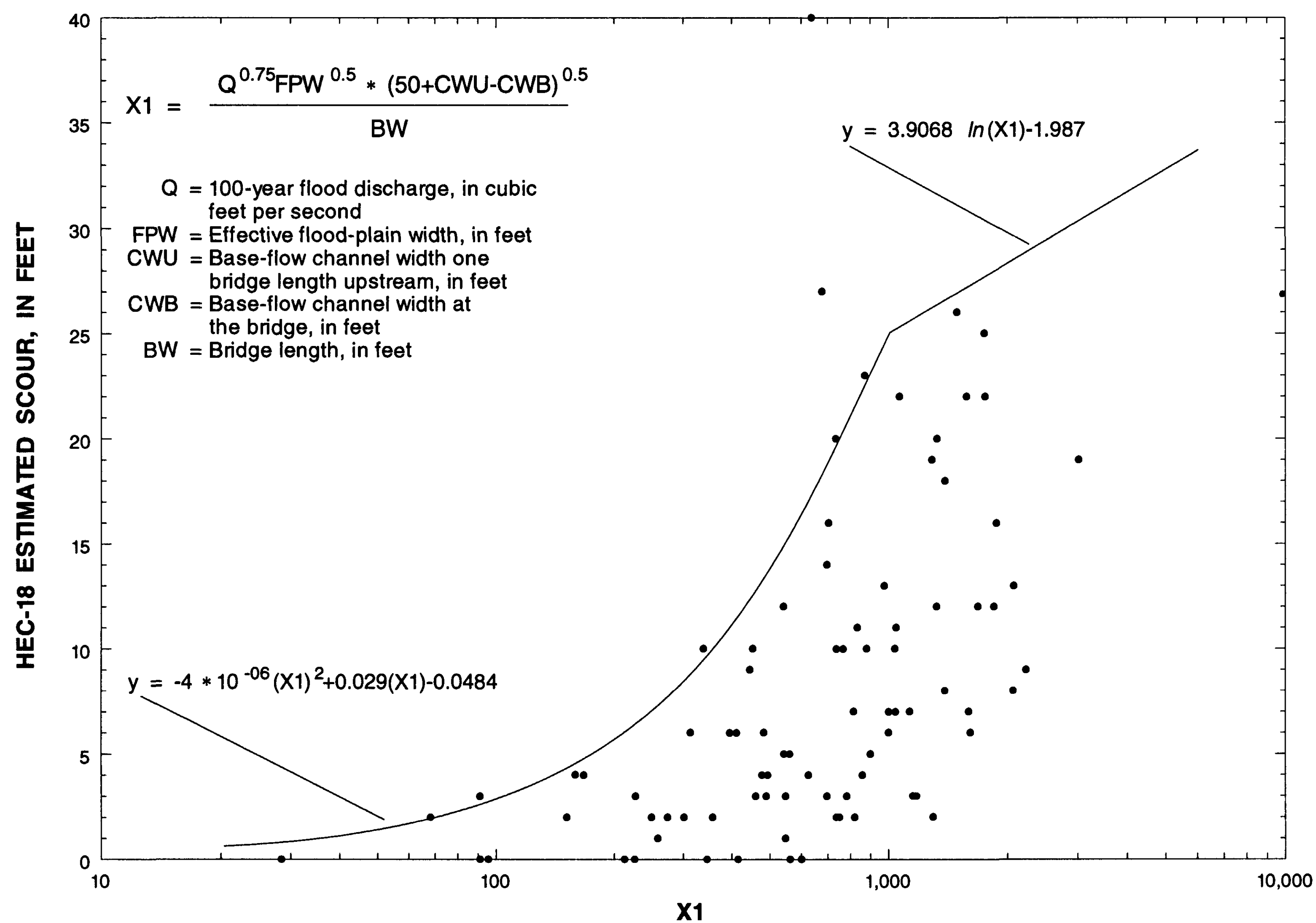


Figure 4. Single-span envelope curve 1 for total scour estimated with the conventional method for bridge sites in Illinois.

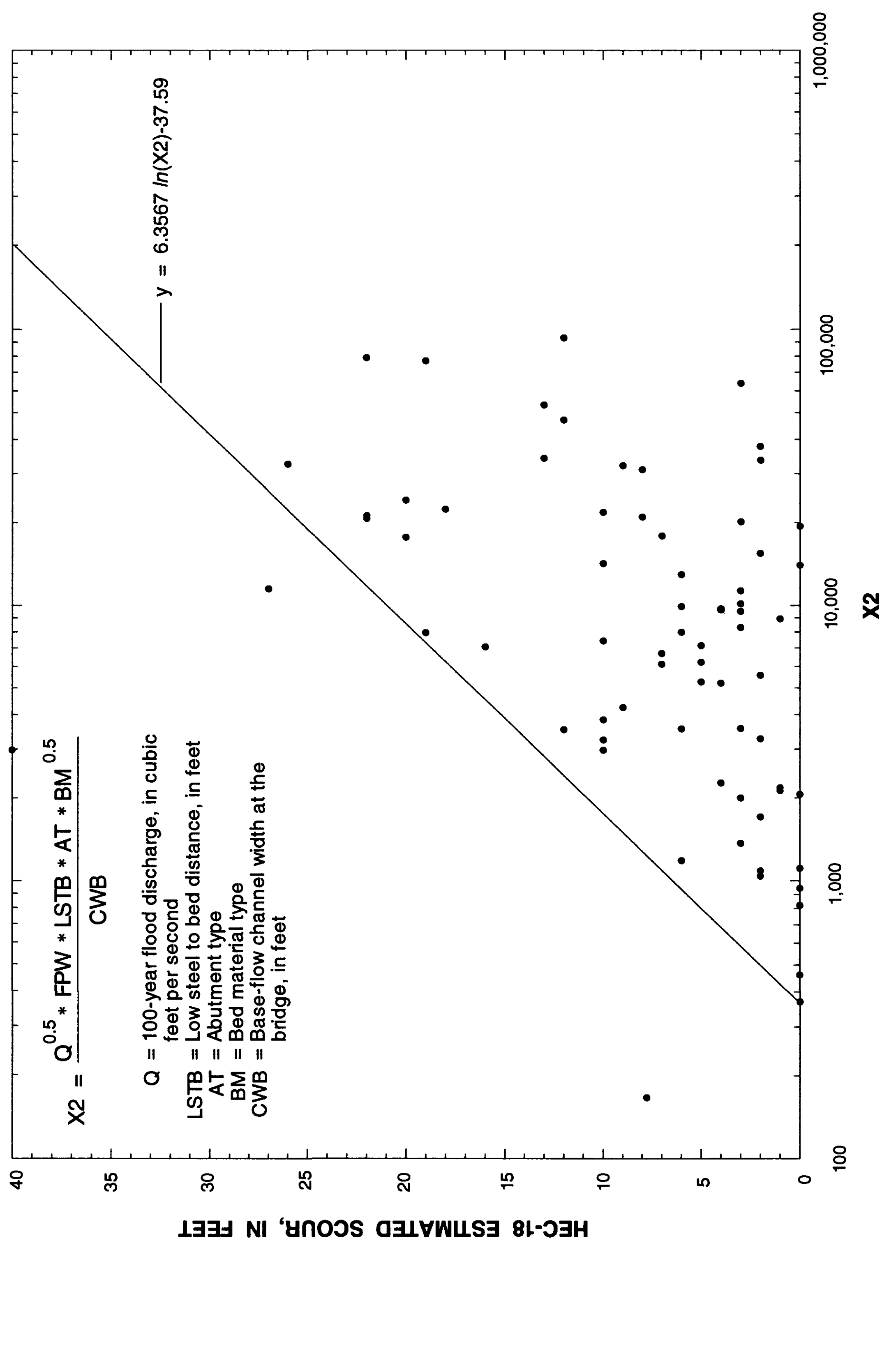


Figure 5. Single-span envelope curve 2 for total scour estimated with the conventional method for bridge sites in Illinois.

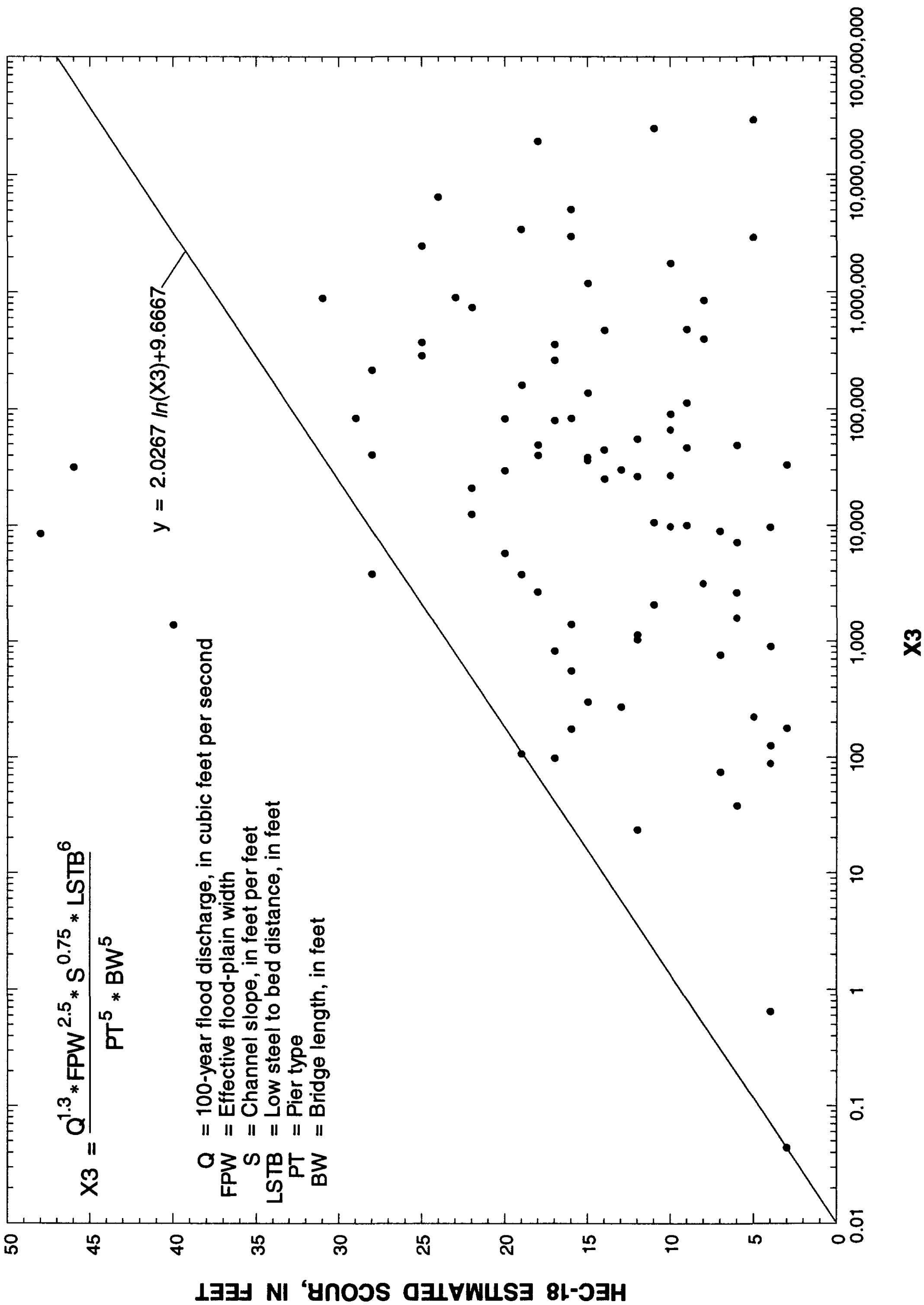


Figure 6. Multi-span envelope curve 1 for total scour estimated with the conventional method for bridge sites in Illinois.

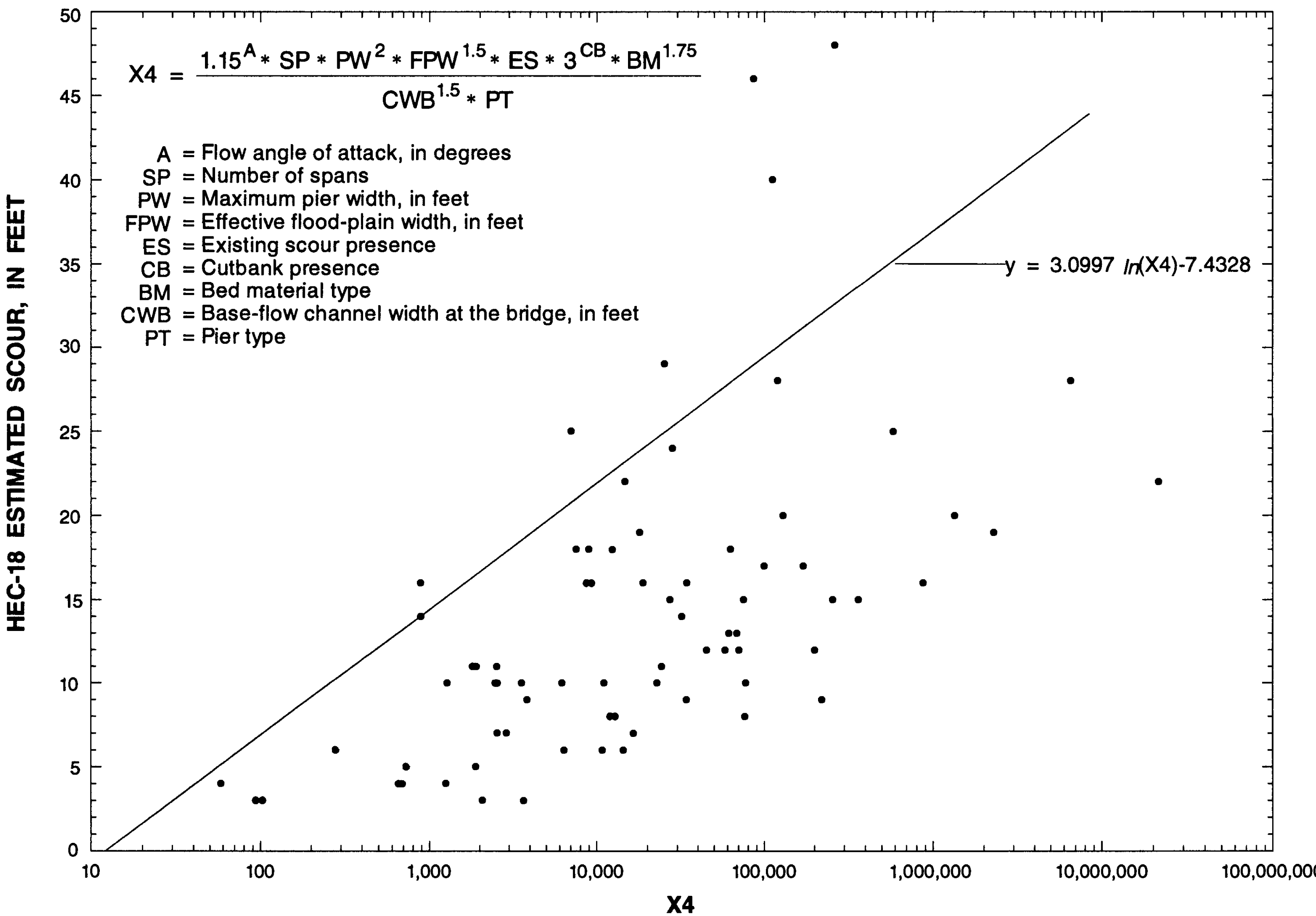


Figure 7. Multi-span envelope curve 2 for total scour estimated with the conventional method for bridge sites in Illinois.

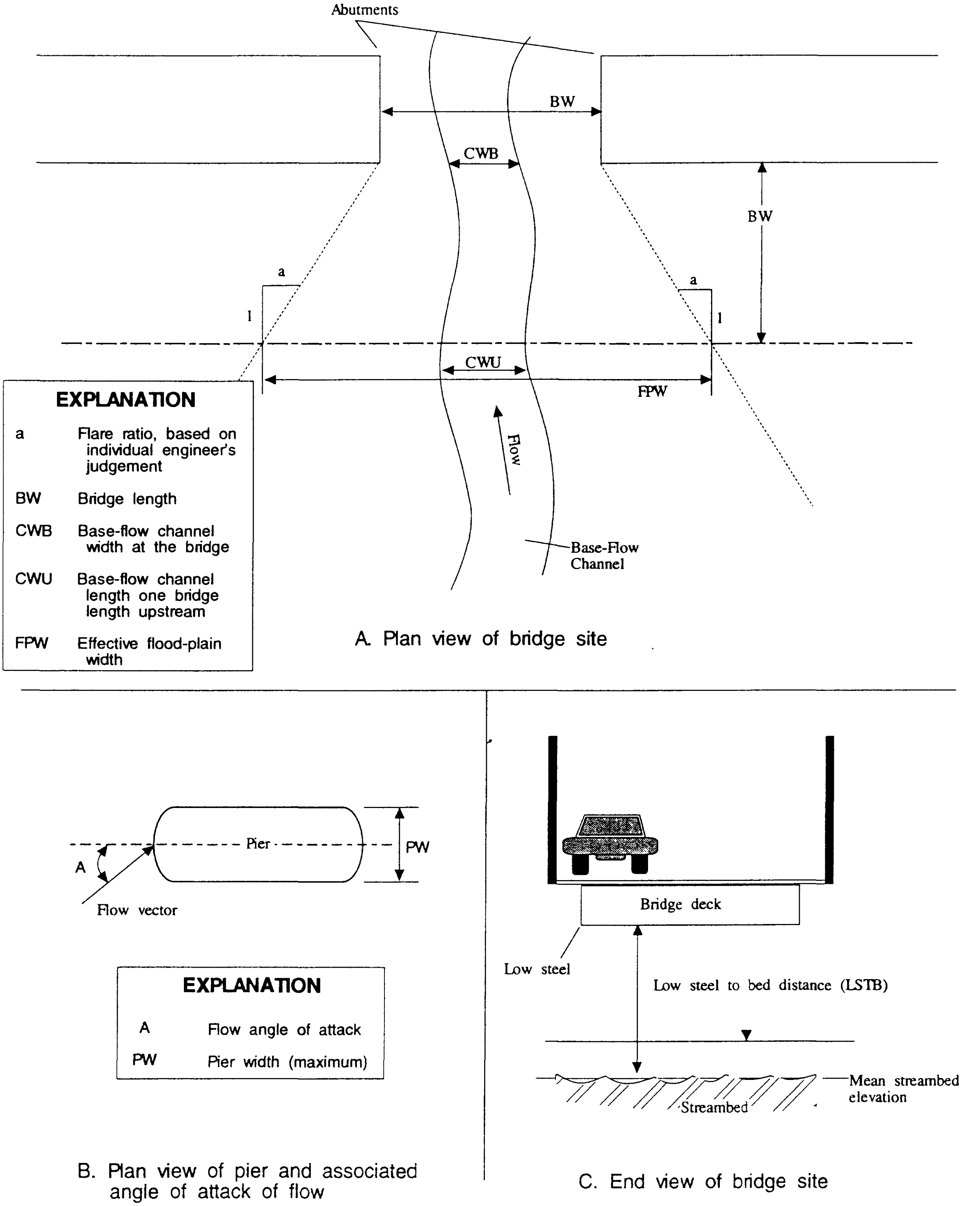
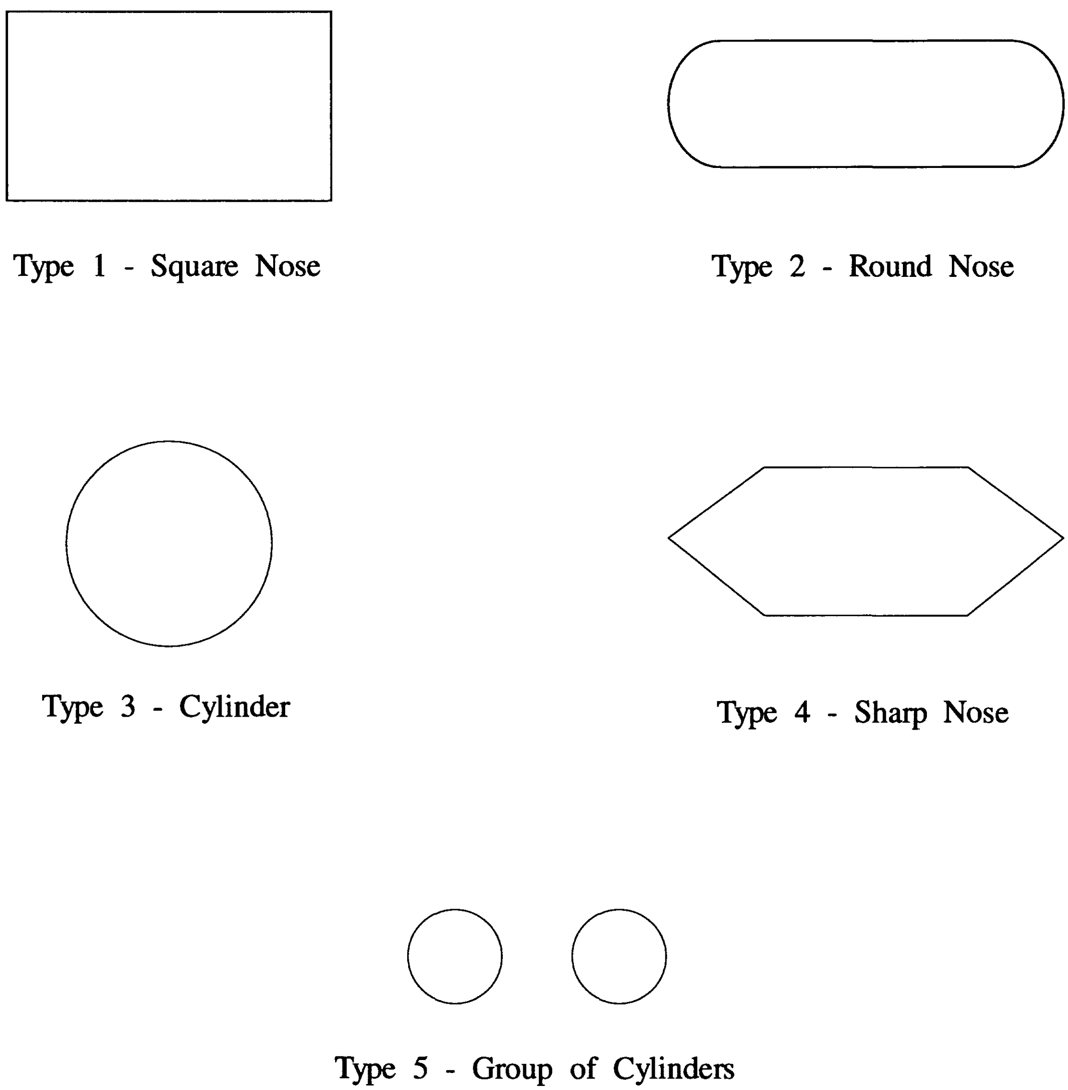


Figure 8. Plan view and detail of bridge site and characteristics for a hypothetical bridge site.



D. Common pier shapes (adapted from Richardson and others, 1993)

Figure 8. Continued.

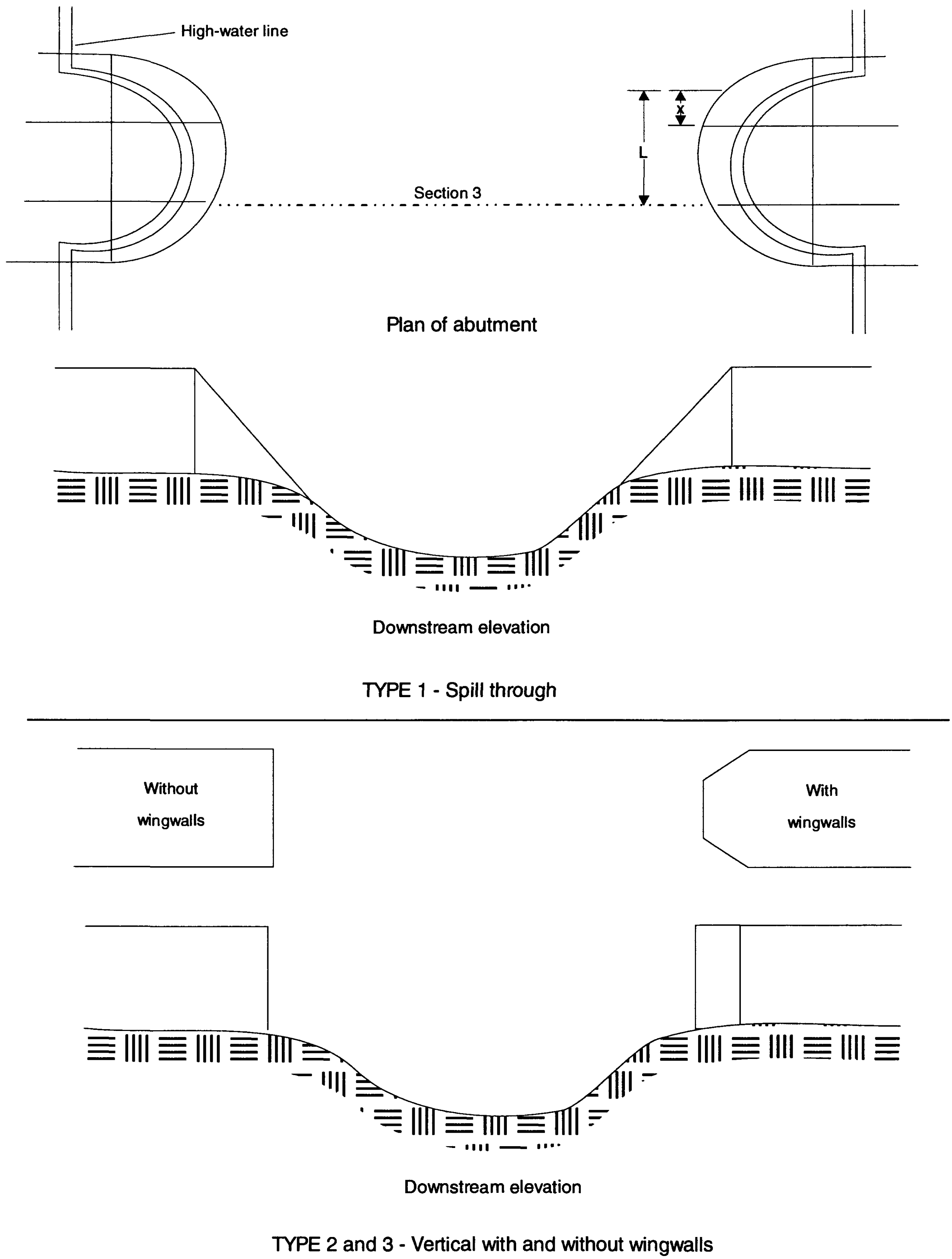


Figure 9. Abutment types (adapted from Matthai, 1968) used in the simplified method.

Table 1. Bridge-site characteristics and associated abbreviations used in the simplified total-streambed scour estimation method in Illinois

Characteristic	Abbreviation	Explanation
Drainage area	DA	That area, in square miles, in a drainage basin above the bridge.
100-year flood discharge	Q	The discharge for a particular drainage area of a particular stream that has a 1-percent chance of occurring in any given year. For Illinois streams, this value can be determined by the U.S. Geological Survey regression equations (Curtis, 1987; Allen and Bejcek, 1979). The units are cubic feet per second.
Effective flood-plain width	FPW	The width of the flood plain, one bridge length upstream from the bridge, that would have water of some velocity overtopping it during the 100-year flood discharge flowing through the bridge opening. For cases with road overflow, only the part of the flood plain containing water flowing at some velocity and proceeding through the bridge opening is considered part of the effective flood-plain width. Without detailed hydraulic information, this value is sometimes difficult to determine. Engineers have sometimes used the bridge-length opening multiplied by a constant value to determine the effective flood-plain width. One value often used is 3 times the bridge length, although no definitive data is available to support the use of this value. Best judgment in selecting the value of the effective flood-plain width (see fig. 8) is required by the user.
Base-flow channel width one bridge length upstream	CWU	The top width of the base-flow channel, in feet, from right descending bank to left descending bank bridge length upstream one bridge length upstream from the bridge (see fig. 8).
Base-flow channel width at the bridge	CWB	The width of the base-flow channel, in feet, from right descending bank to left descending bank at the bridge (see fig. 8).
Bridge length	BW	The bridge length, in feet, from abutment to abutment (see fig. 8).
Abutment type	AT	The type of abutment that is present at the bridge: spill through abutments–1, vertical abutments with wingwalls–2, vertical abutments without wingwalls–3, (see fig. 9).
Cutbank presence	CB	From a visual inspection of the bridge site, the amount of cutting present in the streambanks. This is a subjective assessment of the amount of cutting present (none–1, slight–2, or extensive–3).
Low steel to bed distance	LSTB	The distance, in feet, between the lowest member of the bridge (that part of the bridge to contact the rising water surface first) and the approximate mean streambed elevation near mid-channel (see fig. 8).
Bed material type	BM	The predominate type of bed material present in the streambed determined from a visual inspection (cobbles–1, clay–2, gravel–3, sand/gravel–4, silt/clay–4, sand/silt–4.5, sand–5).
Channel slope	S	The local channel slope, in feet per feet, near the bridge site.
Pier type	PT	The type of pier present at the bridge (see fig. 8D). For bridges with multiple types of piers, by trial-and-error, the pier type that results in the most conservative scour estimate.
Flow angle of attack	A	The predominate angle, in degrees, at which the flow during floods will impact the bridge pier (see fig. 8B).
Number of spans	SP	The number of spans present at the bridge site.
Maximum pier width	PW	The maximum pier width of the bridge.
Existing scour presence	ES	From a visual site inspection, the degree, if any, of noticeable scour at the piers, abutments or wingwalls. This is a subjective assessment of the amount of existing scour (none–1, slight–2, moderate–3, or extensive–4).

bridges, to verify the applicability of the simplified method. For each bridge, the bridge-site characteristics were used with the applicable envelope curves to estimate the 500-year flood total scour. Each scour estimate determined with the simplified method was compared with the 500-year flood scour estimated with the conventional scour-estimation method. A comparison of the total 500-year flood scour estimated with the simplified method and the 500-year flood scour determined with the conventional method is shown in figure 10. Perfect agreement of results between methods is the 1:1 slope line through the origin. The goal in the verification of the method was to have the verification data plot on or just to the right of the line of perfect agreement. This would indicate that the simplified method either produced an exact match to the conventional method or overestimated the total scour estimated with the conventional method.

In developing the simplified method, seven development/verification iterations were made to try to plot the data in figure 10 as close to the line of perfect agreement as possible, without many points plotting to the left of the line. As shown in figure 10, the verification of the method was successful. Total scour was underestimated with the simplified method in comparison to the conventional method at only six of the bridges verification data sets. One bridge was underestimated by more than 25 ft, but review of the data file for that bridge indicates that the conventional estimate of scour was affected by having over 70 percent of the flow apportioned to the overbank at the approach cross section. Because HEC-18 computations are very sensitive to the amount of overbank discharge, the unusually high scour estimate is because of the inappropriate flow apportionment at the approach cross section.

Limitations of the Method

The simplified method was developed from data at bridge sites in Illinois where conventional scour analysis had previously been done. The following ranges of values for bridge characteristics were present at the bridge sites used to develop the simplified method.

Drainage Area:	single-span: 0.29 to 43.3 mi^2 multi-span: 1.05 to 8,610 mi^2
100-Year Discharge:	single-span: 66 to 5,319 ft^3/s multi-span: 696 to 67,000 ft^3/s
Flood-plain width:	single-span: 14 to 292 ft multi-span: 54 to 3,278 ft
Base-Flow Channel Width at Bridge:	single-span: 12 to 74 ft multi-span: 16 to 1,000 ft
Base-Flow Channel Width One Bridge Length Upstream:	single-span: 10 to 184 ft multi-span: 13 to 1,274 ft
Bridge Length:	single-span: 13 to 95 ft multi-span: 20 to 966 ft
Low Steel To Bed Distance:	single-span: 3.7 to 23.7 ft multi-span: 5 to 51 ft
Channel Slope at Bridge:	single-span: 0.00013 to 0.0148 multi-span: 0.0001 to 0.011
Angle of Attack on Bridge Pier:	multi-span: 0 to 35 degrees
Number of spans:	multi-span: 2 to 14
Pier Width:	multi-span: 1 to 8 ft

In addition, the development of the method was limited to bridge sites in the data set that satisfied the following criteria.

- No dual bridges were used (for example, interstate highways).
- The ratio of base-flow channel width at the bridge to base-flow channel width one bridge length upstream was greater than 0.5.
- The ratio of base-flow channel width at the bridge to flood-plain width was greater than 0.03.

Total-streambed scour estimates from the simplified method for bridge sites with characteristics outside of these ranges should be used with caution.

The simplified method was developed to assist in performing the enormous task of evaluating the over 10,000 local agency bridges in Illinois. The simplified method was developed in a way such that hydraulic computations were not necessary. As such the estimates of scour are conservative. However, in cases where the estimate of scour from the simplified method presents a borderline bridge instability problem, a conventional analysis should be performed. In addition, the simplified method should not be used for design of new bridge structures.

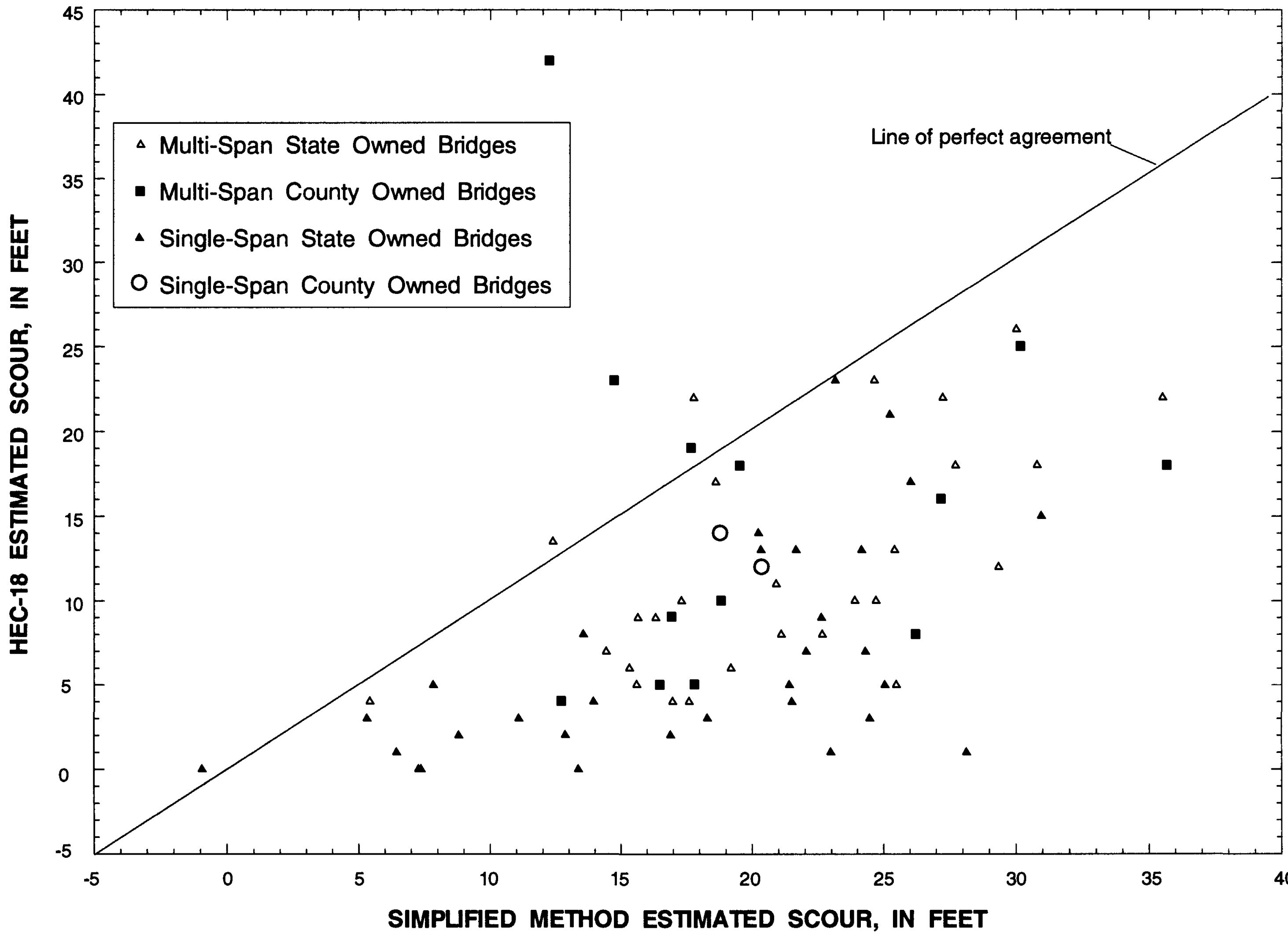


Figure 10. Estimated total-streambed scour determined with the conventional method and estimated total-streambed scour determined with the simplified method for bridge sites in Illinois.

Application of the Method

For each bridge to be evaluated with the simplified method, several bridge-site characteristics must first be determined. The field/office data sheets that can be used to compile the bridge-site characteristic data needed to successfully apply the simplified method are shown in figures 11 and 12 for single- and multi-span bridges, respectively. After the necessary bridge-site characteristic data have been compiled, the user can manually determine the estimates from the applicable total-streambed-scour envelope curves and compute the minimum value. The computer program ILSCOUR (see Appendix 2), specifically written to estimate the total-streambed scour with the simplified method, also can be used to determine the estimates.

For both single- and multi-span bridges, the 100-year flood discharge is required for the simplified method. This may have been previously determined during design of the bridge or may have to be computed from methods outlined either in Curtis (1987) for rural basins or Allen and Bejcek (1979)[1] for urbanized basins in northeastern Illinois. Options to compute the 100-year discharge by either of these two methods are contained in the ILSCOUR program.

As previously discussed, the simplified method, by design, is conservative in estimating the total-streambed scour at a bridge site. Each bridge would be analyzed with the simplified method and bridges evaluated as stable for the total-scour estimate with the simplified method would need no further analysis, whereas bridges that were determined to be unstable or borderline, could be reanalyzed on the basis of the conventional method outlined in HEC-18. Furthermore, the past occurrence of scour at the bridge site during major floods should also be taken into consideration. The years that greater than 50- and greater than 100-year floods have occurred for the period of record at USGS stream-gaging stations are listed in table 2 for the gages shown in figure 13 to assist in documenting when significant floods have occurred on various streams in Illinois.

An example of both a single- and multi-span bridge is presented to demonstrate the application of the simplified method. Total time to collect office and field data and compute the total-streambed scour estimate was approximately one-half day per bridge site.

Single-Span Bridges

Knowledge of all the bridge-site characteristics on the field data sheet shown in figure 10 is required in the simplified method for single-span bridges. Once the bridge-site characteristics are determined and listed on the field data sheet, the two envelope curves for single-span bridges should be used to determine the estimated total scour at the bridge site. The collection of the necessary data from single-span bridges and determination of the total-scour estimate are demonstrated in the following example.

A single-span bridge over Flatville Drainage Ditch near Flatville, Illinois (fig. 14) was evaluated. Site plans, provided by the Champaign County Engineer's Office, and a topographic map of the bridge site and associated watershed were reviewed in the office before visiting the site. For many bridge sites, the construction plans contain such information as the abutment type, drainage area, 100-year flood discharge, bed-material type, or bridge length from abutment to abutment. However, for this bridge site, only abutment type and bridge length were readily determinable. From the topographic map, the drainage area was determined to be 10.8 mi^2. In addition, the elevations and thalweg distance required to compute the 100-year flood discharge outlined in Curtis (1987) were also determined from the topographic map. The Rainfall Intersection and Geographic Region values are determined from the graphs in Curtis (1987).

At the bridge site, most of the other bridge-site characteristics were determined and listed on the field data sheet for single-span bridges (fig. 15). For this bridge site, flood-plain width for the 100-year flood was taken as the distance between the top of the banks (37 ft). This is because for flows above the banks, the water would go over the road, as this area is very flat. For the simplified method, the effective flood-plain width is that width which contains water of some velocity greater than zero (not ponded) that goes through the bridge. For cases with road overflow, only the part of the flood plain containing water flowing at some velocity and proceeding through the bridge opening is considered part of the effective

[1]The method outlined by Allen and Bejcek (1979) is rarely used in Illinois as it has often yielded smaller 100-year flood discharges for urban basins when compared with the method outlined in Curtis (1987). If the Allen and Bejcek (1979) method is used, it is recommended that the larger of the two 100-year discharge estimates from these two methods be used.

Data-Collection Sheet
Simplified Method for Bridge Scour Estimation
FOR USE WITH SINGLE-SPAN BRIDGES ONLY

FIELD PARTY____________________ **County**____________________ **Date**______________
Structure Number_________________ **Feature Crossed**___________________________
Facility Carried____________________ **Location**_______________________________

TO BE COMPLETED IN THE FIELD OR FROM TOPOGRAPHIC MAP		COMPLETE IN OFFICE	
Flood-Plain Width For 100-Year Flood (FPW)	_______feet	Drainage Area	__________ sq. miles
Base-Flow Channel Width @bridge (CWB) Base-Flow Channel Width 1 Bridge Length Upstream (CWU)	_______feet _______feet	100-Year Flood (Q)	__________cfs
		Percent Imperviousness *(If using urban relations from Allen & Bejcek, 1979)*	__________
Bridge Length From (BW) Abutment to Abutment	_______feet	Elevation @ 10% distance from bridge to basin divide along stream thalweg	________feet
Abutment Type (AT) *(Spill Through–1, Vertical With Wingwalls–2, Vertical Without Wingwalls–3)*	_______	Elevation @ 85% distance from bridge to basin divide along stream thalweg	________feet
Cutbank Presence (CB) *(None–1, Slight–2, Extensive–3)*	_______	Distance between 85% and 10% elevation	________miles
Low Steel To Bed Distance (LSTB)	________feet	Rainfall Intensity *(from Curtis, 1987—USGS Water-Resources Investigations Report 87–4207)*	________inches
Bed Material (BM) *(Cobbles–1, Clay–2, Gravel–3, Sand/Gravel–4, Silt/Clay–4, Sand/Silt–4.5, Sand–5)*	__________	Geographic Region *(from Curtis, 1987—USGS Water-Resources Investigations Report 87–4207)*	__________

Information Entered Into Computer Program On________________

Entered By______________________________________

Estimated Scour____________________________________

Figure 11. Field and office data-collection sheet for single-span bridge sites in Illinois.

Data-Collection Sheet
Simplified Method for Bridge Scour Estimation
FOR USE WITH MULTI-SPAN BRIDGES ONLY

FIELD PARTY__________________ **County**____________________ **Date**_____________
Structure Number________________ **Feature Crossed**__________________________
Facility Carried___________________ **Location**________________________________

TO BE COMPLETED IN THE FIELD OR FROM TOPOGRAPHIC MAP	COMPLETE IN OFFICE
Flood-Plain Width For 100-Year Flood (FPW) ________feet	Drainage Area __________ sq. miles
Base-Flow Channel Width @bridge (CWB) ________feet Base-Flow Channel Width 1 Bridge Length Upstream (CWU) ________feet	100-Year Flood (Q) __________cfs
Bridge Length From (BW) Abutment to Abutment _______feet Number of Spans (SP) _______	Elevation @ 10% distance from bridge to basin divide along stream thalweg ________feet
Slope Of Channel in Vicinity of Bridge Site (S) _______feet/feet	Elevation @ 85% distance from bridge to basin divide along stream thalweg ________feet
Cutbank Presence (CB) ________ *(None–1, Slight–2, Extensive–3)* Existing Scour Near Piers/Abutment (ES) _________ *(None–1, Slight–2, Moderate–3, Extensive–4)*	Distance between 85% and 10% elevation _________miles
Pier Type (1, 2, 3, 4, 5, . . . see instructions) (PT) _________ Angle of Flow Attack on pier (A) _________	Rainfall Intensity ________inches *(from Curtis, 1987—USGS Water-Resources Investigations Report 87–4207)*
Maximum Pier Width (PW) _________feet Low Steel To Bed Distance (LSTB) _________feet	Percent Imperviousness __________ *(If using urban relations from Allen & Bejcek, 1979)*
Bed Material (BM) __________ *(Cobbles–1, Clay–2, Gravel–3, Sand/Gravel–4, Silt/Clay–4, Sand/Silt–4.5, Sand–5)*	Geographic Region __________ *(from Curtis, 1987—USGS Water-Resources Investigations Report 87–4207)*

Information Entered Into Computer Program On________________
Entered By____
Estimated Scour____

Figure 12. Field and office data-collection sheet for multi-span bridge sites in Illinois.

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded

[Q50, 50-year discharge (from Curtis, 1987); Q100, 100-year flood discharge (from Curis, 1987); ft^3/s, cubic feet per second; freq., frequency; No., number]

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
1	03336100	Big Four Ditch tributary near Paxton, Ill.	320	none	356	none	1956-80	25
2	03336500	Bluegrass Creek at Potomac, Ill.	4,780	1968	5,370	none	1950-82	33
3	03336900	Salt Fork near St. Joseph, Ill.	6,980	none	7,960	none	1959-91	33
4	03337000	Boneyard Creek at Urbana, Ill.	780	1979;1990-93	833	1979;1990-93	1948-93	46
5	03337500	Saline Branch at Urbana, Ill.	3,480	1964	3,870	1964	1937-75	39
6	03338000	Salt Fork near Homer, Ill.	9,770	1964	10,900	none	1945-82	38
7	03338100	Salt Fork tributary near Catlin, Ill.	731	none	828	none	1959-80	22
8	03338500	Vermilion River near Catlin, Ill.	30,000	1943	34,800	1943	1939-58	20
9	03338800	North Fork Vermilion River tributary near Danville, Ill.	1,040	1974	1,250	1974	1956-76	21
10	03339000	Vermilion River near Danville, Ill.	36,800	1943;1959;1939	41,400	1939	1915-21;1929;1931-93	71
11	03341700	Big Creek tributary near Dudley, Ill.	634	none	740	none	1961-75	15
12	03341900	Racoon Creek tributary near Annapolis, Ill.	63	none	72	none	1956-80	25
13	03343400	Embarras River near Camargo, Ill.	7,360	none	8,020	none	1961-93	33
14	03344000	Embarras River near Diona, Ill.	23,500	none	26,500	none	1939-40;1943;1945-47;1971-92	28
15	03344250	Embarras River tributary near Greenup, Ill.	68	1974	73	none	1956-80	25
16	03344425	Muddy Creek tributary at Woodbury, Ill.	140	none	172	none	1959-76	18
17	03344500	Range Creek near Casey, Ill.	3,400	1961	4,070	none	1951-91	41
18	03345500	Embarras River at St. Marie, Ill.	45,800	none	53,000	none	1908;1910-12;1915-93	83
19	03346000	North Fork Embarras River near Oblong, Ill.	25,200	1950	28,900	none	1941-93	53
20	03378000	Bonpas Creek at Browns, Ill.	7,060	1961	7,890	none	1941-93	53
21	03378635	Little Wabash River near Effingham, Ill.	12,400	none	13,700	none	1967-93	27
22	03378650	Second Creek tributary at Keptown, Ill.	796	1970	931	1970	1956-72	17
23	03378900	Little Wabash River at Louisville, Ill.	30,000	none	33,600	none	1966-92	27
24	03378980	Little Wabash River tributary at Clay City, Ill.	506	none	586	none	1959-80	22
25	03379500	Little Wabash River below Clay City, Ill.	48,000	none	56,200	none	1915-93	79
26	03379650	Madden Creek near West Salem, Ill.	1,260	1961	1,480	1961	1956-76	21
27	03380300	Dums Creek tributary near Iuka, Ill.	135	1961	155	1961	1956-80	25
28	03380350	Skillet Fork near Iuka, Ill.	17,000	1967	19,600	none	1966-83	18
29	03380400	Horse Creek tributary near Cartter, Ill.	796	none	927	none	1961-72	12
30	03380450	White Feather Creek near Marlow, Ill.	413	none	469	none	1956-80	25

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
31	03380475	Horse Creek near Keenes, Ill.	9,230	1961;1990	10,400	1961;1990	1960-90	31
32	03380500	Skillet Fork at Wayne City, Ill.	28,700	1961;1986;1990	33,300	1961;1990	1909-12;1915-21;1929-93	76
33	03381500	Little Wabash River at Carmi, Ill.	41,400	1961	47,300	none	1940-93	54
34	03381600	Little Wabash River tributary near New Haven, Ill.	333	1974	395	1974	1960-76	17
35	03382025	Little Saline Creek tributary near Goreville, Ill.	545	1969	601	none	1959-80	22
36	03382100	South Fork Saline River near Carrier Mills, Ill.	6,680	none	7,360	none	1966-93	28
37	03382170	Brushy Creek near Harco, Ill.	2,540	1977	2,850	none	1969-82	14
38	03382500	Saline River near Junction, Ill.	34,200	1945;1950;1964	39,900	none	1940-75	36
39	03382510	Eagle Creek near Equality, Ill.	1,020	none	1,090	none	1967-82	16
40	03382520	Black Branch tributary near Junction, Ill.	701	none	836	none	1960-72	13
41	03384450	Lusk Creek near Eddyville, Ill.	12,900	1985	14,800	1985	1968-93	26
42	03385000	Hayes Creek at Glendale, Ill.	7,230	1985	8,470	1985	1950-93	44
43	03385500	Lake Glendale Inlet near Dixon Springs, Ill.	1,670	none	1,890	none	1955-80	26
44	03386500	Sugar Creek near Dixon Springs, Ill.	2,910	1973	3,220	1973	1950-81	32
45	03612000	Cache River at Forman, Ill.	11,700	none	13,400	none	1923-87;1989-93	70
46	03612200	Q Ditch tributary near Choat, Ill.	480	none	560	none	1956-76	21
47	03614000	Hess Bayou tributary near Mound City, Ill.	925	none	1,030	none	1959-72	14
48	04087300	Lake Michigan tributary at Winthrop Harbor, Ill.	350	1969	419	none	1956-72	17
49	04087400	Kellogg Ravine at Zion, Ill.	726	1969	849	1969	1962-76	15
50	05414820	Sinsinawa River near Menominee, Ill.	11,300	1969	13,500	none	1968-93	26
51	05415500	East Fork Galena River at Council Hill, Ill.	10,400	1947	13,000	1947	1940-69	30
52	05418750	South Fork Apple River near Nora, Ill.	736	none	839	none	1961-80	20
53	05418800	Mill Creek tributary near Scales Mound, Ill.	916	none	1,060	none	1956-75	20
54	05419000	Apple River near Hanover, Ill.	14,100	none	16,000	none	1935-93	59
55	05420000	Plum River below Carroll Creek near Savanna, Ill.	12,300	none	14,300	none	1941-77	37
56	05435000	Cedar Creek near Winslow, Ill.	953	none	1,190	none	1952-76	25
57	05435500	Pecatonica River at Freeport, Ill.	18,700	none	21,800	none	1914-93	80
58	05435650	Lost Creek tributary near Shannon, Ill.	681	none	762	none	1961-76	16
59	05436900	Otter Creek tributary near Durand, Ill.	296	none	358	none	1961-80	20
60	05437000	Pecatonica River at Shirland, Ill.	20,500	none	22,600	none	1940-71	32

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
61	05437500	Rock River at Rockton, Ill.	33,300	none	36,600	none	1904-08;1915-19;1937;1940-93	65
62	05437600	Rock River tributary near Rockton, Ill.	543	none	619	none	1961-76	16
63	05437950	Kishwaukee River near Huntley, Ill.	290	none	314	none	1965-78	14
64	05438250	Coon Creek at Riley, Ill.	4,330	1978	4,880	1978	1962-91	30
65	05438300	Lawrence Creek tributary near Harvard, Ill.	303	none	350	none	1961-80	20
66	05438390	Piscasaw Creek below Mokeler Creek near Capron, Ill.	4,510	none	5,060	none	1970-79	10
67	05438500	Kishwaukee River at Belvidere, Ill.	13,600	none	15,600	none	1940-93	54
68	05438850	Middle Branch of South Branch Kishwaukee River near Malta, Ill.	450	none	511	none	1956-80	25
69	05439000	South Branch Kishwaukee River at De Kalb, Ill.	2,910	1983	3,400	1983	1926-33;1980-93	22
70	05439500	South Branch Kishwaukee River near Fairdale, Ill.	9,570	none	10,400	none	1940-93	54
71	05439550	South Branch Kishwaukee River tributary near Irene, Ill.	593	none	726	none	1959-76	18
72	05440000	Kishwaukee River near Perryville, Ill.	21,900	none	24,500	none	1940-93	54
73	05440500	Killbuck Creek near Monroe Center, Ill.	7,910	none	8,830	none	1940-80	41
74	05440650	Stillman Creek tributary near Holcomb, Ill.	336	none	393	none	1959-76	18
75	05440900	Leaf River tributary near Forreston, Ill.	260	none	316	none	1956-79	24
76	05441000	Leaf River at Leaf River, Ill.	10,600	none	12,100	none	1940-82	43
77	05441500	Rock River at Oregon, Ill.	57,300	none	64,300	none	1940-49	10
78	05442000	Kyte River near Flagg Center, Ill.	3,580	none	4,020	none	1940-51	12
79	05443500	Rock River at Como, Ill.	54,600	1973	59,000	1973	1915-86;1991-94	76
80	05444000	Elkhorn Creek near Penrose, Ill.	7,260	none	7,960	none	1938;1940-93	55
81	05444100	Spring Creek tributary near Coleta, Ill.	951	none	1,100	none	1959-72	14
82	05446000	Rock Creek at Morrison, Ill.	5,180	1946	5,820	1946	1940-71;1978-93	48
83	05446500	Rock River near Joslin, Ill.	55,100	none	60,500	none	1940-93	54
84	05446950	Green River tributary near Amboy, Ill.	603	none	755	none	1961-76	16
85	05447000	Green River at Amboy, Ill.	6,950	1981	7,590	1981	1940-82	43
86	05447050	Green River tributary No. 2 near Ohio, Ill.	667	none	776	none	1959-72	14
87	05447200	Normandy Ditch at Normandy, Ill.	123	none	136	none	1956-71	16
88	05447350	Mud Creek tributary near Atkinson, Ill.	716	1967	851	1967	1961-76	16
89	05447500	Green River near Geneseo, Ill.	12,800	none	13,900	none	1936-93	58
90	05448000	Mill Creek at Milan, Ill.	9,980	none	11,500	none	1940-86;1990-93	51

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
91	05448050	Sand Creek near Milan, Ill.	258	none	323	none	1956-80	25
92	05466000	Edwards River near Orion, Ill.	7,190	1951	7,780	1951	1941-93	53
93	05466500	Edwards River near New Boston, Ill.	11,600	1973	13,000	1973	1935-93	59
94	05467000	Pope Creek near Keithsburg, Ill.	7,110	1973;1982;1993	8,150	1973	1935-86;1991-93	55
95	05467500	Henderson Creek near Little York, Ill.	10,000	1982	12,300	1982	1941-82	42
96	05468000	North Henderson Creek near Seaton, Ill.	2,590	none	2,840	none	1941-51	11
97	05468500	Cedar Creek at Little York, Ill.	10,800	1982;1993	13,000	1993	1941-78;1980-93	52
98	05469000	Henderson Creek near Oquawka, Ill.	18,500	1982;1993	22,200	1982;1993	1935-93	59
99	05469500	South Henderson Creek at Biggsville, Ill.	8,050	1973;1982	10,000	1982	1940-82	43
100	05469750	Ellison Creek tributary near Roseville, Ill.	175	1958	200	none	1956-80	25
101	05495200	Little Creek near Breckenridge, Ill.	1,460	none	1,710	none	1956-80	25
102	05495500	Bear Creek near Marcelline, Ill.	26,500	1985	30,000	none	1944-93	50
103	05496900	Homan Creek tributary near Quincy, Ill.	925	none	1,070	none	1956-76	21
104	05501500	Burton Creek tributary near Burton, Ill.	733	1962	879	none	1961-76	16
105	05502020	Hadley Creek near Barry, Ill.	10,800	none	12,100	none	1956-90;1992-93	37
106	05502040	Hadley Creek at Kinderhook, Ill.	18,100	none	20,200	none	1940-86	47
107	05502120	Kiser Creek tributary near Barry, Ill.	1,270	1966	1,500	none	1956-80	25
108	05512500	Bay Creek at Pittsfield, Ill.	15,100	none	17,200	none	1940-93	54
109	05513000	Bay Creek at Nebo, Ill.	22,200	1946	25,200	none	1940-86	47
110	05513200	Salt Spring Creek near Gilead, Ill.	1,450	none	1,760	none	1956-80	25
111	05520000	Singleton Ditch at Illinoi, Ill.	3,180	1976	3,420	1976	1945-77	33
112	05520500	Kankakee River at Momence, Ill.	12,400	1979	13,300	1979	1915-93	79
113	05525000	Iroquois River at Iroquois, Ill.	8,690	1958	9,640	1958	1945-93	49
114	05525050	Eastburn Hollow near Sheldon, Ill.	1,460	1957	1,790	1957	1956-72	17
115	05525500	Sugar Creek at Milford, Ill.	21,300	1951	24,600	none	1949-93	45
116	05526000	Iroquois River near Chebanse, Ill.	29,100	1913	32,100	1913	1913;1924-93	71
117	05526150	Kankakee River tributary near Bourbonnais, Ill.	238	none	303	none	1956-80	25
118	05526500	Terry Creek near Custer Park, Ill.	968	1970	1,200	1970	1950-75	26
119	05527050	Prairie Creek near Frankfort, Ill.	369	1957	447	1957	1956-72	17
120	05527500	Kankakee River near Wilmington, Ill.	60,700	1957;1983;1991	68,100	1957	1915-93	79
121	05527800	Des Plaines River at Russell, Ill.	2,640	none	3,030	none	1960-66;1968-93	33
122	05527840	Des Plaines River at Wadsworth, Ill.	2,840	none	3,190	none	1962-76	15
123	05527870	Mill Creek at Wedges Corner, Ill.	282	1960	329	1960	1960-76	17
124	05527900	North Mill Creek at Hickory Corners, Ill.	519	none	578	none	1960-76	17
125	05527950	Mill Creek at Old Mill Creek, Ill.	1,420	none	1,570	none	1960;1962-76;1990-93	20

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
126	05528000	Des Plaines River near Gurnee, Ill.	3,120	1986	3,440	1986	1946-93	48
127	05528150	Indian Creek at Diamond Lake, Ill.	1,110	1960	1,290	none	1960-76	17
128	05528170	Diamond Lake Drain at Mundelein, Ill.	120	none	133	none	1961-76	16
129	05528200	Hawthorn Drainage Ditch near Mundelein, Ill.	576	none	659	none	1961-76	16
130	05528230	Indian Creek at Prairie View, Ill.	1,500	none	1,710	none	1960-61;1963-65;1967-71; 1973-76;1990-93	18
131	05528360	Aptakisic Creek at Aptakisic, Ill.	375	1972	434	none	1961-76	16
132	05528400	Des Plaines River at Wheeling, Ill.	4,180	none	4,540	none	1962-63;1967;1969-70;1972-77	11
133	05528440	Buffalo Creek near Lake Zurich, Ill.	250	none	287	none	1961-76	16
134	05528470	Buffalo Creek at Long Grove, Ill.	643	none	717	none	1961-76	16
135	05528500	Buffalo Creek near Wheeling, Ill.	924	none	1,010	none	1953-93	41
136	05529000	Des Plaines River near Des Plaines, Ill.	4,800	1938;1987	5,220	none	1938;1941-93	54
137	05529300	McDonald Creek near Wheeling, Ill.	695	1957	806	none	1955;1957;1961-79	21
138	05529500	McDonald Creek near Mount Prospect, Ill.	800	1987	930	none	1953-92	40
139	05529900	Weller Creek at Mount Prospect, Ill.	1,490	none	1,720	none	1961-79	19
140	05530000	Weller Creek at Des Plaines, Ill.	1,720	none	1,900	none	1951-93	43
141	05530400	Higgins Creek near Mount Prospect, Ill.	536	none	631	none	1961-79	19
142	05530480	Willow Creek at Orchard Place, Ill.	2,310	none	2,710	none	1955;1957;1961-79	21
143	05530600	Des Plaines River at River Grove, Ill.	4,620	none	4,890	none	1960-77	18
144	05530700	Silver Creek at Melrose Park, Ill.	746	1972	793	none	1955;61-80	21
145	05530800	Des Plaines River at Forest Park, Ill.	5,050	none	5,350	none	1954-76	23
146	05530940	Salt Creek at Palatine, Ill.	503	1972	573	none	1961-80	20
147	05530960	Salt Creek near Palatine, Ill.	851	none	969	none	1961-79	19
148	05530990	Salt Creek at Rolling Meadows, Ill.	1,110	1987;1989	1,180	1987	1974-93	20
149	05531000	Salt Creek near Arlington Heights, Ill.	1,220	none	1,360	none	1951-76	26
150	05531050	Salt Creek near Wood Dale, Ill.	1,810	none	2,070	none	1955;1957;1960-79	22
151	05531080	Spring Brook at Bloomingdale, Ill.	477	1972	549	1972	1961-79	19
152	05531100	Meacham Creek at Medinah, Ill.	192	1972	227	1972	1956-79	24
153	05531130	Spring Brook at Walnut Avenue at Itasca, Ill.	627	1972	711	1972	1961-79	19
154	05531200	Salt Creek at Addison, Ill.	1,760	1972	1,950	1972	1948;1950;1955;1957;1960-76	21
155	05531300	Salt Creek at Elmhurst, Ill.	1,940	1972	2,140	1972	1948;1950;1955;1957; 1960-80;1989	26
156	05531380	Salt Creek at Oak Brook, Ill.	1,850	none	1,970	none	1948;1950;1955;1957;1960-76	21
157	05531500	Salt Creek at Western Springs, Ill.	2,150	1987;1990	2,300	1987;1990	1946-93	48
158	05531800	Addison Creek at Northlake, Ill.	470	none	490	none	1961-80	20
159	05532000	Addison Creek at Bellwood, Ill.	846	1982;1987;1990	902	1987	1952-93	42
160	05532500	Des Plaines River at Riverside, Ill.	7,370	1919;1987	7,900	1987	1914-93	80

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
161	05533000	Flag Creek near Willow Springs, Ill.	2,560	1961	3,000	none	1960-93	34
162	05533200	Sawmill Creek tributary near Tiedtville, Ill.	349	none	365	none	1961-79	19
163	05533300	Wards Creek near Woodridge, Ill.	173	none	188	none	1962-76	15
164	05533400	Sawmill Creek near Lemont, Ill.	1,500	1990;1993	1,630	1990	1961-79;1986-93	27
165	05533500	Des Plaines River at Lemont, Ill.	5,920	none	6,320	none	1915-44	30
166	05534300	North Branch Chicago River at Lake Forest, Ill.	380	none	409	none	1961-76	16
167	05534400	North Branch Chicago River at Bannockburn, Ill.	432	none	456	none	1960-76	17
168	05534500	North Branch Chicago River at Deerfield, Ill.	709	1982;1987	783	1987	1953-93	41
169	05534600	North Branch Chicago River at Northfield, Ill.	571	none	603	none	1960-80	21
170	05534900	Skokie River at Lake Bluff, Ill.	532	none	591	none	1962-76	15
171	05535000	Skokie River at Lake Forest, Ill.	448	1986	483	1986	1952-93	42
172	05535070	Skokie River near Highland Park, Ill.	744	1987	803	1987	1967-93	27
173	05535150	Skokie River at Northfield, Ill.	567	1967	597	none	1960-79	20
174	05535200	North Branch Chicago River at Glenview, Ill.	1,210	1976	1,310	none	1960-77	18
175	05535300	West Fork of North Branch Chicago River at Bannockburn, Ill.	427	none	464	none	1961-76	16
176	05535400	West Fork of North Branch Chicago River at Deerfield, Ill.	601	none	638	none	1961-76	16
177	05535500	West Fork of North Branch Chicago River at Northbrook, Ill.	1,030	1982;1987	1,120	1987	1953-93	41
178	05535700	West Fork of North Branch Chicago River at Glenview, Ill.	1,220	none	1,320	none	1960-77	18
179	05535800	North Branch Chicago River at Morton Grove, Ill.	1,950	1967	2,110	1967	1960-79	20
180	05536000	North Branch Chicago River at Niles, Ill.	2,020	1967;1987	2,170	1967;1987	1951-93	43
181	05536201	Thorn Creek at Park Forest, Ill.	1,480	none	1,830	none	1955;1957;1962-78	19
182	05536207	Thorn Creek tributary at Chicago Heights, Ill.	868	1968	1,040	1968	1962-77	16
183	05536210	Thorn Creek near Chicago Heights, Ill.	2,380	none	2,660	none	1965-79	15
184	05536215	Thorn Creek at Glenwood, Ill.	2,820	none	3,210	none	1950-93	44
185	05536235	Deer Creek near Chicago Heights, Ill.	1,120	1957	1,230	1957	1948-93	46

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
186	05536238	Butterfield Creek near Lincoln Estates, Ill.	600	none	711	none	1961-79	19
187	05536255	Butterfield Creek at Flossmoor, Ill.	2,430	none	2,900	none	1948-55;1957-93	45
188	05536265	Lansing Ditch near Lansing, Ill.	473	none	517	none	1948-93	46
189	05536270	North Creek near Lansing, Ill.	817	none	899	none	1948-79	32
190	05536275	Thorn Creek at Thornton, Ill.	4,850	none	5,380	none	1947-93	47
191	05536290	Little Calumet River at South Holland, Ill.	4,820	none	5,180	none	1947-93	47
192	05536310	Calumet Union Drainage Canal near Markham, Ill.	546	none	581	none	1955;1957;1961-76	18
193	05536325	Little Calumet River at Harvey, Ill.	4,860	none	5,350	none	1917-33	17
194	05536335	Midlothian Creek near Tinley Park, Ill.	460	1955;1957	512	none	1954-79	26
195	05536340	Midlothian Creek at Oak Forest, Ill.	578	1973	652	none	1951-93	43
196	05536460	Tinley Creek near Oak Forest, Ill.	1,110	none	1,250	none	1961-79	19
197	05536500	Tinley Creek near Palos Park, Ill.	1,910	1955	2,240	none	1951-55;1957-93	42
198	05536510	Navajo Creek at Palos Heights, Ill.	474	none	520	none	1961-79	19
199	05536560	Melvina Ditch near Oak Lawn, Ill.	453	none	519	none	1962-80	19
200	05536570	Stony Creek (West) at Worth, Ill.	1,420	1976	1,630	none	1962-76	15
201	05536620	Mill Creek near Palos Park, Ill.	317	1966	354	none	1961-77	17
202	05536630	Mill Creek at Palos Park, Ill.	1,400	1955	1,830	1955	1955;1961-79	20
203	05537500	Long Run near Lemont, Ill.	2,330	1955;1957	2,790	1955	1951-93	43
204	05538000	Des Plaines River at Joliet, Ill.	22,400	none	23,400	none	1915-32	18
205	05538440	Spring Creek near Orland Park, Ill.	100	1955	112	1955	1955;1961-77	18
206	05539000	Hickory Creek at Joliet, Ill.	12,900	1902;1957;1981	16,100	1902;1981	1902;1926;1942;1945-93	52
207	05539870	West Branch Du Page River at Ontarioville, Ill.	853	none	944	none	1961-79	19
208	05539890	West Branch Du Page River near Wayne, Ill.	1,540	1955	1,780	none	1955;1961-79	20
209	05539900	West Branch Du Page River near West Chicago, Ill.	1,010	none	1,100	none	1961-93	33
210	05539950	Klein Creek at Carol Stream, Ill.	642	1972	768	1972	1961-79	19
211	05540030	West Branch Du Page River at West Chicago, Ill.	1,610	1972	1,760	none	1955;1961-79	20
212	05540060	Kress Creek at West Chicago, Ill.	616	1964	687	none	1961-80;1986-93	28
213	05540080	Spring Brook at Wheaton, Ill.	392	1972	449	1972	1961-79	19
214	05540095	West Branch Du Page River near Warrenville, Ill.	2,370	1987	2,590	1987	1969-93	25
215	05540110	Ferry Creek at Warrenville, Ill.	245	none	279	none	1961-79	19

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
216	05540140	East Branch Du Page River near Bloomingdale, Ill.	227	none	261	none	1961-79	19
217	05540150	East Branch Du Page River at Glen Ellyn, Ill.	755	1972	861	1972	1961;1963-80	19
218	05540160	East Branch Du Page River near Downers Grove, Ill.	1,850	none	2,130	none	1955;1961;1963-76;1990-93	20
219	05540190	St. Joseph Creek at Belmont, Ill.	855	none	945	none	1961-77	17
220	05540240	Prentiss Creek near Lisle, Ill.	609	none	716	none	1961-80	20
221	05540500	Du Page River at Shorewood, Ill.	10,800	1948;1955	12,400	none	1941-93	53
222	05541750	Mazon River tributary near Gardner, Ill.	240	none	260	none	1959-80	22
223	05542000	Mazon River near Coal City, Ill.	22,300	1983	24,400	none	1940-93	54
224	05543500	Illinois River at Marseilles, Ill.	95,500	none	105,000	none	1892;1894-98;1900;1904-93	97
225	05548280	Nippersink Creek near Spring Grove, Ill.	3,070	none	3,340	none	1966-93	28
226	05549000	Boone Creek near McHenry, Ill.	337	1986	372	none	1949-92	44
227	05549700	Mutton Creek at Island Lake, Ill.	416	none	501	none	1960;1962-76	16
228	05549850	Flint Creek near Fox River Grove, Ill.	432	1960	467	1960	1960;1962-76;1990-93	20
229	05549900	Fox River tributary near Cary, Ill.	64	none	78	none	1956-79	24
230	05550000	Fox River at Algonquin, Ill.	6,810	none	7,430	none	1916-93	78
231	05550300	Tyler Creek at Elgin, Ill.	653	none	703	none	1962-63;1965-76;1978-80	17
232	05550430	East Branch Poplar Creek near Palatine, Ill.	223	1967	255	1967	1961-77	17
233	05550450	Poplar Creek near Ontarioville, Ill.	537	none	597	none	1961-77	17
234	05550470	Poplar Creek tributary near Bartlett, Ill.	472	1967	546	1967	1961-79	19
235	05550500	Poplar Creek at Elgin, Ill.	924	none	1,030	none	1952-93	42
236	05551030	Brewster Creek at Valley View, Ill.	817	none	938	none	1962-79	18
237	05551050	Norton Creek near Wayne, Ill.	589	1957;1967	740	1957	1957;1962-79	19
238	05551060	Norton Creek near St. Charles, Ill.	579	1967	700	1967	1957;1962-79	19
239	05551200	Ferson Creek near St. Charles, Ill.	2,440	none	2,700	none	1961-93	33
240	05551520	Indian Creek near North Aurora, Ill.	405	1978	461	none	1961-79	19
241	05551530	Indian Creek at Aurora, Ill.	860	none	905	none	1961-79	19
242	05551620	Blackberry Creek near Kaneville, Ill.	785	none	849	none	1961-63;1965-67;1969-79	17
243	05551650	Lake Run tributary near Batavia, Ill.	362	none	455	none	1961-76	16
244	05551700	Blackberry Creek near Yorkville, Ill.	2,010	1983	2,240	none	1961-93	33
245	05551800	Fox River tributary No. 2 near Fox, Ill.	422	none	525	none	1961-78;1980	19

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
246	05551900	East Branch Big Rock Creek near Big Rock, Ill.	1,540	1974	1,730	none	1965-79	15
247	05551930	Welch Creek near Big Rock, Ill.	793	none	881	none	1965-80	16
248	05552500	Fox River at Dayton, Ill.	33,800	1955	38,300	1955	1915-24;1926-93	78
249	05554000	North Fork Vermilion River near Charlotte, Ill.	6,240	none	6,900	none	1943-93	51
250	05554500	Vermilion River at Pontiac, Ill.	14,000	none	15,600	none	1933;1943-62;1964-93	51
251	05554600	Mud Creek tributary near Odell, Ill.	180	none	207	none	1959-76	18
252	05555000	Vermilion River at Streator, Ill.	21,200	none	23,700	none	1915-30	16
253	05555300	Vermilion River near Leonore, Ill.	34,700	none	39,100	none	1931-93	63
254	05555400	Vermilion River tributary at Lowell, Ill.	226	none	296	none	1956-76	21
255	05555775	Vermilion Creek tributary at Meriden, Ill.	138	none	158	none	1959-72	14
256	05556500	Big Bureau Creek at Princeton, Ill.	13,000	none	14,400	none	1937-93	57
257	05557000	West Bureau Creek at Wyanet, Ill.	10,700	1972;1974	12,600	1974	1937-91	55
258	05557100	West Bureau Creek tributary near Wyanet, Ill.	392	none	472	none	1956-79	24
259	05557500	East Bureau Creek near Bureau, Ill.	8,450	none	9,710	none	1937-91;1993	56
260	05558000	Big Bureau Creek at Bureau, Ill.	21,000	none	23,500	none	1941-51	11
261	05558050	Coffee Creek tributary near Florid, Ill.	107	1958	130	none	1956-76	21
262	05558075	Coffee Creek tributary near Hennepin, Ill.	323	1958	399	none	1956-77;1979-80	24
263	05558500	Crow Creek (West) near Henry, Ill.	6,120	1970	7,310	none	1950-82	33
264	05559000	Gimlet Creek at Sparland, Ill.	2,330	none	2,600	none	1946-82	37
265	05559500	Crow Creek near Washburn, Ill.	6,050	none	6,870	none	1945-82	38
266	05560000	Illinois River at Peoria, Ill.	64,800	none	68,500	none	1903-39	37
267	05560500	Farm Creek at Farmdale, Ill.	993	1980	1,070	none	1949;1951-85	36
268	05561000	Ackerman Creek at Farmdale, Ill.	3,720	1980	4,510	1980	1954-80	27
269	05561500	Fondulac Creek near East Peoria, Ill.	612	none	688	none	1948-85	38
270	05562000	Farm Creek at East Peoria, Ill.	18,800	1947	23,300	none	1943-80	38
271	05563000	Kickapoo Creek near Kickapoo, Ill.	28,500	none	33,900	none	1945-76;1978-93	48
272	05563100	Kickapoo Creek tributary near Kickapoo, Ill.	182	1959	229	1959	1956-80	25
273	05563500	Kickapoo Creek at Peoria, Ill.	29,300	1974;1981	35,600	1974	1943-93	51
274	05564400	Money Creek near Towanda, Ill.	2,710	none	3,100	none	1958-82	25
275	05564500	Money Creek above Lake Bloomington, Ill.	3,100	1947	3,620	1947	1934-58	25

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
276	05565000	Hickory Creek above Lake Bloomington, Ill.	1,940	none	2,220	none	1939-58	20
277	05566000	East Branch Panther Creek near Gridley, Ill.	811	1951	1,000	1951	1950-72	23
278	05566500	East Branch Panther Creek at El Paso, Ill.	2,820	1951	3,520	1951	1950-82	33
279	05567000	Panther Creek near El Paso, Ill.	8,410	1951	9,950	1951	1950-93	44
280	05567500	Mackinaw River near Congerville, Ill.	31,000	1951;1980;1983;1987	37,200	1983	1945-93	49
281	05567800	Indian Creek tributary near Hopedale, Ill.	600	none	693	none	1960-71	12
282	05568000	Mackinaw River near Green Valley, Ill.	38,000	1980;1983	47,500	1983	1922-58;1960-93	71
283	05568500	Illinois River at Kingston Mines, Ill.	92,400	none	99,600	none	1941-93	53
284	05568650	Duck Creek near Canton, Ill.	189	none	216	none	1956-73	17
285	05568800	Indian Creek near Wyoming, Ill.	4,890	1974	5,730	1974	1960-93	34
286	05568850	Forman Creek tributary near Victoria, Ill.	483	none	571	none	1961-76	16
287	05569500	Spoon River at London Mills, Ill.	30,400	1985;1974	35,600	1974	1943-93	51
288	05569825	Cedar Creek tributary at St. Augustine, Ill.	1,280	1967	1,510	none	1956-80	25
289	05570000	Spoon River at Seville, Ill.	34,400	1924;1974;1993	38,900	none	1916-17;1919-93	77
290	05570350	Big Creek at St. David, Ill.	2,070	1974	2,330	none	1972-86	15
291	05570360	Evelyn Branch near Bryant, Ill.	219	1986;1987	247	1986;1987	1972-92	21
292	05570370	Big Creek near Bryant, Ill.	2,060	none	2,270	none	1972-92	21
293	05570380	Slug Run near Bryant, Ill.	438	1986;1990	491	1986	1975-92	18
294	05571000	Sangamon River at Mahomet, Ill.	14,100	1956	16,400	none	1948-78	31
295	05572000	Sangamon River at Monticello, Ill.	17,000	1927	19,500	none	1908-13;1915-93	85
296	05572100	Wildcat Creek tributary near Monticello, Ill.	80	none	90	none	1956-76	21
297	05572450	Friends Creek at Argenta, Ill.	6,210	none	7,330	none	1967-82	16
298	05572500	Sangamon River near Oakley, Ill.	18,900	none	22,100	none	1951-77	27
299	05574000	South Fork Sangamon River near Nokomis, Ill.	4,950	1957;1970	6,270	1957	1951-82	32
300	05574500	Flat Branch near Taylorville, Ill.	11,700	1957	13,300	none	1950-82	33
301	05575500	South Fork Sangamon River at Kincaid, Ill.	17,700	1957;1979	21,000	1957	1908-12;1915-27;1929-30 1932-33;1943;1945-92	71
302	05575800	Horse Creek at Pawnee, Ill.	4,900	none	5,450	none	1968-85	18
303	05576000	South Fork Sangamon River near Rochester, Ill.	18,300	none	20,600	none	1950-93	44
304	05576500	Sangamon River at Riverton, Ill.	42,800	1979;1943	47,300	1943	1908-12;1915-27;1929-31; 1933-73;1975-79;1981-93	80
305	05577500	Spring Creek at Springfield, Ill.	9,080	none	10,900	none	1948-93	46

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
306	05577700	Sangamon River tributary at Andrew, Ill.	830	none	966	none	1956-80	25
307	05578500	Salt Creek near Rowell, Ill.	18,000	1968	22,000	1968	1908-12;1943-93	56
308	05579500	Lake Fork near Cornland, Ill.	12,600	1943	16,100	1943	1943;1948-93	47
309	05579750	Kickapoo Creek tributary at Heyworth, Ill.	1,440	1956	1,720	1956	1956-73	18
310	05580000	Kickapoo Creek at Waynesville, Ill.	18,600	1979;1981	22,800	1981	1948-93	46
311	05580500	Kickapoo Creek near Lincoln, Ill.	20,000	1979;1982	24,400	none	1945-92	48
312	05580700	Salt Creek tributary at Middletown, Ill.	899	1961	1,120	1961	1961-76	16
313	05580950	Sugar Creek near Bloomington, Ill.	5,950	1983;1986	6,480	1983	1975-93	19
314	05581500	Sugar Creek near Hartsburg, Ill.	29,200	1981;1983	36,600	1982	1945-92	48
315	05582000	Salt Creek near Greenview, Ill.	40,800	1943	46,900	none	1942-93	52
316	05582200	Cabiness Creek tributary near Petersburg, Ill.	867	65	1,100	65	1956-76	21
317	05582500	Crane Creek near Easton, Ill.	879	none	1,010	none	1950-81	32
318	05583000	Sangamon River near Oakford, Ill.	71,600	43	80,700	43	1910-12;1915-18;1921-22; 1926-29;1931-93	76
319	05584400	Drowning Fork at Bushnell, Ill.	2,900	1980	3,410	1980	1961-92	32
320	05584450	Wigwam Hollow Creek near Macomb, Ill.	647	none	741	none	1961-76	16
321	05584500	La Moine River at Colmar, Ill.	32,500	1985	38,200	1985	1945-93	49
322	05584950	West Creek at Mount Sterling, Ill.	712	none	822	none	1961-72	12
323	05585000	La Moine River at Ripley, Ill.	26,600	1985;1990	30,500	none	1921-93	73
324	05585220	Indian Creek tributary near Sinclair, Ill.	1,520	none	1,770	none	1956-80	25
325	05585500	Illinois River at Meredosia, Ill.	126,000	none	137,000	none	1921-89	69
326	05585700	Dry Fork tributary near Mount Sterling, Ill.	106	none	122	none	1956-76	21
327	05586000	North Fork Mauvaise Terre Creek near Jacksonville, Ill.	4,200	1977;1983;1990	4,830	none	1950-90;1992-93	43
328	05586200	Illinois River tributary at Florence, Ill.	1,020	none	1,160	none	1956-80	25
329	05586350	Little Sandy Creek tributary near Murrayville, Ill.	1,720	none	2,010	none	1961-72	12
330	05586500	Hurricane Creek near Roodhouse, Ill.	1,030	1957	1,240	1957	1951-90;1992-93	42
331	05586850	Bear Creek tributary near Reeders, Ill.	49	none	58	none	1956-80	25
332	05587000	Macoupin Creek near Kane, Ill.	36,600	1943	42,100	none	1921-33;1941-93	66
333	05587850	Cahokia Creek tributary No. 2 near Carpenter, Ill.	627	1958	736	1958	1956-80	25
334	05587900	Cahokia Creek at Edwardsville, Ill.	11,200	none	12,200	none	1969-93	25
335	05588000	Indian Creek at Wanda, Ill.	8,070	1946	9,730	none	1941-93	53

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
336	05589500	Canteen Creek at Caseyville, Ill.	6,950	1946;1957	8,240	1946;1957	1939-84	46
337	05589780	Little Canteen Creek tributary near Collinsville, Ill.	1,090	none	1,360	none	1959-72	14
338	05590000	Kaskaskia Ditch at Bondville, Ill.	1,620	none	1,950	none	1924-27;1949-90	46
339	05590400	Kaskaskia River near Pesotum, Ill.	4,100	none	4,540	none	1965-79	15
340	05590500	Kaskaskia River at Ficklin, Ill.	5,940	none	6,750	none	1954-64	11
341	05590800	Lake Fork at Atwood, Ill.	5,110	none	5,610	none	1973-93	21
342	05591200	Kaskaskia River at Cooks Mills, Ill.	12,000	none	13,200	none	1971-93	23
343	05591500	Asa Creek at Sullivan, Ill.	1,460	1974	1,710	none	1951-82	32
344	05591750	Stringtown Branch tributary near Lake City, Ill.	190	none	216	none	1961-80	20
345	05592000	Kaskaskia River at Shelbyville, Ill.	29,200	none	32,900	none	1908-13;1939;1941-93	60
346	05592025	Mud Creek tributary near Tower Hill, Ill.	458	none	553	none	1956-76	21
347	05592300	Wolf Creek near Beecher City, Ill.	8,690	none	9,860	none	1959-82	24
348	05592500	Kaskaskia River at Vandalia, Ill.	49,000	1943;1950;1957	58,700	1957	1908-12;1915-20;1922-93	83
349	05592700	Hurricane Creek tributary near Witt, Ill.	143	none	157	none	1956-80	25
350	05592800	Hurricane Creek near Mulberry Grove, Ill.	19,200	none	21,400	none	1971-93	23
351	05593000	Kaskaskia River at Carlyle, Ill.	51,500	1943	59,800	none	1908-12;1915;1930-93	70
352	05593520	Crooked Creek near Hoffman, Ill.	13,900	1986;1990	15,500	1986;1990	1975-93	19
353	05593575	Little Cooked Creek near New Minden, Ill.	11,000	1990	12,400	none	1968-93	26
354	05593600	Blue Grass Creek near Raymond, Ill.	2,250	none	2,470	none	1961-91	31
355	05593700	Blue Grass Creek tributary near Raymond, Ill.	338	1966	383	none	1959-71	13
356	05593900	East Fork Shoal Creek near Coffeen, Ill.	6,040	1967	6,870	none	1964-93	30
357	05594000	Shoal Creek near Breese, Ill.	32,900	1943	38,200	1943	1910-13;1943;1946-93	53
358	05594090	Sugar Creek at Albers, Ill.	11,700	none	13,400	none	1973-82	10
359	05594200	Williams Creek near Cordes, Ill.	1,200	none	1,410	none	1956-72	17
360	05594330	Mud Creek near Marissa, Ill.	7,830	none	9,200	none	1971-82	12
361	05594450	Silver Creek near Troy, Ill.	13,300	none	15,000	none	1967-93	27
362	05594800	Silver Creek near Freeburg, Ill.	17,700	none	20,000	none	1971-93	23
363	05595000	Kaskaskia River at New Athens, Ill.	92,900	none	109,000	none	1908-13;1915-21;1935-71	50
364	05595200	Richland Creek near Hecker, Ill.	15,000	1973	17,100	none	1970-93	24
365	05595500	Marys River near Sparta, Ill.	6,610	1968	8,050	none	1949-71	23
366	05595510	Lick Branch near Eden, Ill.	951	none	1,160	none	1959-72	14
367	05595550	Marys River tributary at Chester, Ill.	627	none	696	none	1959-73	15
368	05595800	Sevenmile Creek near Mt. Vernon, Ill.	3,030	none	3,440	none	1961-82	22
369	05596000	Big Muddy River near Benton, Ill.	29,900	1961	35,600	1961	1946-70	25
370	05596100	Andy Creek tributary at Valier, Ill.	887	none	1,030	none	1956-72	17

Table 2. Magnitude of 50- and 100-year flood discharges at U.S. Geological Survey stream-gaging stations in Illinois with associated years when values were exceeded—Continued

Map reference number (see fig. 13)	Station Number	Station name	Q50 (ft^3/s) –from weighted freq. curve	Years Q50 was exceeded	Q100 (ft^3/s) –from weighted freq. curve	Years Q100 was exceeded	Period of record	No. of years observed
371	05597000	Big Muddy River at Plumfield, Ill.	23,200	1946;1961	26,000	1946;1961	1909-12;1915-93	83
372	05597450	Crab Orchard Creek tributary near Pittsburg, Ill.	419	1961	458	none	1960-72	13
373	05597500	Crab Orchard Creek near Marion, Ill.	4,580	none	5,150	none	1952-93	42
374	05599000	Beaucoup Creek near Mathews, Ill.	20,500	none	24,600	none	1946-82	37
375	05599500	Big Muddy River at Murphysboro, Ill.	35,800	none	39,700	none	1916-17;1919;1931-93	66
376	05599560	Clay Lick Creek near Makanda, Ill.	2,420	1969	2,880	1969	1960-76	17
377	05599580	Big Muddy River tributary near Gorham, Ill.	137	none	161	none	1961-76	16
378	05599640	Green Creek tributary near Jonesboro, Ill.	724	none	815	none	1956-80	25
379	05599800	Orchard Creek near Fayville, Ill.	231	none	269	none	1961-72	12
380	05600000	Big Creek near Wetaug, Ill.	4,920	1943	5,550	1943	1942-93	52

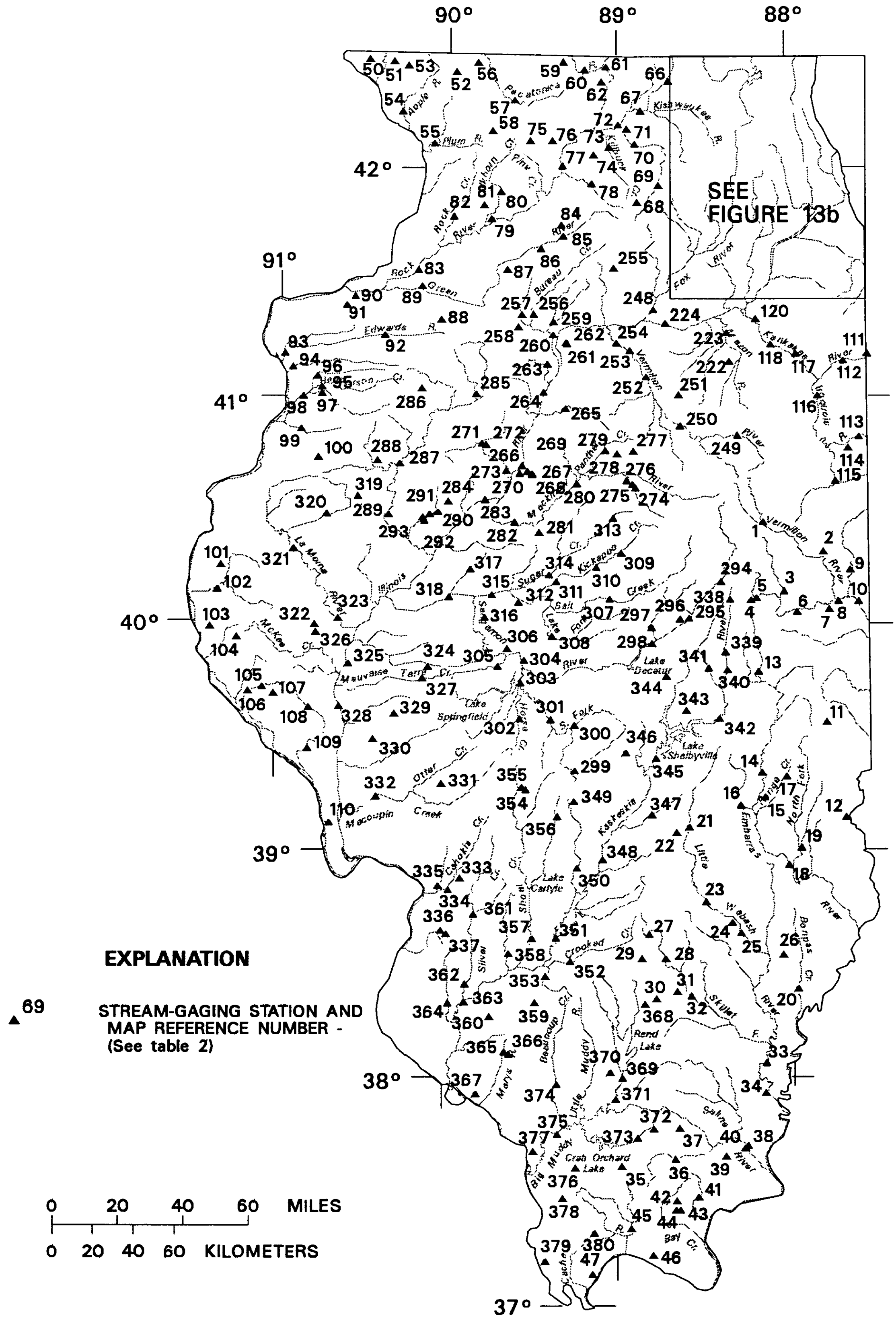


Figure 13. U.S. Geological Survey stream-gaging stations in Illinois corresponding to flood frequency/exceedance data.

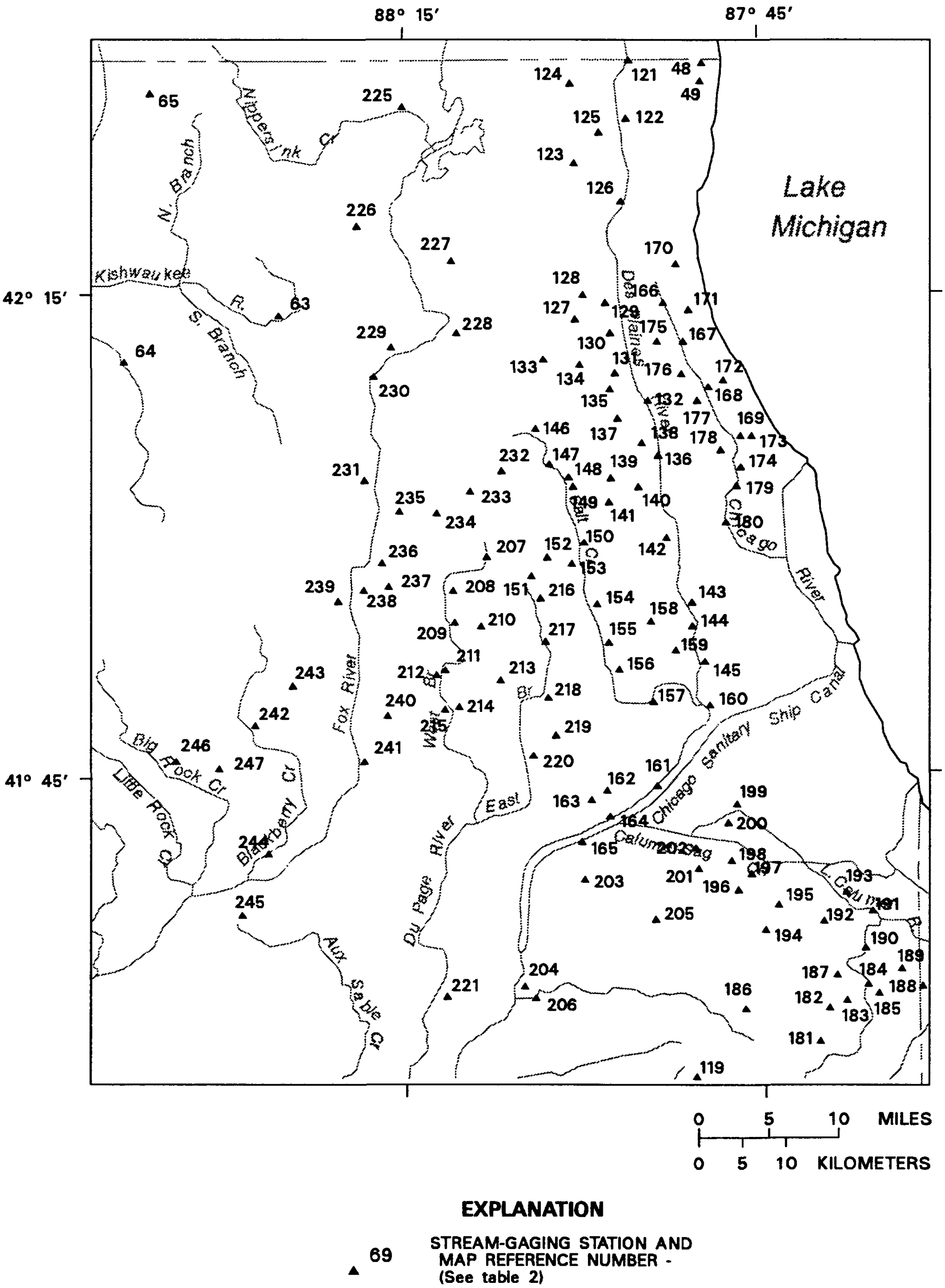


Figure 13. Continued.

Figure 14. County Road 2050 East single-span bridge over Flatville Drainage Ditch near Flatville, Ill.

flood-plain width. For very wide flood plains, an effective flood-plain width that is some factor times the length is recommended (fig. 8), especially when levees or other distinguishing laterally controlling features (for example, a valley wall) are absent. The magnitude of the factor can vary as based on engineering judgement.

The base-flow channel width was measured from the left descending bank water surface to the right descending bank water surface with an engineer's steel tape. The base-flow channel width was 23 ft at the bridge and 26 ft one bridge length upstream. The abutment type, determined from bridge plans and verified from the site visit, was a spill through. A "1" was coded on the field sheet as specified in the instructions. Diagrams of spill through and other types of bridge abutments adapted from Matthai (1968) are shown in figure 9. No cutbanks were noted after examining the streambanks both upstream and downstream in the vicinity of the bridge, and "1" was entered onto the field sheet in the Cutbank Presence category. The distance from the low steel of the bridge to the average streambed of the main channel was measured at 11 ft with a steel tape. The bed-material type was determined by collecting and inspecting a sample of the streambed. By qualitative inspection, the material was determined to be of a sand/silt composition and a "4.5" value was entered into the Bed Material category as specified in the instructions.

Once all necessary data were collected, an estimate of total scour was made utilizing the simplified method. The 100-year flood discharge was not known; therefore, methods outlined in Curtis (1987) were applied, resulting in a 100-year flood discharge estimate of 2,080 ft^3/s. To estimate the total scour, the predictor variable for both single-span envelope curves (figs. 3 and 4) was calculated and a corresponding total-scour estimate was determined from each of the two curves as 5.7 ft, and 9.8 ft, respectively. The minimum of these two values was used as the final estimate of the total scour at this bridge site. As a final check, all the bridge characteristics for the site were in the acceptable range of values used to develop the simplified method (see "Limitations of the Method" section). In addition, the ratio of base-flow channel width at the bridge to base-flow channel width one bridge length upstream was 0.88, which is greater than the 0.5 limiting value described in the "Limitations of the Method" section. The ratio of base-flow channel width at the bridge to the flood-plain width

Data-Collection Sheet
Simplified Method for Bridge Scour Estimation
FOR USE WITH SINGLE-SPAN BRIDGES ONLY

FIELD PARTY CJD & JTM **County** ______ **Date** 5-17-95
Structure Number 4357 **Feature Crossed** DRAINAGE DITCH
Facility Carried 2400N **Location** FLATVILLE

TO BE COMPLETED IN THE FIELD OR FROM TOPOGRAPHIC MAP		COMPLETE IN OFFICE	
Flood-Plain Width For 100-Year Flood (FPW)	37 feet	Drainage Area	10.75 sq. miles
Base-Flow Channel Width @bridge (CWB)	23 feet	100-Year Flood (Q)	______ cfs
Base-Flow Channel Width 1 Bridge Length Upstream (CWU)	26 feet	Percent Imperviousness *(If using urban relations from Allen & Bejcek, 1979)*	______
Bridge Length From (BW) Abutment to Abutment	67 feet	Elevation @ 10% distance from bridge to basin divide along stream thalweg	665 feet
Abutment Type (AT) *(Spill Through–1, Vertical With Wingwalls–2, Vertical Without Wingwalls–3)*	1	Elevation @ 85% distance from bridge to basin divide along stream thalweg	725 feet
Cutbank Presence (CB) *(None–1, Slight–2, Extensive–3)*	1	Distance between 85% and 10% elevation	4.85 miles
Low Steel To Bed Distance (LSTB)	11.05 feet	Rainfall Intensity *(from Curtis, 1987—USGS Water-Resources Investigations Report 87–4207)*	3.0 inches
Bed Material (BM) *(Cobbles–1, Clay–2, Gravel–3, Sand/Gravel–4, Silt/Clay–4, Sand/Silt–4.5, Sand–5)*	4.5	Geographic Region *(from Curtis, 1987—USGS Water-Resources Investigations Report 87–4207)*	1

Information Entered Into Computer Program On 10-26-95

Entered By RRH

Estimated Scour 5.7 ft

Figure 15. Sample of a completed single-span field and office data-collection sheet for County Road 2050 East bridge over Flatville Drainage Ditch near Flatville, Ill.

was 0.62. This is greater than the 0.03 limiting value also described in the "Limitations of the Method" section.

Multi-Span Bridges

Knowledge of all the bridge-site characteristics on the field data sheet shown in figure 12 is required in the application of the simplified method for multi-span bridges. Once the bridge-site characteristics are determined and listed on the field data sheet, the two envelope curves for multi-span bridges should be used to determine the estimated total scour at the bridge site. The collection of the necessary multi-span bridge characteristic data and determination of the total-scour estimate are described in the following example.

A multi-span bridge over the Embarass River (fig. 16) was evaluated for this example. As in the single-span bridge example, a topographic map of the bridge site and associated watershed was reviewed in the office before visiting the site. The drainage area was 16 mi^2 and the slope in the vicinity of the bridge was 0.00039 ft/ft. In addition, the elevations and thalweg distance needed for the 100-year flood discharge computation (Curtis, 1987) were determined. The Rainfall Intensity and Geographic Region values were determined from the graphs in Curtis (1987).

At the bridge site, most of the other bridge-site characteristics were determined and listed on the field data sheet for multi-span bridges (fig. 17). For this bridge site, flood-plain width for the 100-year flood was estimated at 375 ft, which is three times the bridge length (a judgement based on engineering experience). This simplified estimate of the flood-plain width was used because the overbank area is very flat resulting in ponded water in the approach flood plain away from the main channel.

The base-flow channel width was measured from the left descending bank water surface to the right descending bank water surface with a steel tape. The base-flow channel width was 49 ft at the bridge and 35 ft one bridge length upstream. The ratio of base-flow channel width at the bridge to base-flow channel width one bridge length upstream was 1.4, which meets the established criterion requiring this value to be greater than 0.5 for the simplified method

Figure 16. County Road 300 North multi-span bridge over the Embarras River near Pesotum, Ill.

Data-Collection Sheet
Simplified Method for Bridge Scour Estimation
FOR USE WITH MULTI-SPAN BRIDGES ONLY

FIELD PARTY Jim **County** ______ **Date** 5-31-95
Structure Number 4184 **Feature Crossed** Embarass River
Facility Carried County Road 300N **Location** County Road 300N 1400 E

TO BE COMPLETED IN THE FIELD OR FROM TOPOGRAPHIC MAP		COMPLETE IN OFFICE	
Flood-Plain Width For 100-Year Flood (FPW)	375 feet	Drainage Area	16.1 sq. miles
Base-Flow Channel Width @bridge (CWB) Base-Flow Channel Width 1 Bridge Length Upstream (CWU)	49 feet ___ feet	100-Year Flood (Q)	___ cfs
Bridge Length From (BW) Abutment to Abutment Number of Spans (SP)	125 feet 3	Elevation @ 10% distance from bridge to basin divide along stream thalweg	648 feet
Slope Of Channel in Vicinity of Bridge Site (S)	0.00039 feet/feet	Elevation @ 85% distance from bridge to basin divide along stream thalweg	705 feet
Cutbank Presence (CB) *(None–1, Slight–2, Extensive–3)* Existing Scour Near Piers/Abutment (ES) *(None–1, Slight–2, Moderate–3, Extensive–4)*	2 1	Distance between 85% and 10% elevation	12.04 miles
Pier Type (1, 2, 3, 4, 5, . . . see instructions) (PT) Angle of Flow Attack on pier (A)	1 0	Rainfall Intensity *(from Curtis, 1987—USGS Water-Resources Investigations Report 87-4207)*	3.05 inches
Maximum Pier Width (PW) Low Steel To Bed Distance (LSTB)	2.25 feet 11.1 feet	Percent Imperviousness *(If using urban relations from Allen & Bejcek, 1979)*	___
Bed Material (BM) *(Cobbles–1, Clay–2, Gravel–3, Sand/Gravel–4, Silt/Clay–4, Sand/Silt–4.5, Sand–5)*	4	Geographic Region *(from Curtis, 1987—USGS Water-Resources Investigations Report 87-4207)*	1

Information Entered Into Computer Program On 10 - 26 - 95
Entered By RRH
Estimated Scour 24.793 ft

Figure 17. Sample of a completed multi-span field and office data-collection sheet for County Road 300 North bridge over the Embarras River near Pesotum, Ill.

to be valid. In addition, the ratio of base-flow channel width at the bridge to flood-plain width was 0.13, which also meets a pre-established criterion that the ratio must be greater than 0.03.

The length from abutment to abutment for the bridge over the Embarrass River was 125 ft. The bridge contained three spans as two piers are present. Both piers have square noses, which are coded on the field sheet as a type 1 pier (see fig. 8D). The angle of attack of the flow on the bridge piers was determined to be zero degrees as the flow lines for a flood appear to be parallel to the length of the bridge piers. The width of each pier was 2.25 ft. If the piers had different widths, the larger pier would have been entered on the field data sheet. The distance from the low steel of the bridge to a mean streambed was measured with a steel tape at 11.1 ft. The location of the representative streambed is subjective, but generally should equal the average streambed elevation for the main channel.

Examining the streambanks both upstream and downstream in the vicinity of the bridge, small localized cutbanks were noted. A "2" was coded onto the field sheet in the Cutbank Presence category to indicate that slight cutbanks were present at the site. No scour was noticeable at either the piers or the abutments. Therefore, a "1" was coded in the Existing Scour Near Piers/Abutments category. The bed material type was determined by collecting and inspecting a sample of the streambed. By qualitative inspection, the material was determined to be of a silt/clay composition and a "4" value was entered into the Bed Material category as specified in the instructions.

Once all the necessary data were collected, an estimate of total scour was made utilizing the simplified method. The 100-year flood discharge was not known; therefore, to determine this value, methods outlined in Curtis (1987) were used to compute a value of 1,770 ft^3/s. Examining the simplified-method envelope curves 1 and 2 for multi-span bridges in figures 5 and 6, the predictor variable for each envelope curve was calculated and a corresponding total-scour estimate was determined from both of these curves at 27.8 ft and 24.8 ft, respectively. The minimum of these two values (24.8 ft) is the final estimate of the total scour at this bridge site.

Computer Program ILSCOUR

The computer program ILSCOUR.EXE can be applied to compute 100-year flood discharge and for estimating the total-streambed scour (combination of contraction and pier scour only) resulting from the 500-year flood at the bridge site. If the Windows[2] software package is utilized, the first data entry page of the ILSCOUR.EXE program is shown in figure 18. Following are instructions to use the Windows version of ILSCOUR.EXE.

1. After invoking the program in Windows, using the right mouse button, click on either the Single-Span Bridge or Multi-Span Bridge button (fig. 18). If Multi-Span Bridge is selected, the user will see the screen shown in figure 19.
2. Using the mouse, position the cursor next to each highlighted category, click, and type in the necessary data.
3. If the 100-year discharge is known, then type in the value, otherwise click on Calculate Discharge and the screen shown in figure 20 will appear. From this screen (fig. 20) click on either Rural Method (method from Curtis (1987) for ungaged basins) or Urban Method (fig. 21) (methods from Allen and Bejcek (1979) for ungaged basins in northeastern Illinois). NOTE/WARNING: The ILSCOUR.EXE program only computes the 100-year discharge based on the Site on Ungaged Stream method in Curtis (1987). If the site is at or near a gage location, consult Curtis (1987) for appropriate methodology. In addition, application of methods outlined in Allen and Bejcek (1979) sometimes result in a smaller 100-year discharge estimate than methods from Curtis (1987). The Rainfall Intensity and Regional Factor categories can be presented in a map if the user desires by clicking on the Show Regions or Show Intensities button.
4. *Single-span bridges*, click on the down arrow for choices of Abutment Type, Cutbank Presence, and Bed Material categories.
   Multi-span bridges, click on the down arrow for choices of Cutbank Presence, Pier Type, Existing Scour Presence, and Bed Material categories.

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[2]Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

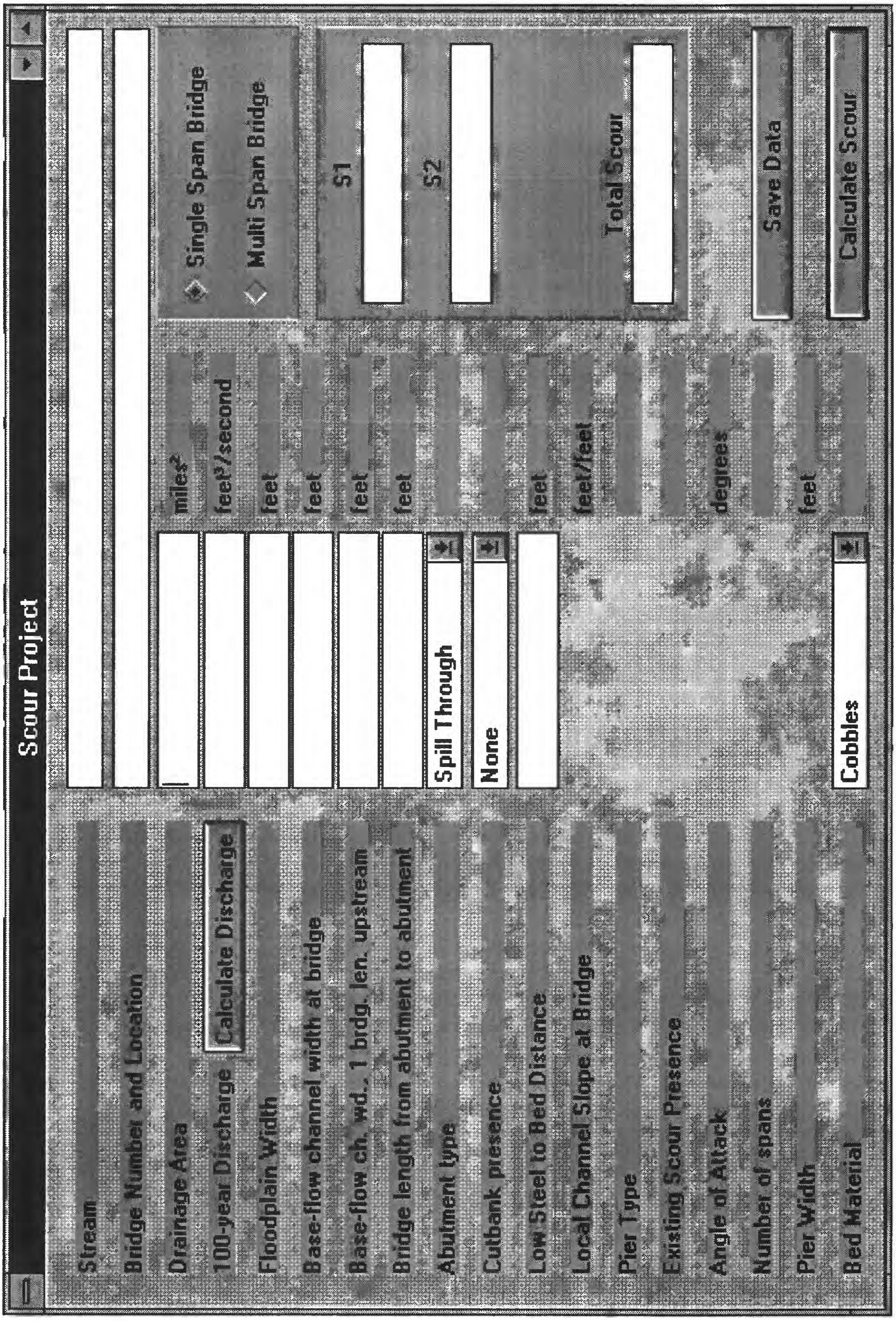

Figure 18. ILSCOUR.EXE input screen for single-span bridges.

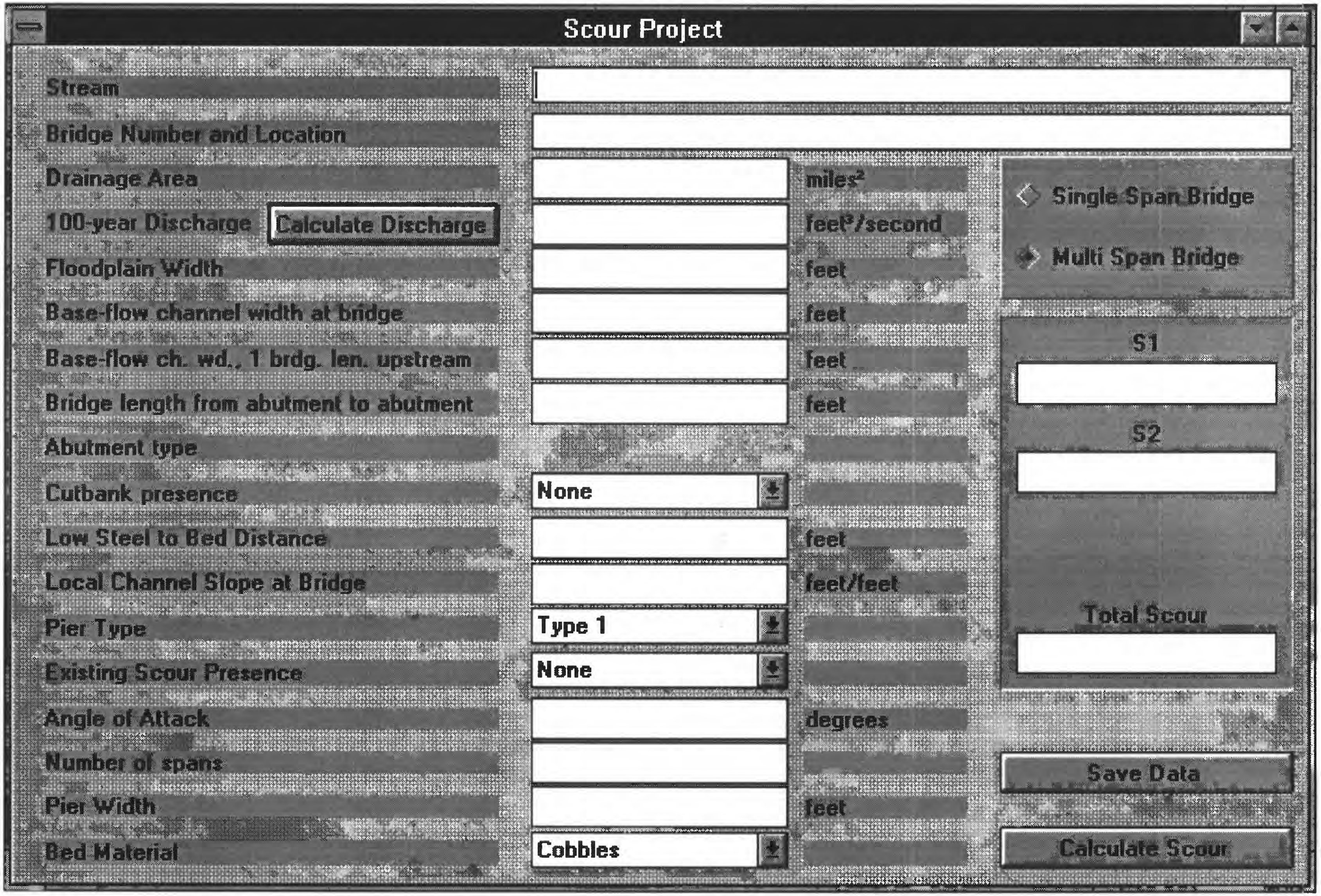

Figure 19. ILSCOUR.EXE input screen for multi-span bridges.

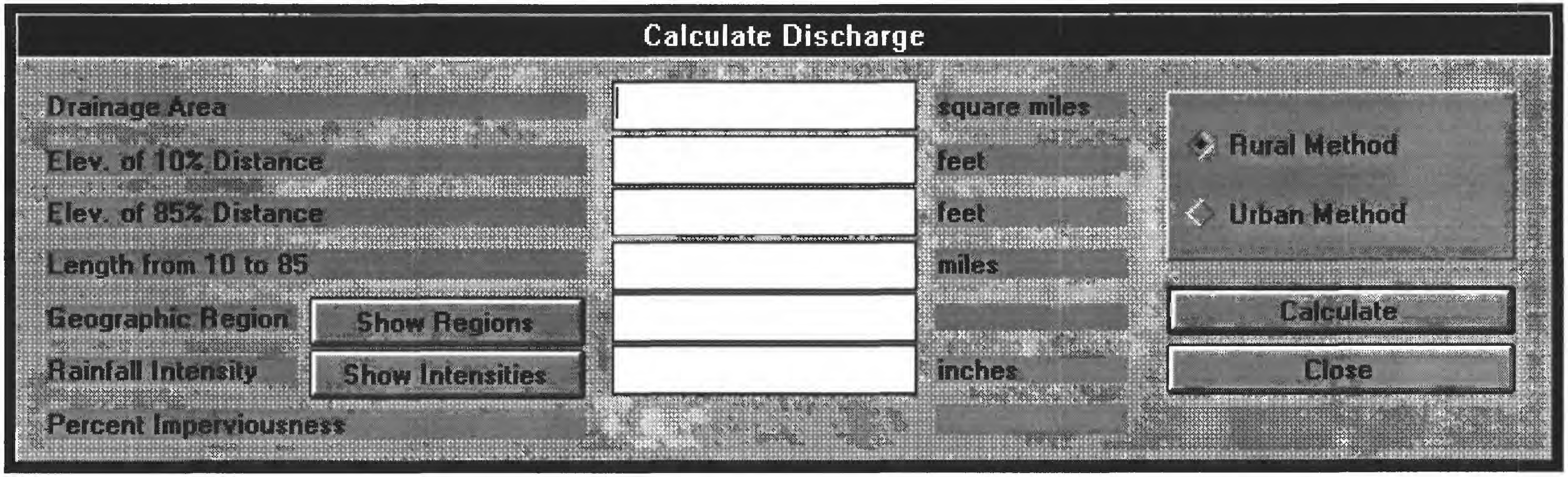

Figure 20. ILSCOUR.EXE input screen for calculating 100-year discharge for ungaged rural basins using methods outlined in Curtis (1987).

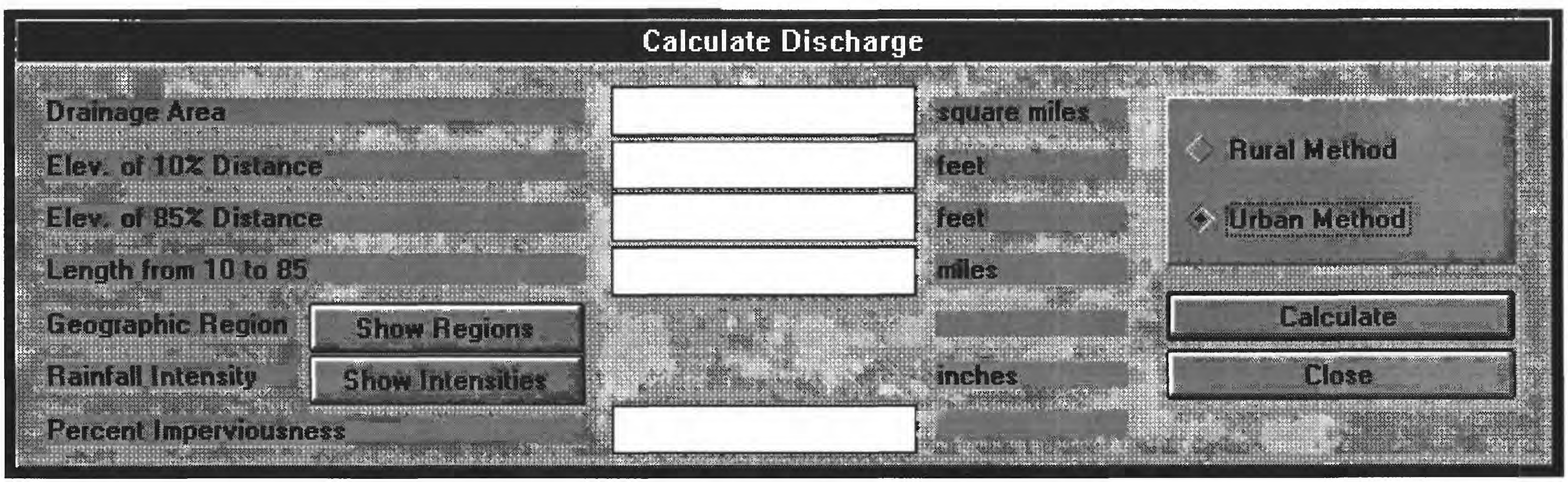

Figure 21. ILSCOUR.EXE input screen for calculating 100-year discharge for ungaged urban basins using methods outlined in Allen and Bejcek (1979).

5. After all categories have been filled in, click on the Calculate Scour button. The estimate of total scour will be near the bottom right of the window.
6. To save the input data and results to a computer file, click the Save Data button. An example output from ILSCOUR for the single-span bridge example previously presented is shown in figure 22.

If the Windows software package is not utilized, the following are instructions for use in the Disk Operating System (DOS) mode.

1. Type ILSCOUR at the DOS prompt. This will invoke the ILSCOUR program.
2. The 100-year flood discharge is not computed in the DOS version of ILSCOUR; therefore, the 100-year flood discharge must be computed by another means before using the program.
3. At each prompt, enter the requested input to compute the total-scour estimate.

SUMMARY AND CONCLUSIONS

A simplified scour estimation method was developed by the U.S. Geological Survey (USGS), in cooperation with the Illinois Department of Transportation, for application to local agency bridges in Illinois. Data from 213 State highway bridges, previously analyzed for total-scour estimates with conventional methods, were utilized to empirically develop 500-year flood total-streambed envelope curves. The State highway bridges were selected on the basis of geographic distribution and similarity to local agency bridges. A separate verification data set of 106 State highway and 15 county highway bridges was used to verify the simplified method. The method consists of determining predictor variables (combinations of bridge-site characteristics) used to estimate the total scour from each applicable envelope curve for a bridge site. Two envelope curves are applicable for single-span bridges and two curves are applicable for multi-span bridges. The minimum of the total-scour estimates from the applicable envelope curves provides an estimate of the 500-year flood total scour. Verification proved successful with the simplified scour-estimation method, underestimating the conventional scour-estimation method on only five bridges in the verification data set.

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ILSCOUR OUTPUT
Scour Project - Illinois District, U.S. Geological Survey, WRD

Stream: Flatville Drainage Ditch near Flatville, Illinois
Bridge Number and Location: Structure 4357, County Road 2050E

Single Span Structure

Drainage Area                 10.75 square miles
100-Year Discharge            2082.933 cfs
Floodplain Width              37 feet
Channel Width at Bridge       23 feet
Channel Width Upstream        26 feet
Bridge Length                 67 feet
Low Steel to Bed Distance     11.05 feet
Bed Material                  Sand/Silt
Cutbank Presence              None
Abutment Type                 Spill Through

S1                            5.695 feet
S2                            9.772 feet

Estimate of Total Scour       5.695 feet
```

Figure 22. Sample output from the computer program ILSCOUR for estimating total-streambed scour at bridge sites in Illinois.

Application of the simplified scour-estimation method requires less field and office time than with the conventional scour-estimation method. The bridge-site characteristics needed to apply the method can be obtained from an office review of bridge plans, USGS 7.5-minute topographical maps, and a brief site inspection. The simplified method has been demonstrated to be conservative in estimation of the 500-year flood total scour when compared to conventional estimates of total scour. The simplified method, conservative in estimating the 500-year flood total-streambed scour, can be utilized in estimating total scour for a large number of bridges without performing the more complex conventional hydraulic and scour computations. This facilitates screening of bridge sites so that the more detailed conventional analysis is only applied to more complex and problem sites. A computer program (ILSCOUR) was written to automate the application of the simplified method.

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