



# Physical-Habitat and Geomorphic Data for Selected River Reaches in Central Arizona Basins, 1995—98

Open-File Report 00 90

*National Water-Quality Assessment Program*

U.S. DEPARTMENT OF THE INTERIOR  
U.S. GEOLOGICAL SURVEY



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*By* K.M. Beaulieu, J.P. Capesius, *and* J.B. Gebler

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NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Tucson, Arizona  
2000

U.S. DEPARTMENT OF THE INTERIOR  
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY  
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## FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resources agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for a specific contamination problem; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) program. In 1991, the USGS began full implementation of the program. The NAWQA program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA program are to:

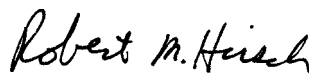
- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.



Robert M. Hirsch  
Associate Director for Water



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# Physical-Habitat and Geomorphic Data for Selected River Reaches in Central Arizona Basins, 1995–98

By K.M. Beaulieu, J.P. Capesius, and J.B. Gebler

## Abstract

This report presents data from physical-habitat and geomorphic measurements that were made at 11 stream reaches in the Central Arizona Basins study area of the U.S. Geological Survey's National Water-Quality Assessment program from 1995 to 1998. Measurements of water velocity and depth, particle size of bed material, embeddedness of substrate, stream aspect, and solar contribution were made at each reach. In addition, the extent and type of dominant riparian vegetation along each reach were characterized. To maintain nationwide consistency, data-collection methods were based on protocols developed by the National Water-Quality Assessment program for the assessment of stream habitat.

Measurements were made at a single reach, designated as reach A, at nine sites (termed basic fixed sites) between October 1995 and January 1996. Measurements were made at three reaches, designated as reaches A, B, and C, at two of these sites (West Clear Creek near Camp Verde and San Pedro River near Charleston) between October and December 1996. In addition, measurements were made at three reaches at two other sites on the San Pedro River in December 1996. In October and November 1997, measurements were made at reach A of West Clear Creek near Camp Verde and reach A of the San Pedro River near Charleston. Cross sections and longitudinal profiles were surveyed on the nine basic fixed sites in late 1997 and in 1998.

## INTRODUCTION

In 1991, the U.S. Geological Survey implemented the National Water-Quality Assessment (NAWQA) program. The NAWQA program was designed to assess the status and trends of the Nation's water quality and to develop an understanding of the major factors that affect water-quality conditions (Hirsch and others, 1988; Leahy and others, 1990). Program goals are addressed through the integration of physical, chemical, and biological data from 59 study areas. The program will provide a baseline of information for use by policy makers and managers at National, State, and local levels. In 1994, data collection and analysis began in the Central Arizona Basins (CAZB) NAWQA study area ([fig. 1](#)).

Ecological assessment, which includes measurements of physical-habitat and geomorphic characteristics, is one aspect of the multidisciplinary NAWQA program. Measurements of riparian and instream characteristics provide information for interpreting water-quality conditions, identifying physical factors critical to biological communities, and yielding an understanding of species distributions relative to habitat characteristics. These data can be used for assessments of long-term trends and changes in biological communities and habitat characteristics that may be caused by changes in physical and chemical constituents, landscape features, and human activities (Gurtz, 1994). The data that are presented in this report were collected with the cooperation of landowners who granted access to the sites.



## Purpose and Scope

This report describes and summarizes data from physical-habitat and geomorphic measurements made between 1995 and 1998 at 11 sites in the study area (fig. 1 and table 1). Measurements of water velocity and depth, bed-material type and sizes, embeddedness of substrate, stream aspect, and solar contribution were made at each reach. In addition, the extent and type of dominant riparian vegetation along each reach were characterized. Measurements were made at nine basic

fixed sites between October 1995 and January 1996. Measurements were made at two of these basic fixed sites (San Pedro River near Charleston and West Clear Creek near Camp Verde) for 3 consecutive years. Measurements were made at multiple reaches at these two sites and at two additional sites on the San Pedro River (San Pedro River near Hereford Road and San Pedro River near Highway 90) in late 1996. Cross-sectional and longitudinal surveys were completed on the nine basic fixed sites during late 1997 through 1998.

**Table 1.** Summary of measurement sites for Central Arizona Basins study area

[<, less than]

Site number (see fig. 1)	Site name	Station-identification number	Latitude	Longitude	Basin name	Drainage area, in square kilometers
1	San Pedro River near Hereford Road <sup>1</sup>	312621110062601	31°26'21"	110°06'26"	Upper San Pedro River	2,400
2	San Pedro River near Highway 90 <sup>1</sup>	313256110080701	31°32'56"	110°08'07"	Upper San Pedro River	2,819
3	San Pedro River at Charleston <sup>1,2</sup>	09471000	31°37'33"	110°10'26"	Upper San Pedro River	3,257
4	Gila River at Kelvin <sup>2</sup>	09474000	33°06'10"	110°58'33"	Middle Gila River	46,648
5	Santa Cruz River at Tubac <sup>1,2</sup>	09481740	31°36'46"	111°02'27"	Upper Santa Cruz River	3,131
6	Santa Cruz River at Cortaro <sup>1,2</sup>	09486500	32°21'04"	111°05'38"	Upper Santa Cruz River	9,073
7	Salt River near Roosevelt <sup>2</sup>	09498500	33°37'10"	110°55'15"	Salt River	11,153
8	Verde River above West Clear Creek near Camp Verde <sup>2</sup>	09505570	34°30'20"	111°50'05"	Verde River	12,173
9	West Clear Creek near Camp Verde <sup>2</sup>	09505800	34°32'19"	111°41'36"	Verde River	624
10	Verde River below Tangle Creek above Horseshoe Dam <sup>2</sup>	09508500	34°04'23"	111°42'56"	Verde River	15,172
11	91st Avenue wastewater-treatment plant outfall near Phoenix <sup>2</sup>	09512407	33°23'22"	112°15'13"	Salt River	( <sup>3</sup> )

Site number (see fig. 1)	Ecological design	Physiographic province <sup>4</sup>	Gaging station	Land use, in percent <sup>5</sup>				
				Urban	Agriculture	Rangeland	Forest	Other
1	Multiple reach/single year	Basin and Range Lowlands	No	4	5	65	5	21
2	Multiple reach/single year	Basin and Range Lowlands	No	3	3	68	25	1
3	Multiple reach/multiple year	Basin and Range Lowlands	Yes	3	2	76	18	1
4	Single reach/single year	Basin and Range Lowlands	Yes	1	1	84	13	1
5	Single reach/single year	Basin and Range Lowlands	Yes	1	1	55	42	1
6	Single reach/single year	Basin and Range Lowlands	Yes	16	2	59	21	2
7	Single reach/single year	Central Highlands	Yes	1	0	16	83	0
8	Single reach/single year	Central Highlands	No	2	5	32	59	2
9	Multiple reach/multiple year	Central Highlands	Yes	0	0	21	79	0
10	Single reach/single year	Central Highlands	Yes	2	4	33	60	1
11	Single reach/single year	Basin and Range Lowlands	No	( <sup>3</sup> )	( <sup>3</sup> )	( <sup>3</sup> )	( <sup>3</sup> )	( <sup>3</sup> )

<sup>1</sup>Land-use information not available for the parts of the study area in Mexico. Land-use percentages are for the part of the study area in United States only.

<sup>2</sup>Basic fixed site.

<sup>3</sup>Not applicable.

<sup>4</sup>Fenneman (1931).

<sup>5</sup>Anderson and others (1976). Urban data for 1990, unpublished, from Maricopa Association of Governments, Pima County, and University of Arizona.



## Description of Study Area

The CAZB study unit encompasses 89,900 km<sup>2</sup> including 2,850 km<sup>2</sup> in Mexico (fig. 1). Five major river systems, the Gila, Salt, Verde, Santa Cruz, and San Pedro, are included in the study area. The climate of the study area is arid to semiarid and has an average precipitation ranging from 15 to 25 cm/yr in the Basin and Range Lowlands and 64 to 102 cm/yr in the Central Highlands (Sellers and Hill, 1974; U.S. Geological Survey, 1969). The population in the study area exceeds 3.1 million people; about 80 percent reside in the Phoenix and Tucson metropolitan areas (Cordy and others, 1998). The environmental setting of the study area is described in detail by Cordy and others (1998).

## DATA-COLLECTION METHODS AND CALCULATIONS

Data collection included measurements of instream characteristics, solar contribution to the system, and identification of riparian vegetation. The methods used to measure physical-habitat and geomorphic characteristics of selected sites in the CAZB are described in Meador and others (1993) as part of the reach-level characterization.

Eleven sites were selected for measuring geomorphic and physical-habitat attributes (fig. 1; table 1). At each site, a reach was selected based primarily on the presence of multiple (two or more) major fluvial geomorphic features, such as riffles, runs, or pools. Reach lengths ranged from 121 to 610 m, and the typical length was about 200 to 300 m. Six transects, each oriented perpendicularly to the stream channel and marked by semi-permanent monuments, were selected at each reach to best characterize the occurrence and extent of the major geomorphic features within the reach. At the nine basic fixed sites, cross sections of the stream and riparian zone were surveyed at all transects using either a total station system or a surveying level with surveying rod. Elevation was established by reference to either a local streamflow-gaging station or benchmarks. The length of each transect was measured using a calibrated tape. Longitudinal profiles of the stream channel were constructed using the depth of the thalweg at each transect and the surveyed distance between transects (Harrelson and others, 1994).

Instream measurements were made at every transect. Velocity measurements were made at the thalweg and at least two other points along the transect. Dominant and subdominant substrate or bed-material types were determined at each of the three points. Embeddedness was determined by a categorical rating of the percentage of surface area of particles (gravel, cobble, and boulder) covered by fine sediment.

At each transect, a clinometer was used to determine the extent of canopy openness above midchannel, and a spherical densiometer (Platts and others, 1987) was used to estimate the relative density of riparian vegetation. A Solar Pathfinder (Platts and others, 1987) was used to estimate the amount of incident solar radiation striking the stream. This device is calibrated so that a single measurement is sufficient to provide estimates of solar insolation at different times of the year (Platts and others, 1987). In general, Solar Pathfinder measurements were taken at midchannel at the downstream most and upstream most transects (transects 1 and 6, respectively) and at a point, referred to as midreach, approximately at the midpoint between transects 3 and 4. In a few cases, an island in the stream channel intersected a transect used for Solar Pathfinder measurements. In such cases, two Solar Pathfinder measurements were taken, each at the midpoint of each channel. In one instance (San Pedro River near Highway 90, reach B), a Solar Pathfinder measurement was taken at an additional transect because it was deemed that the extra measurement would increase the representativeness of solar insolation for the reach. The aspect, or compass bearing, corrected for magnetic declination, was determined for the direction of downstream flow at the midpoint of each transect.

To determine bed-material type and sizes, pebble counts were made at all six transects of each reach using a modified Wolman method (Wolman, 1954; Harrelson and others, 1994). Starting at the left edge of water, the investigator took a step, picked up the particle at the toe of his/her boot, and measured the intermediate axis. Particles less than 0.5 cm were identified by texture. This procedure was repeated until the right edge of water was reached (table 2). Consequently, the number of particles measured at each transect varied depending on the width of the wetted channel. These data are represented graphically as percentages for each transect. The average for a reach was determined as the number of particles in a size-class category divided by the total number of particles measured for the reach.

**Table 2.** Size classes used to quantify streambed substrate in the Wolman Pebble Count procedure

[Categories modified from classes of Wentworth (1922). &gt;, greater than; &lt;, less than]

Particle classes	Size, in millimeters	Particle classes	Size, in millimeters
Boulder	>256	Gravel	5 to <16
Cobble	64 to <256	Sand	.06 to <5
Pebble	16 to <64	Silt	.004 to <.06

The point-centered quarter method was used to evaluate density and dominance of woody vegetation (Mueller-Dombois and Ellenberg, 1974). Twelve points in each reach—one point on each bank for each transect—were defined by the intersection of the transect and a line perpendicular to the transect at the top of the bank. From each point, four quadrats were established by the same intersecting lines. In each quadrat, the closest individual woody plant was identified, and the diameter of the plant at breast height and its distance from the point were measured.

Four measures—mean basal area, dominance, absolute frequency, and relative density—were computed for each species to characterize the community of riparian woody vegetation. For each species, basal area for each individual was computed by dividing the diameter at breast height by two (to obtain the radius), squaring that value, and multiplying by  $\pi$  (truncated at five places past the decimal). Mean basal area for each species was obtained by summing the result for each individual and dividing by the total number of individuals of that species. Dominance was computed by dividing the mean basal area of a particular species by the number of trees of that species in 100 m<sup>2</sup>. In order to compute dominance, values for total distance and mean distance from the measurement point and the number of trees of all species in 100 m<sup>2</sup>, were first obtained. Dominance for a particular species was then determined by multiplying the proportion of that species by the total number of trees of all species in 100 m<sup>2</sup> to compute the number of that species in 100 m<sup>2</sup>. This value was then multiplied by the mean basal area for the species, which gives dominance (Mueller-Dombois and Ellenberg, 1974).

Absolute frequency for each species was determined by dividing the number of points with which the species was associated by the total number of points. For example, if an individual of a particular species was found in one or more quadrats for 3 of the

12 points, the absolute frequency of that species was 25 percent. More than one individual of a given species associated with a point, such as would be the case if the species was found in more than one quadrat for that point, does not increase the absolute frequency of the plant. Relative density was computed by dividing the number of individuals of a given species by the total number of individuals of all species.

## PHYSICAL-HABITAT AND GEOMORPHIC DATA

Physical-habitat and geomorphic data are presented in tabular and graphical formats by reach for each site in downstream order. A map showing the approximate location of the site and transects is given for each site. For basic fixed sites, cross-sectional and longitudinal-survey information is then presented. A table presenting habitat characteristics follows for all sites. Graphs of solar insolation and bed-material types appear and are followed by a table that contains measures of woody vegetation.

## REFERENCES CITED

- Anderson, J.R., Hardy, E.E., Road, J.T., and Witmer, R.E., 1976, A land use and land cover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 964, 28 p.
- Cordy, G.E., Rees, J.A., Edmonds, R.J., Gebler, J.B., Wirt, Laurie, Gellenbeck, D.J., and Anning, D.W., 1998, Water-quality assessment of the Central Arizona Basins, Arizona and northern Mexico— Environmental setting and overview of water quality: U.S. Geological Survey Water-Resources Investigations Report 98–4097, 71 p.
- Fenneman, N.M., 1931, Physiography of Western United States: New York, McGraw-Hill, 534 p.

- Gurtz, M.E., 1994, Design of biological components of the National Water-Quality Assessment (NAWQA) program, *in* Loeb, S.L., and Spacie, A., eds., Biological monitoring of aquatic systems: Boca Raton, Florida, Lewis Publishers, chap. 15, p. 323–354.
- Harrelson, C.C., Rawlings, C.L., and Potyondy, J.P., 1994, Stream channel reference sites—An illustrated guide to field techniques: U.S. Forest Service General Technical Report RM-245, 61 p.
- Hirsch, R.M., Alley, W.M., and Wilber, W.G., 1988, Concepts for a National Water-Quality Assessment program: U.S. Geological Survey Circular 1021, 42 p.
- Leahy, P.P., Rosenshein, J.S., and Knopman, D.S., 1990, Implementation plan for the National Water-Quality Assessment program: U.S. Geological Survey Open-File Report 90-174, 10 p.
- Leopold, L.B., Wolman, M.G., and Miller, J.P., 1964, Fluvial processes in geomorphology: San Francisco, California, W.H. Freeman, 522 p.
- Meador, M.R., Hupp, C.L., Cuffney, T.F., and Gurtz, M.E., 1993, Methods for characterizing stream habitat as part of the National Water-Quality Assessment program: U.S. Geological Survey Open-File Report 93-408, 48 p.
- Mueller-Dombois, Dieter, and Ellenberg, Heinz, 1974, Aims and methods of vegetation ecology: New York, John Wiley and Sons, 547 p.
- Platts, W.S., Armour, Carl, Booth, G.D., Bryant, Mason, Bufford, J.L., Cuplin, Paul, Jensen, Sherman, Lienkaemper, G.W., Minshall, G.W., Monsen, S.B., Nelson, R.L., Sedell, J.R., and Tuhy, J.S., 1987, Methods for evaluating riparian habitats with applications to management: Ogden, Utah, U.S. Forest Service, General Technical Report INT-221, 177 p.
- Sellers, W.D., and Hill, R.H., eds., 1974, Arizona climate, 1931–1972: Tucson, Arizona, University of Arizona Press, 616 p.
- U.S. Geological Survey, 1969, Annual report of ground water in Arizona, spring 1967 to spring 1968: Phoenix, Arizona State Land Department Water-Resources Report 38, 54 p.
- Wentworth, C.K., 1922, A method for measuring and plotting the shapes of pebbles: U.S. Geological Survey Bulletin 730-C, p. 91–114.
- Wolman, M.G., 1954, A method of sampling coarse river-bed material: Washington, D.C., American Geophysical Union, Transactions, v. 35, no. 6, p. 951–956.

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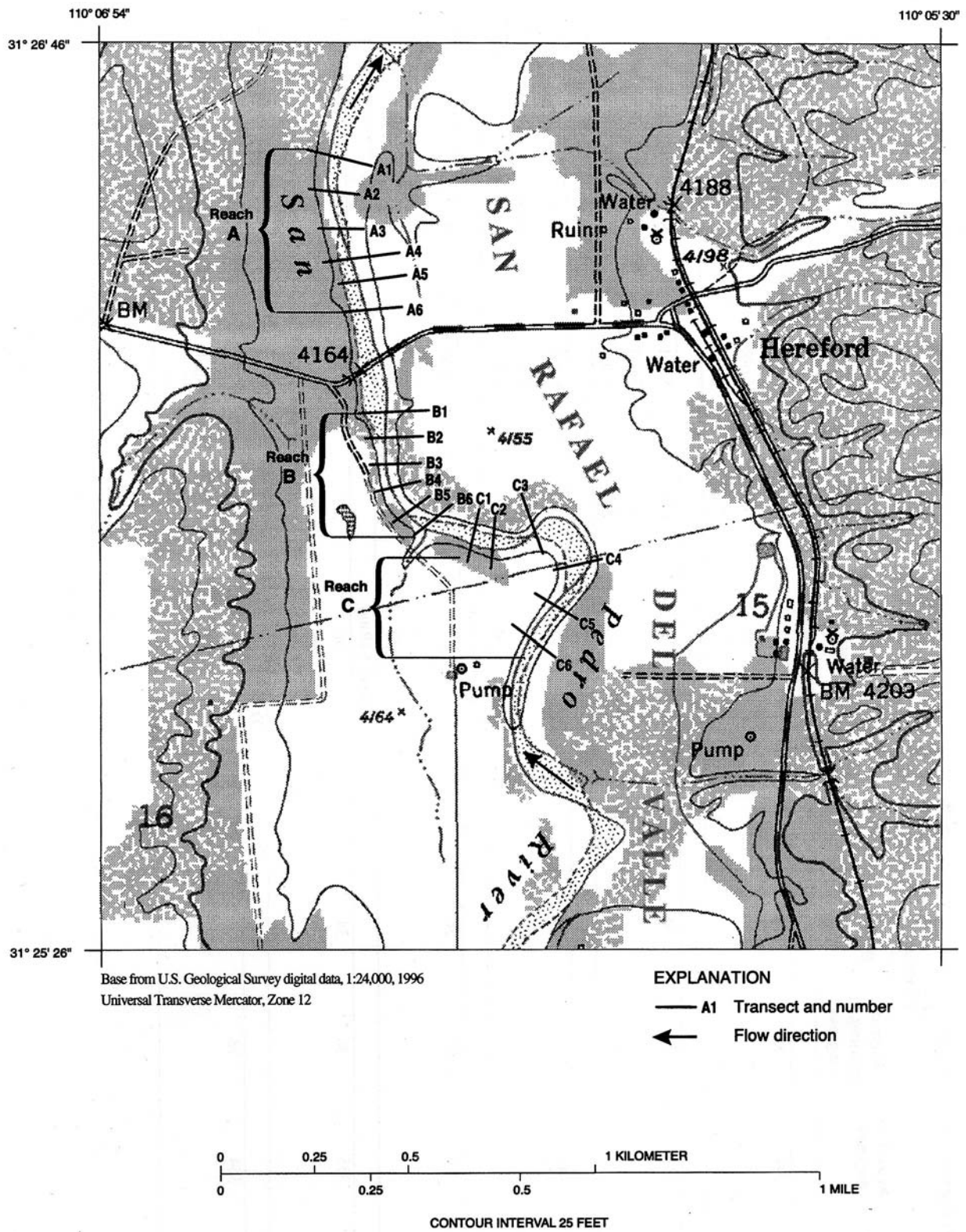
**PHYSICAL AND GEOMORPHIC DATA  
FOR SELECTED RIVER SEGMENTS**

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**San Pedro River near Hereford Road, Arizona**  
**(USGS station number: 312621110062601)**

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**Figure 2.** Location of transects 1–6, reaches A–C, San Pedro River near Hereford, Arizona.

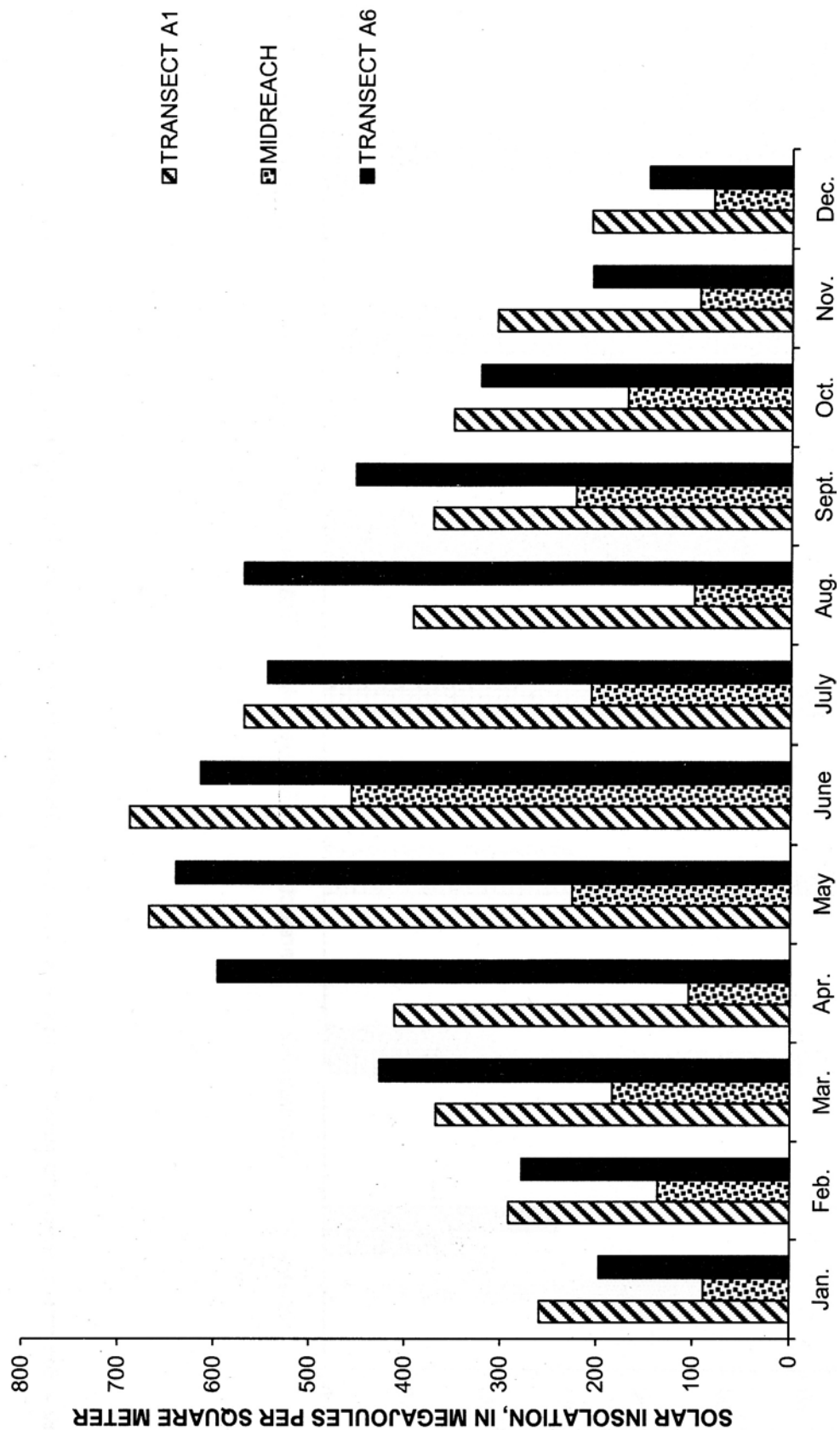
**Table 3.** Habitat characteristics of reach A, San Pedro River near Hereford Road, Arizona, December 12, 1996

[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 3, 26 to 50 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. Dashes indicate no data. <, less than]

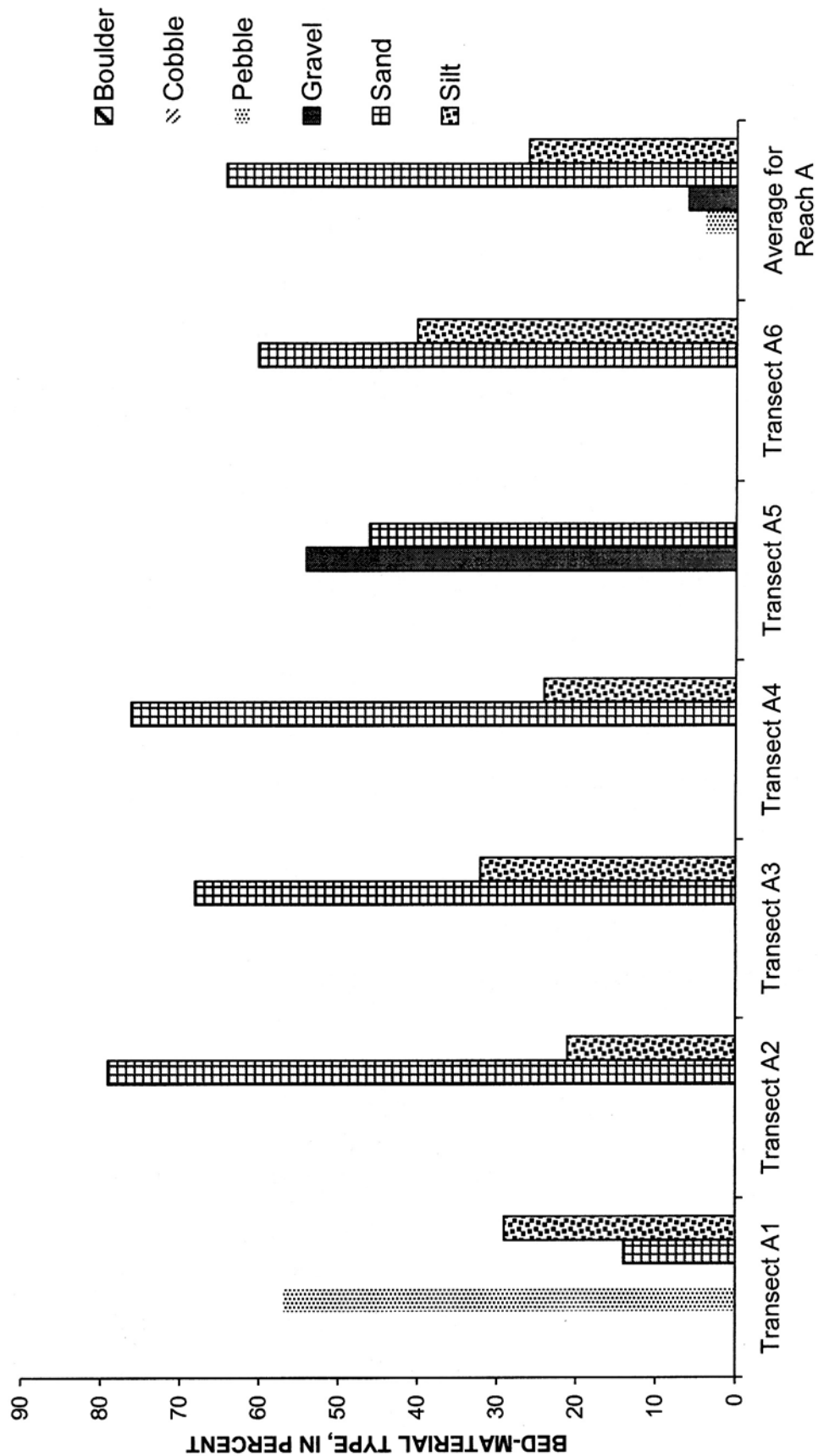
Width of wetted channel, in meters	Aspect, in degrees	Canopy		Velocity			Substrate		
		Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
1.7	340	89	6	0.6	0.11	0.24	Gravel	Cobble	5
				1.3	<sup>1</sup> .22	.68	Cobble	Gravel	3
				1.5	.16	.71	Gravel	Cobble	5
Transect 2 (Pool)									
8.0	348	28	68	2.1	<sup>1</sup> .26	.08	Sand	Silt	0
				4.2	.23	.07	Sand	Silt	0
				6.1	.20	.06	Silt	Sand	0
Transect 3 (Pool)									
9.1	341	4	82	1.0	<sup>1</sup> .57	.19	Sand	Silt	0
				3.7	.43	<.01	Silt	Sand	0
				6.4	.56	.01	Silt	Sand	0
Transect 4 (Run)									
5.1	6	25	56	1.4	.13	.06	Sand	Silt	0
				2.7	.17	.15	Sand	Silt	0
				4.1	<sup>1</sup> .30	.16	Sand	Silt	0
Transect 5 (Run)									
3.9	355	38	34	1.2	.06	.02	Sand	Gravel	5
				2.4	.08	.16	Sand	Gravel	5
				3.6	<sup>1</sup> .23	.44	Sand	Gravel	5
Transect 6 (Run)									
6.2	354	78	25	1.4	.12	.17	Sand	Silt	0
				2.9	<sup>1</sup> .18	.12	Sand	Gravel	5
				4.6	.16	.12	---	---	---

<sup>1</sup>Thalweg.





**Figure 3.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, San Pedro River near Hereford Road, Arizona, based on measurements made December 12, 1996.



**Figure 4.** Bed-material types at transects 1–6 and average for reach A, San Pedro River near Hereford Road, Arizona, December 12, 1996.

**Table 4.** Density and dominance of woody vegetation for reach A, San Pedro River near Hereford Road, Arizona, December 12, 1996  
[Length of reach, 233 meters]

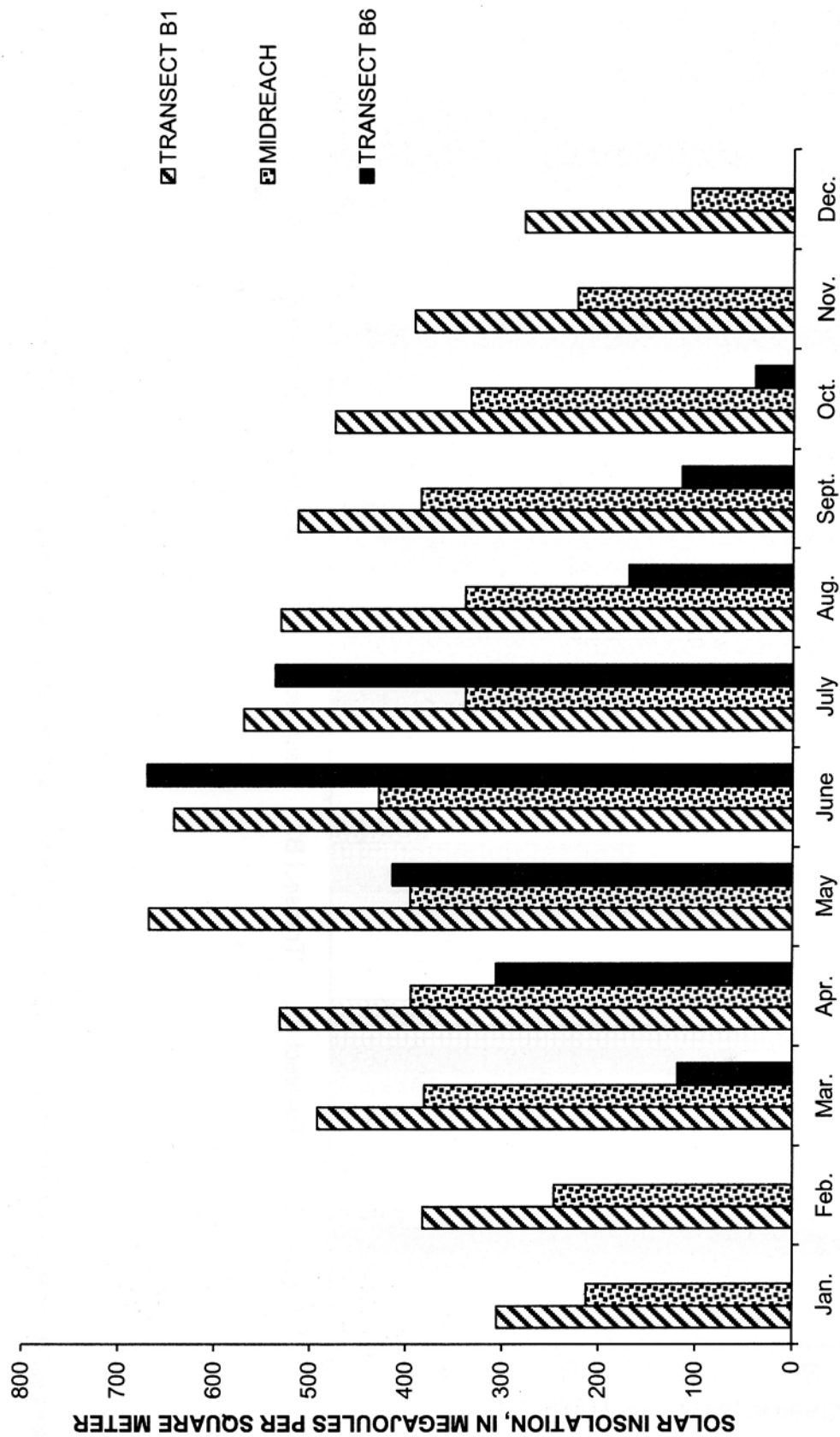
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	369	236	42	20
Mesquite ( <i>Prosopis sp.</i> )	204	65	25	10
Willow ( <i>Salix sp.</i> )	202	452	92	70

**Table 5.** Habitat characteristics of reach B, San Pedro River near Hereford Road, Arizona, December 18, 1996

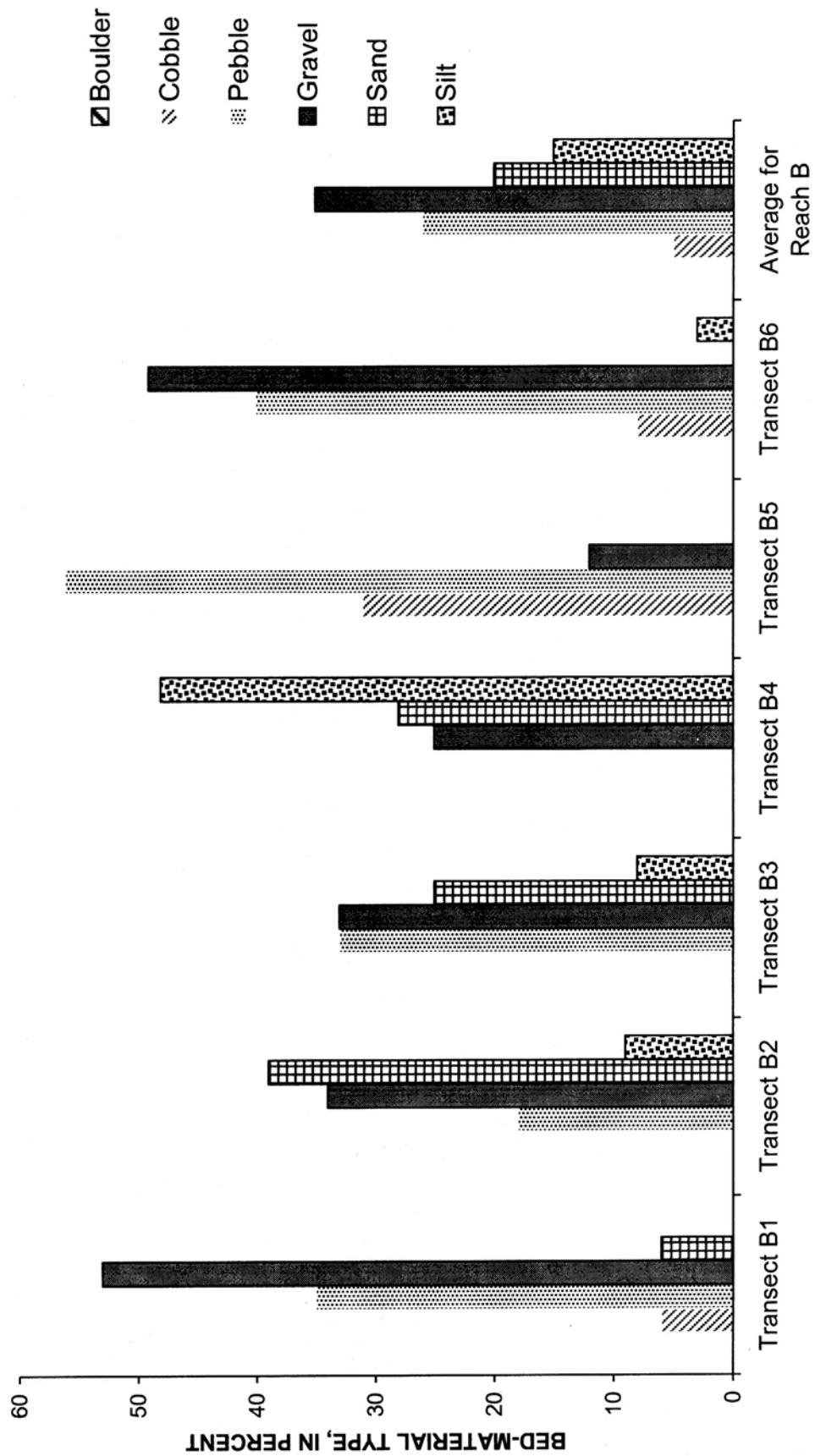
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 2, 51 to 75 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. NA, not applicable; <, less than]

Stream width, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle, in degrees	Density, in percent	Distance from left bank, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
5.0	347	59	35	1.5	<sup>1</sup> 0.13	0.52	Gravel	Sand	5
				2.7	.09	.02	Gravel	Sand	5
				4.8	.08	.87	Gravel	Sand	5
Transect 2 (Riffle)									
15.5	352	82	46	.9	<sup>1</sup> 1.18	.13	Sand	Silt	0
				5.0	.07	<.01	Sand	Silt	0
				1.5	.8	<.01	Sand	Silt	0
Transect 3 (Run)									
7.6	354	77	7	2.0	.24	<.01	Gravel	Sand	5
				4.0	.27	.04	Gravel	Sand	5
				6.0	<sup>1</sup> 1.30	.02	Sand	Silt	0
Transect 4 (Pool)									
12.4	2	38	63	3.7	<sup>1</sup> 1.98	.02	Silt	NA	0
				7.0	.34	<.01	Silt	Gravel	5
				10.0	.32	<.01	Gravel	Silt	2
Transect 5 (Riffle)									
5.0	322	49	40	1.2	.09	.12	Cobble	Gravel	4
				2.5	<sup>1</sup> 1.13	.81	Cobble	Gravel	4
				3.9	.08	.37	Cobble	Gravel	4
Transect 6 (Riffle)									
10.8	347	55	75	3.4	.08	.03	Gravel	Cobble	5
				6.4	<sup>1</sup> 1.11	.40	Gravel	Cobble	5
				10.2	.08	.16	Gravel	Sand	5

<sup>1</sup>Thalweg.



**Figure 5.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach B, San Pedro River near Hereford Road, Arizona, based on measurements made December 18, 1996.



**Figure 6.** Bed-material at transects 1–6 and average for reach B, San Pedro River near Hereford Road, Arizona, December 18, 1996.

**Table 6.** Density and dominance of woody vegetation for reach B, San Pedro River near Hereford Road, Arizona, December 18, 1996  
[Length of reach, 328 meters]

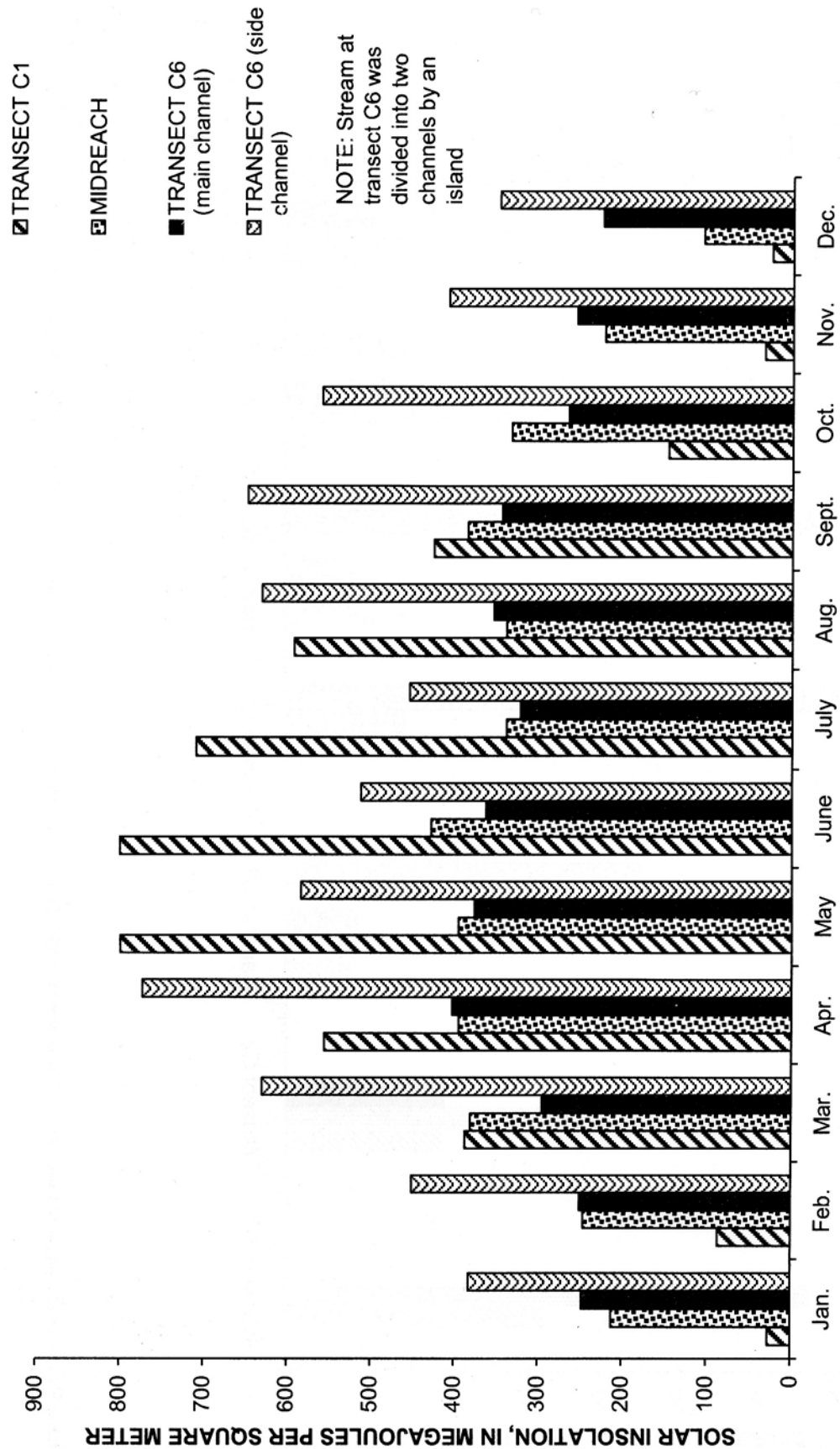
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	850	484	67	41
Willow ( <i>Salix sp.</i> )	318	258	75	59

**Table 7.** Habitat characteristics of reach C, San Pedro River near Hereford Road, Arizona, December 17, 1996

[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 1, more than 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. NA, not applicable; <, less than]

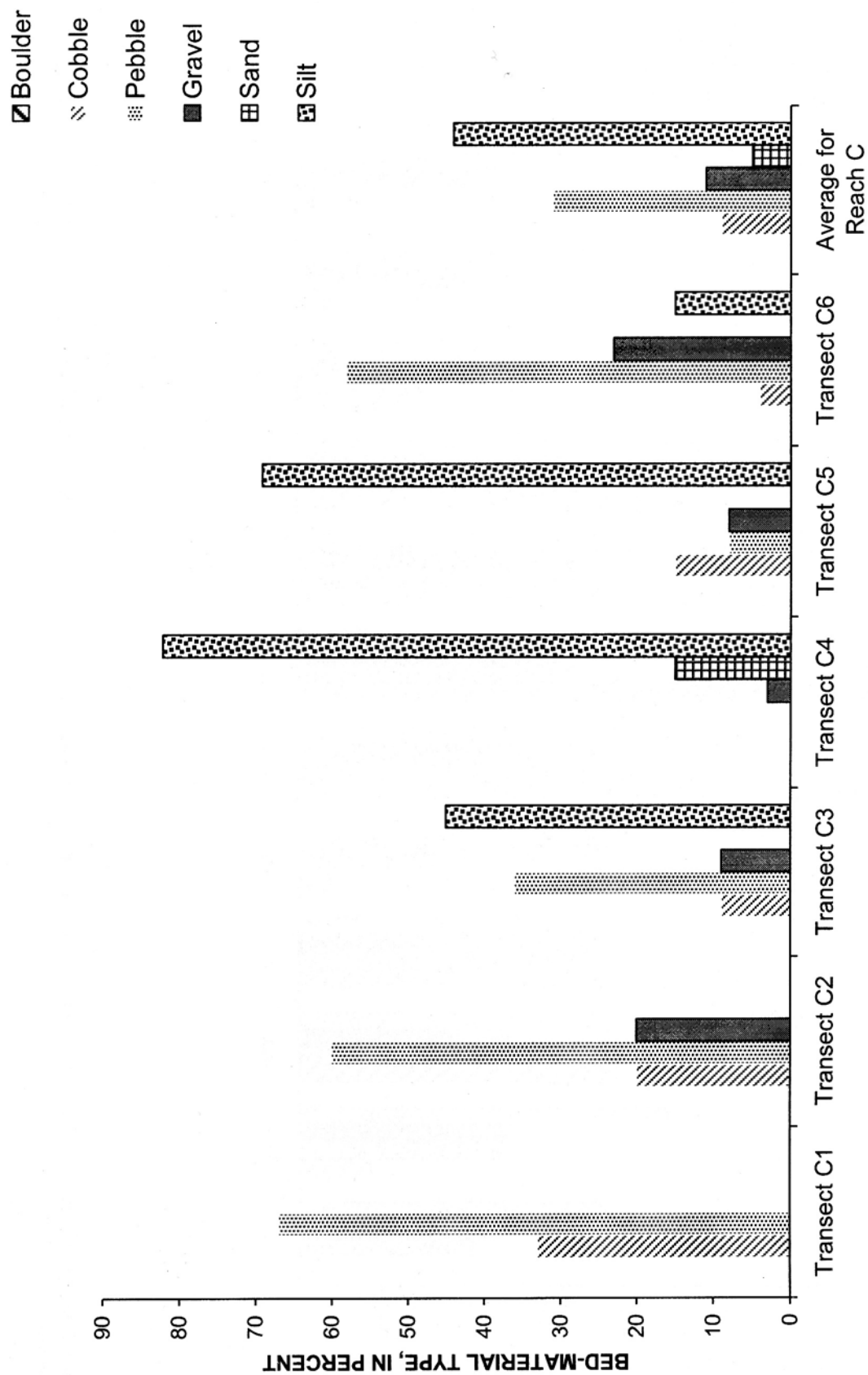
Stream width, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle, in degrees	Density, in percent	Distance from left bank, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
2.6	245	84	34	1.0	0.09	0.91	Cobble	Gravel	4
				1.5	<sup>1</sup> .12	.38	Cobble	Gravel	4
				2.0	.10	.27	Cobble	Gravel	4
Transect 2 (Riffle)									
3.2	206	114	25	.6	.05	.43	Cobble	NA	4
				1.4	<sup>1</sup> .11	.84	Cobble	NA	4
				2.0	.08	.32	Cobble	NA	4
Transect 3 (Pool)									
4.1	305	75	94	1.7	<sup>1</sup> .52	.07	Cobble	Silt	3
				2.6	.49	.12	Cobble	Silt	3
				3.2	.21	.03	Cobble	Silt	1
Transect 4 (Run)									
10.5	343	102	15	2.4	.30	<.01	Silt	Gravel	5
				4.9	<sup>1</sup> .36	.02	Silt	Gravel	5
				7.3	.30	.04	Silt	Gravel	5
Transect 5 (Run)									
3.4	301	139	22	1.4	.12	.13	Gravel	Silt	5
				1.9	<sup>1</sup> .27	<.01	Silt	Gravel	5
				2.5	.18	.07	Silt	Cobble	0
Transect 6 (Riffle)									
11.8	361	99	35	3.7	.07	.41	Cobble	Gravel	3
				4.7	<sup>1</sup> .10	.63	Gravel	Cobble	3
				11.0	.05	.13	Cobble	NA	3

<sup>1</sup>Thalweg.



**Figure 7.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach C, San Pedro River near Hereford Road, Arizona, based on measurements made December 19, 1996.





**Figure 8.** Bed-material types at transects 1–6 and average for reach C, San Pedro River near Hereford Road, Arizona, December 19,1996.

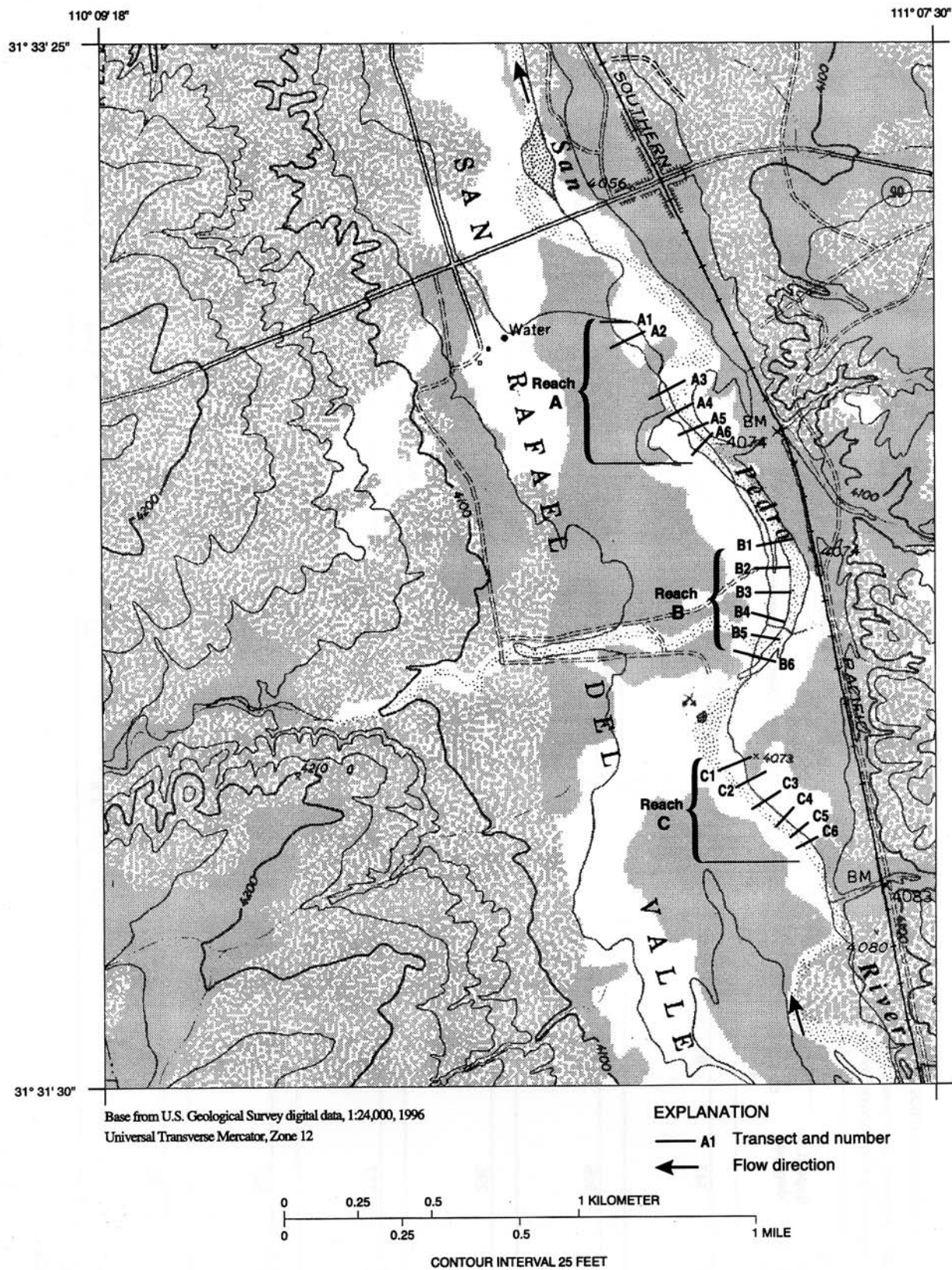
**Table 8.** Density and dominance of woody vegetation for reach C, San Pedro River near Hereford Road, Arizona, December 17, 1996  
[Length of reach, 365 meters. <, less than]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	363	214	100	76
Mesquite ( <i>Prosopis sp.</i> )	13	<1	8	4
Willow ( <i>Salix sp.</i> )	229	37	42	20

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**San Pedro River near Highway 90, Arizona**  
**(USGS station number: 313256110080701)**

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**Figure 9.** Location of transects 1–6, reaches A–C, San Pedro River near Highway 90, Arizona.

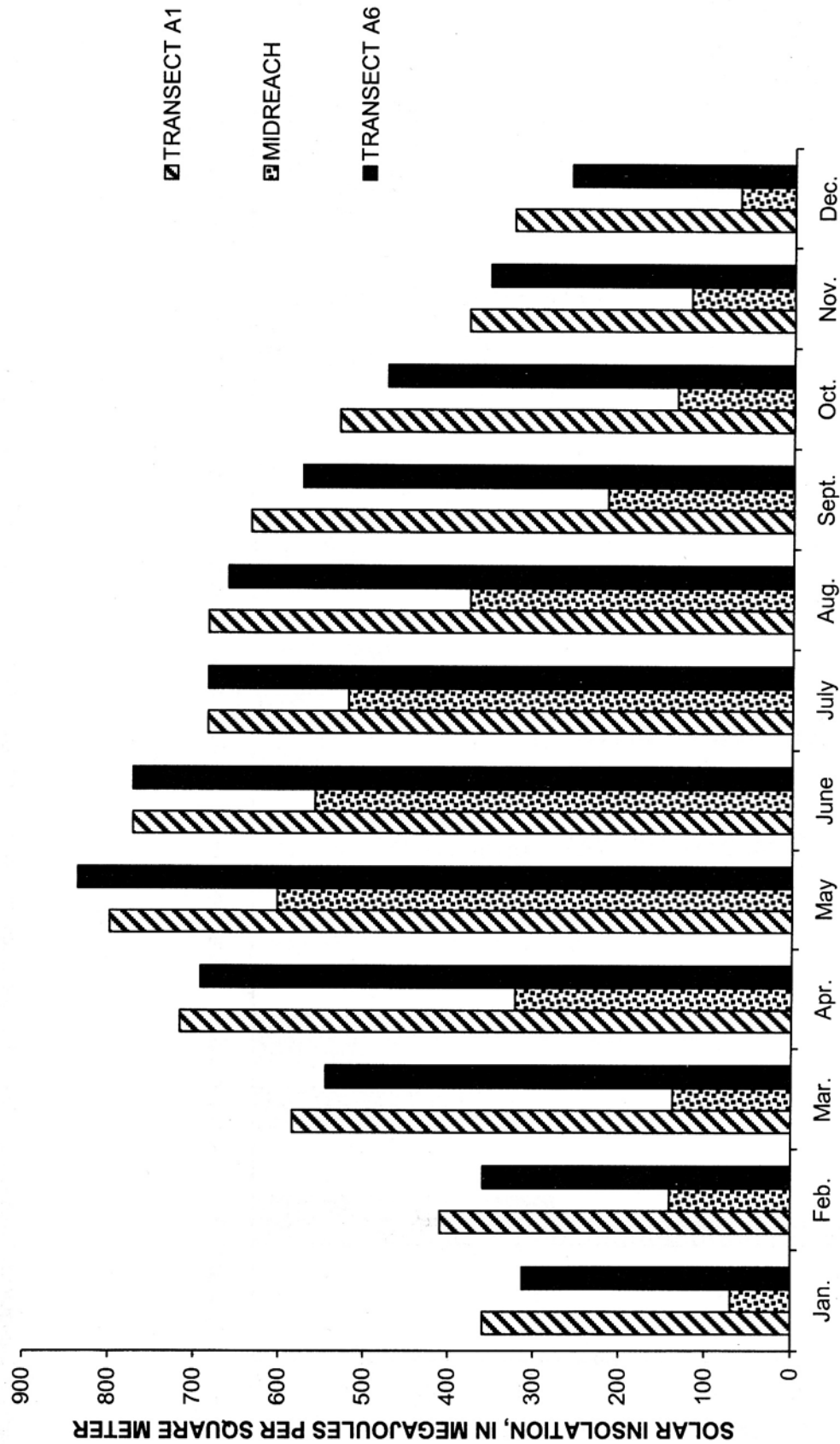
**Table 9.** Habitat characteristics of reach A, San Pedro River near Highway 90, Arizona, December 5, 1996

[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. <, less than]

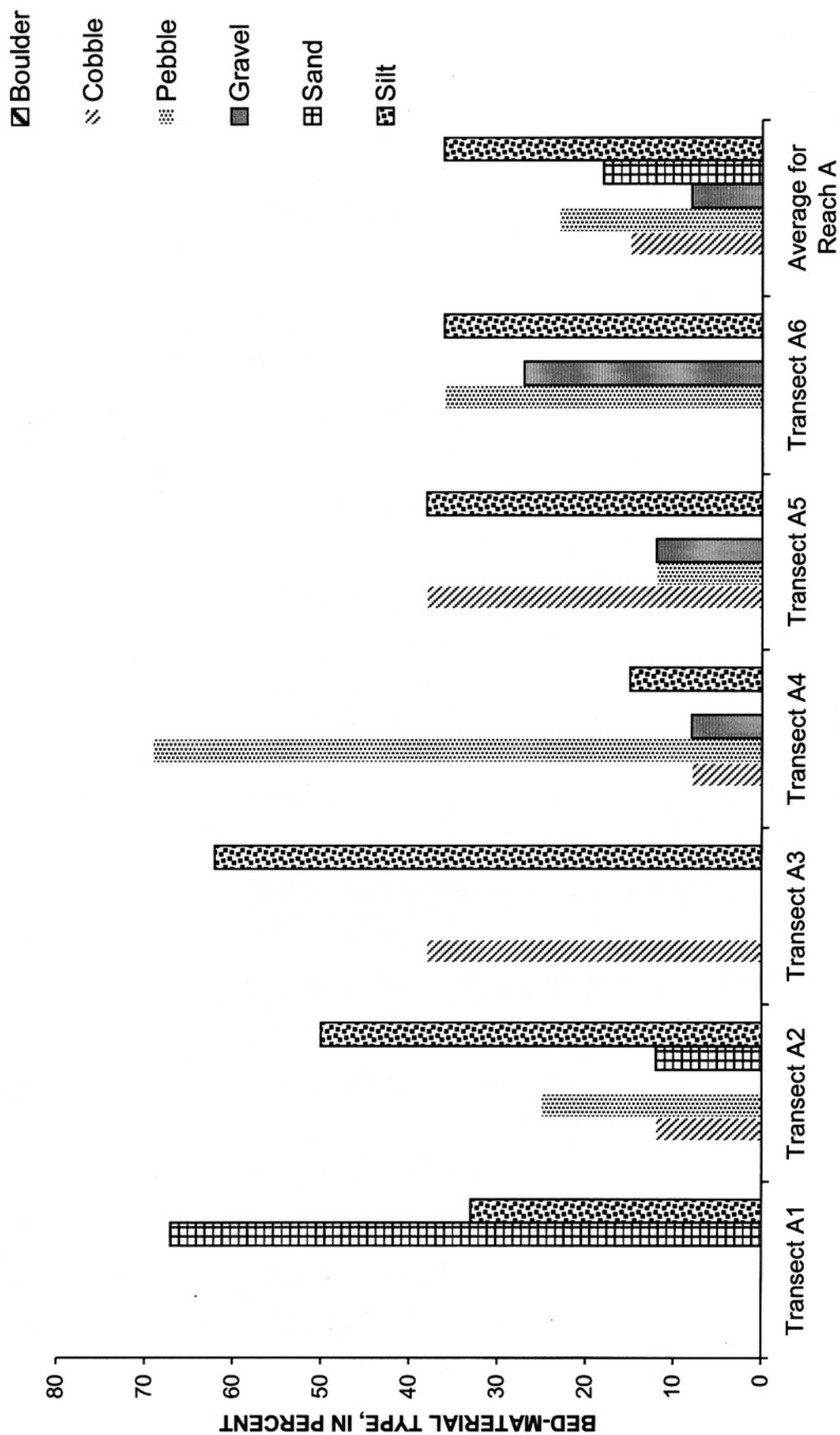
Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Run)									
5.5	345	95	4	2.0	0.27	<sup>2</sup> <0.01	Sand	Silt	0
				4.1	<sup>1</sup> .46	.22	Sand	Silt	0
				4.8	.27	.09	Silt	Sand	0
Transect 2 (Riffle)									
2.2	306	82	12	.8	<sup>1</sup> .27	.21	Gravel	Sand	5
				1.5	.21	.67	Gravel	Cobble	4
				1.9	.08	.21	Silt	Sand	0
Transect 3 (Run)									
2.6	296	75	22	.8	.27	.17	Sand	Cobble	3
				1.5	<sup>1</sup> .40	.63	Cobble	Sand	3
				2.0	.32	<sup>2</sup> .02	Sand	Silt	2
Transect 4 (Riffle)									
3.6	277	47	18	.9	.12	.27	Cobble	Gravel	3
				1.6	<sup>1</sup> .18	.54	Cobble	Gravel	3
				2.3	.12	.43	Cobble	Gravel	3
Transect 5 (Pool)									
4.1	327	47	63	.2	.67	.12	Cobble	Gravel	3
				1.1	<sup>1</sup> .73	.10	Cobble	Gravel	2
				1.8	.73	.05	Cobble	Gravel	2
Transect 6 (Run)									
2.5	333	69	7	.7	.12	.50	Gravel	Cobble	3
				1.2	.21	.56	Gravel	Cobble	3
				1.8	<sup>1</sup> .23	.24	Sand	Gravel	5

<sup>1</sup>Thalweg.

<sup>2</sup>Reverse flow.



**Figure 10.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, San Pedro River near Highway 90, Arizona, based on measurements made December 5, 1996.



**Figure 11.** Bed-material types at transects 1–6 and average for reach A, San Pedro River near Highway 90, Arizona, December 5, 1996.



**Table 10.** Density and dominance of woody vegetation for reach A, San Pedro River near Highway 90, Arizona, December 5, 1996  
[Length of reach, 274 meters]

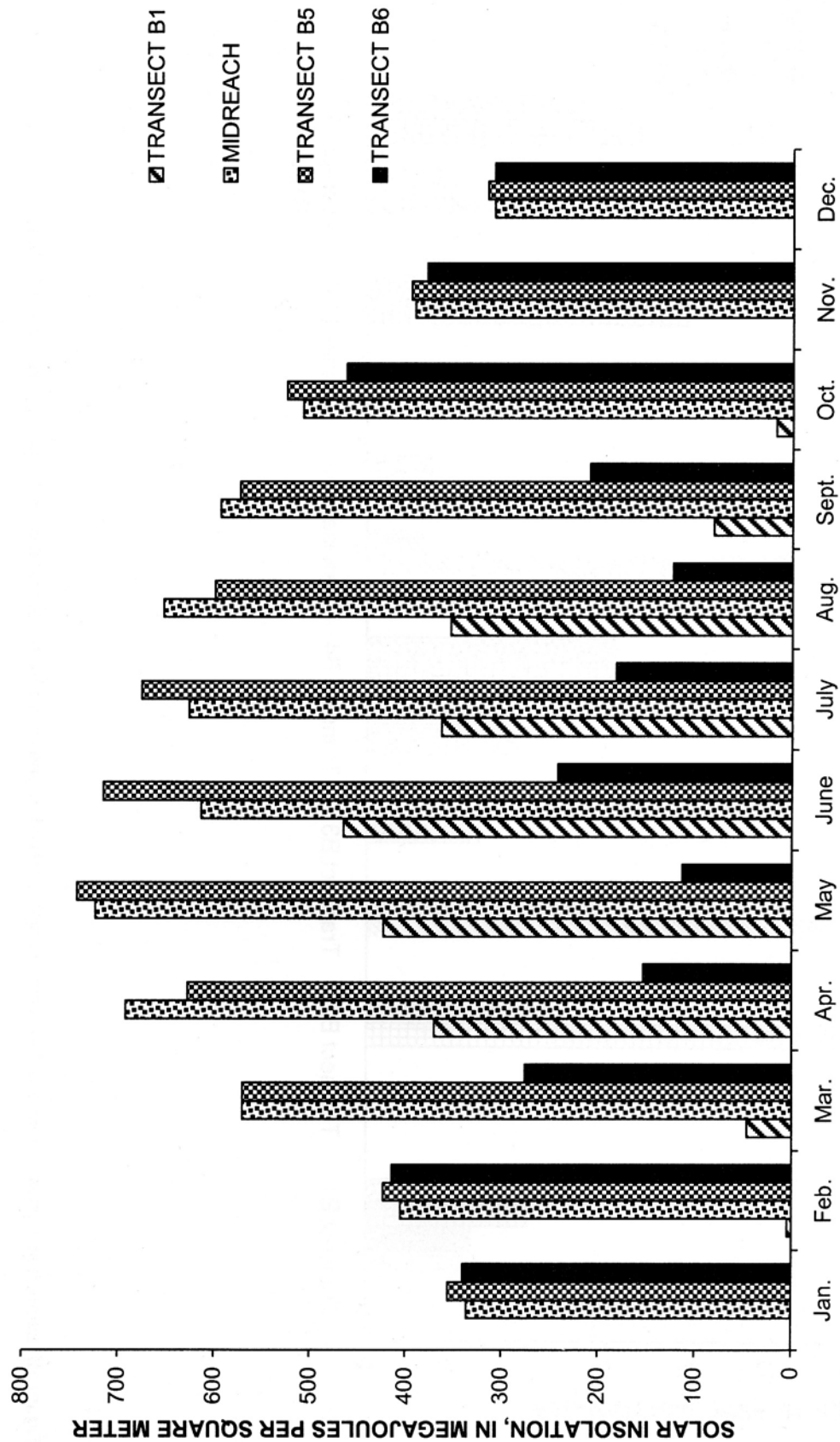
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	383	406	50	38
Willow ( <i>Salix sp.</i> )	115	200	83	62

**Table 11.** Habitat characteristics of reach B, San Pedro River near Highway 90, Arizona, December 5, 1996

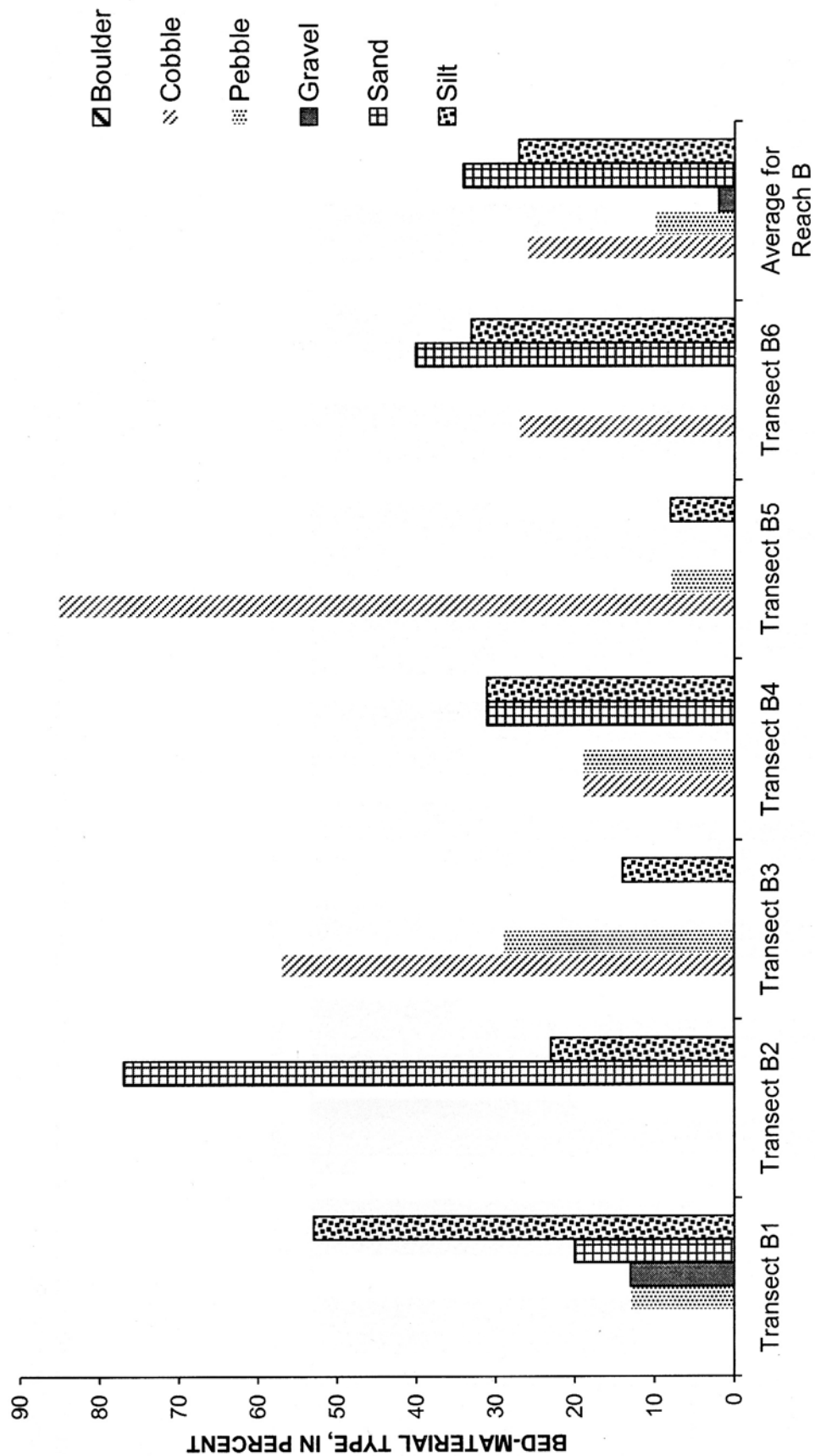
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 1, more than 75 percent covered by fine sediment; 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. <, less than]

Stream width, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle, in degrees	Density, in percent	Distance from left bank, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
3.6	313	35	48	0.8	0.20	0.53	Gravel	Sand	5
				1.6	<sup>1</sup> .29	.36	Sand	Gravel	5
				2.6	.22	<.01	Silt	Sand	0
Transect 2 (Pool)									
8.3	342	76	65	2.5	.21	<.01	Sand	Silt	0
				5.0	.31	.08	Sand	Silt	0
				7.4	<sup>1</sup> .46	.13	Sand	Silt	0
				7.8	.41	.07	Sand	Silt	0
Transect 3 (Riffle)									
4.6	268	88	9	1.3	.08	.24	Cobble	Gravel	3
				2.6	<sup>1</sup> .13	.94	Cobble	Gravel	4
				3.6	.08	.22	Cobble	Gravel	3
Transect 4 (Pool)									
4.9	302	39	78	1.9	.38	.04	Cobble	Silt	1
				3.8	<sup>1</sup> .52	.16	Cobble	Sand	2
				4.4	.52	.11	Cobble	Sand	2
Transect 5 (Riffle)									
3.8	321	59	35	1.9	.15	.92	Cobble	Gravel	3
				2.0	<sup>1</sup> .18	.19	Cobble	Gravel	4
				2.9	.09	.26	Cobble	Gravel	4
Transect 6 (Pool)									
5.5	317	124	70	1.3	.20	.14	Cobble	Sand	1
				2.6	.25	.13	Cobble	Sand	3
				3.8	<sup>1</sup> .40	.10	Silt	Cobble	1

<sup>1</sup>Thalweg.



**Figure 12.** Monthly distribution of solar insolation at transects 1, 5, 6, and midreach, reach B, San Pedro River near Highway 90, Arizona, based on measurements made December 5, 1996.



**Figure 13.** Bed-material types at transects 1–6 and average for reach B, San Pedro River near Highway 90, Arizona, December 5, 1996.

**Table 12.** Density and dominance of woody vegetation for reach B, San Pedro River at Highway 90, Arizona, December 5, 1996

[Length of reach, 197 meters]

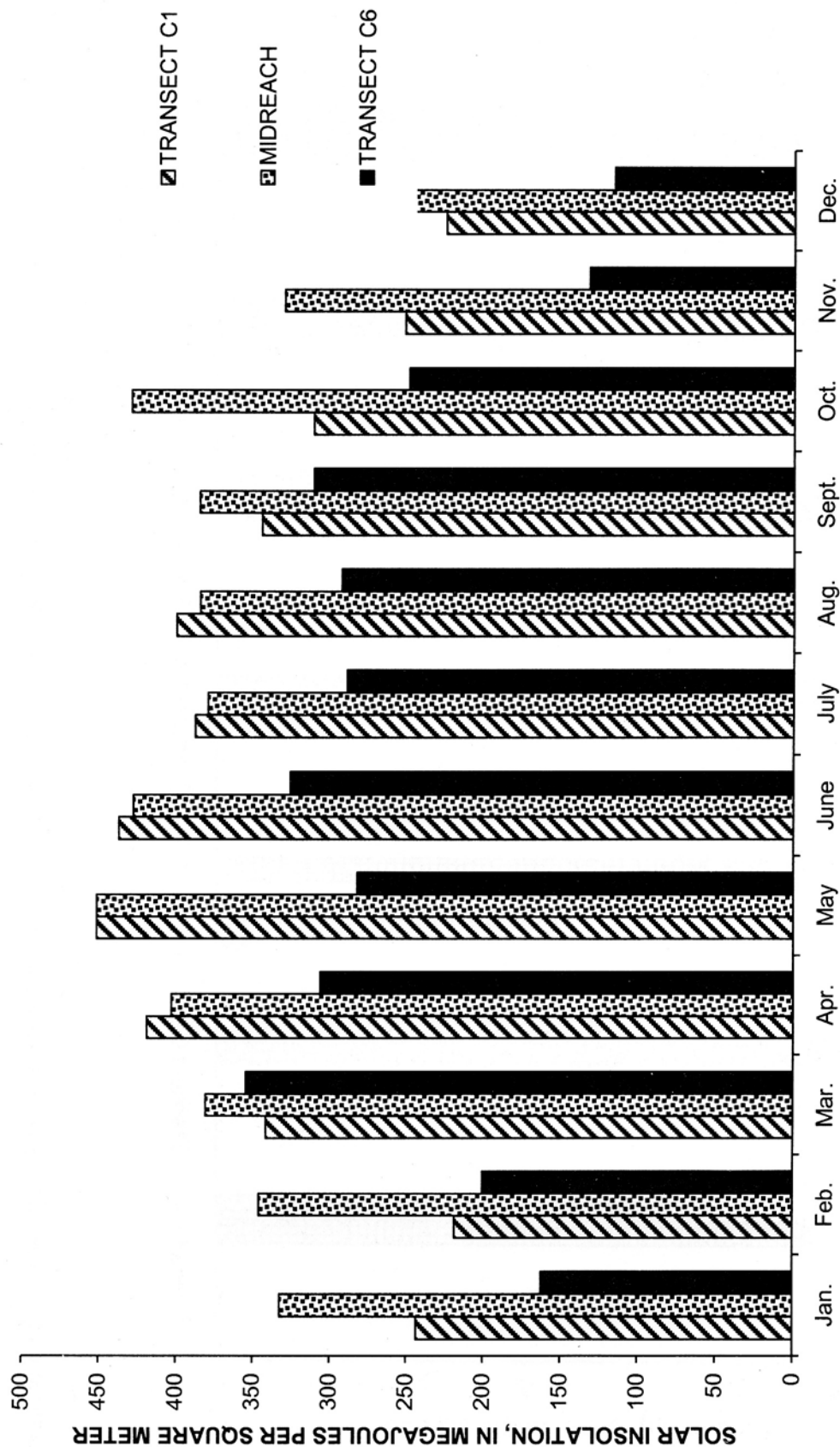
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	989	623	58	20
Mesquite ( <i>Prosopis sp.</i> )	7	1	8	3
Willow ( <i>Salix sp.</i> )	98	236	100	77

**Table 13.** Habitat characteristics of reach C, San Pedro River near Highway 90, Arizona, December 6, 1996

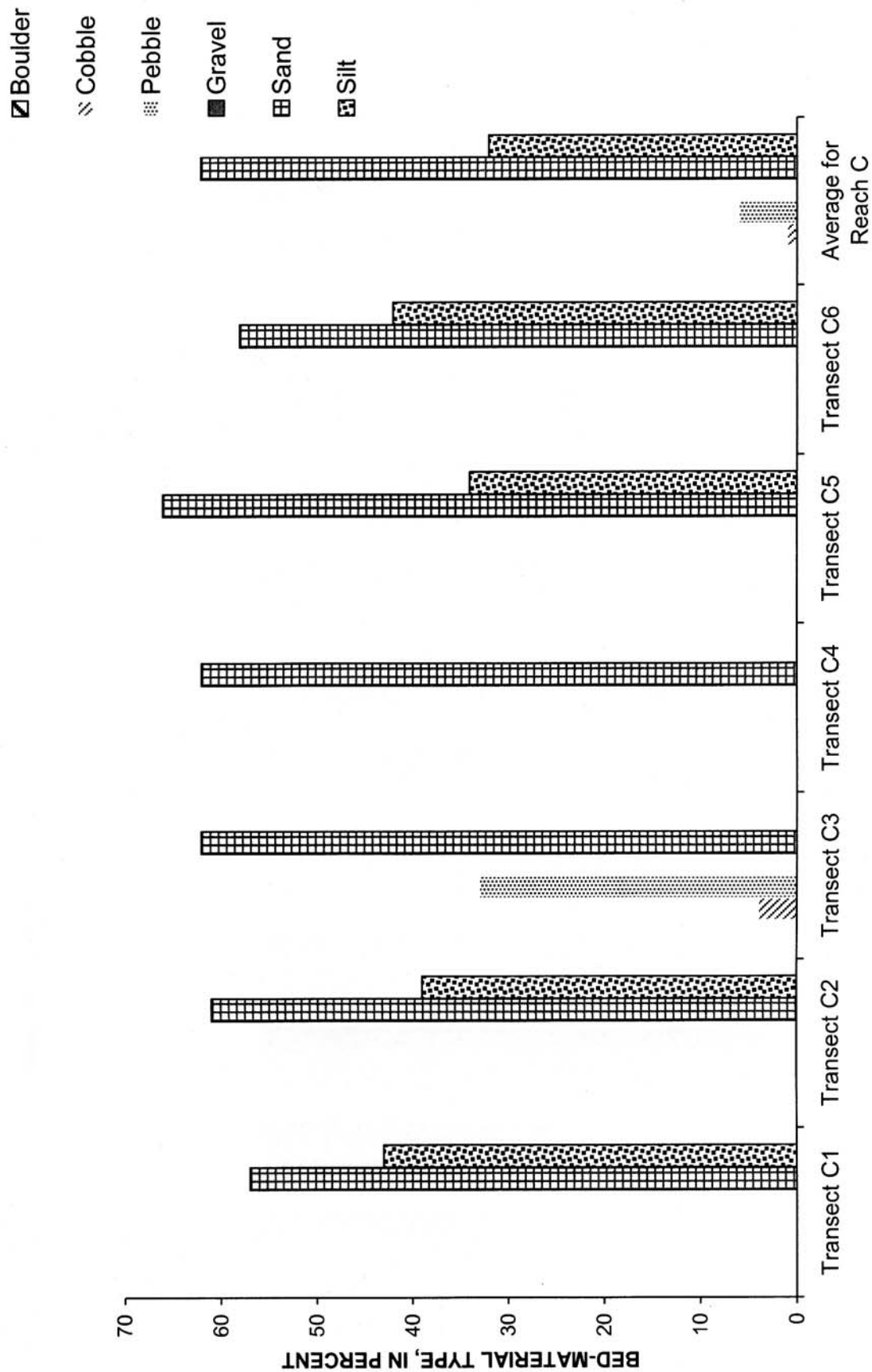
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 3, 26 to 50 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. &lt;, less than]

Stream width, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle, in degrees	Density, in percent	Distance from left bank, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
1.9	343	59	26	0.6	0.19	0.07	Silt	Sand	0
				1.2	<sup>1</sup> .40	.52	Gravel	Sand	5
				1.4	.27	.27	Sand	Gravel	5
Transect 2 (Pool)									
10.6	1	44	25	1.4	.41	.01	Silt	Sand	0
				2.8	.30	.03	Sand	Silt	0
				5.6	.22	.06	Silt	Sand	0
				8.4	<sup>1</sup> .54	.04	Silt	Sand	0
Transect 3 (Riffle)									
10.8	357	40	35	.6	<sup>1</sup> .20	.45	Cobble	Gravel	5
				1.8	.07	.34	Cobble	Gravel	3
				8.8	.20	.01	Sand	Gravel	5
				9.8	.18	0	Sand	Silt	0
Transect 4 (Pool)									
6.4	355	46	53	1.6	.70	.05	Sand	Gravel	5
				3.2	.72	.06	Sand	Gravel	5
				4.8	<sup>1</sup> .73	.03	Sand	Gravel	5
Transect 5 (Pool)									
10.2	355	46	40	2.1	<sup>1</sup> .67	.04	Silt	Sand	0
				4.8	.36	.36	Sand	Silt	0
				7.5	.21	.21	Sand	Silt	0
Transect 6 (Pool)									
8.3	19	33	43	2.5	<sup>1</sup> .84	<sup>2</sup> <.01	Sand	Silt	0
				5.0	.75	.12	Sand	Silt	0
				6.6	.67	.02	Sand	Silt	0

<sup>1</sup>Thalweg.<sup>2</sup>Reverse flow.



**Figure 14.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach C, San Pedro River near Highway 90, Arizona, based on measurements made December 6, 1996.



**Figure 15.** Bed-material types at transects 1–6 and average for reach C, San Pedro River near Highway 90, Arizona, December 6, 1996.



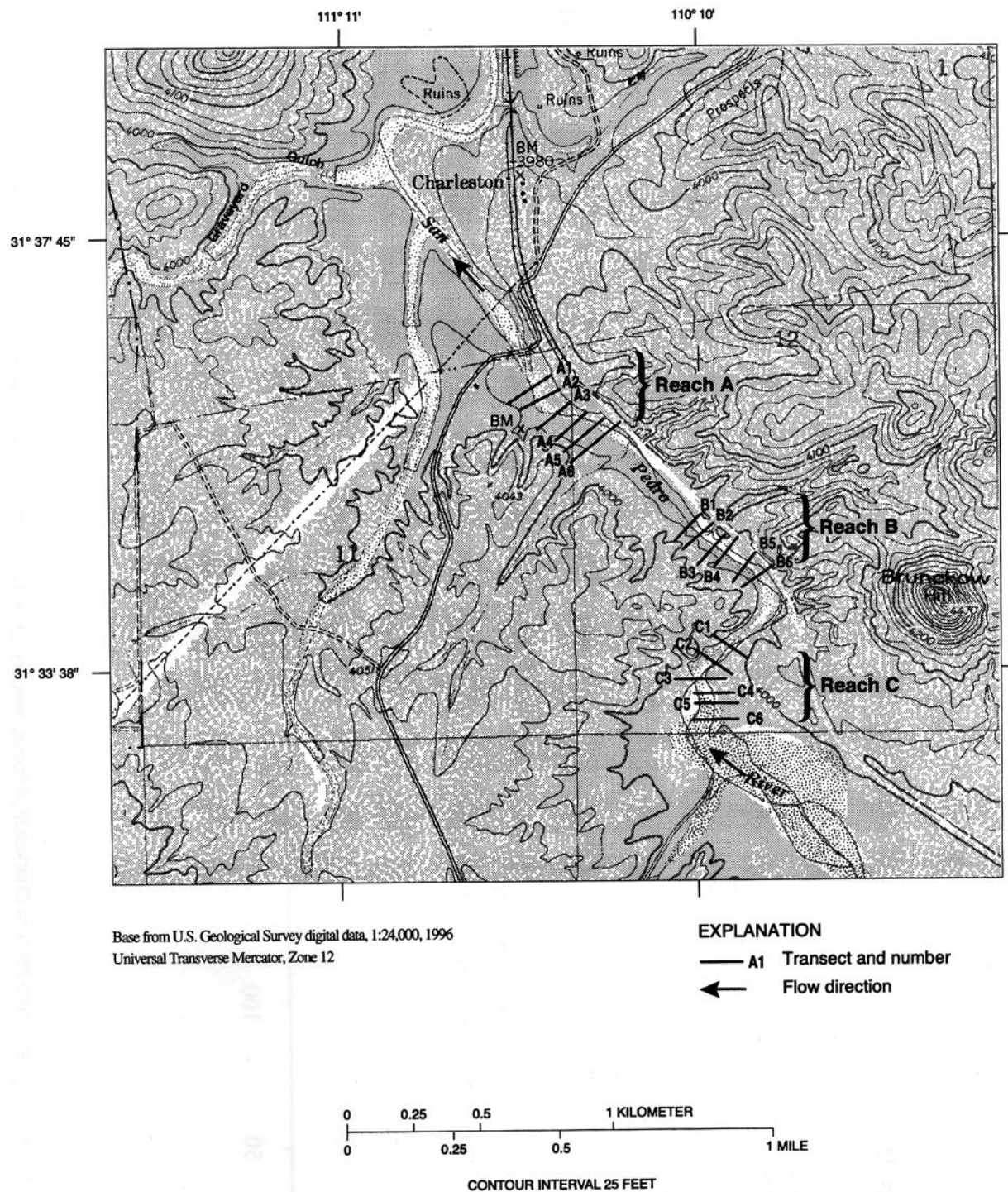
**Table 14.** Density and dominance of woody vegetation for reach C, San Pedro River near Highway 90, Arizona, December 6, 1996  
[Length of reach, 310 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	574	1,022	42	24
Willow ( <i>Salix sp.</i> )	86	484	83	76

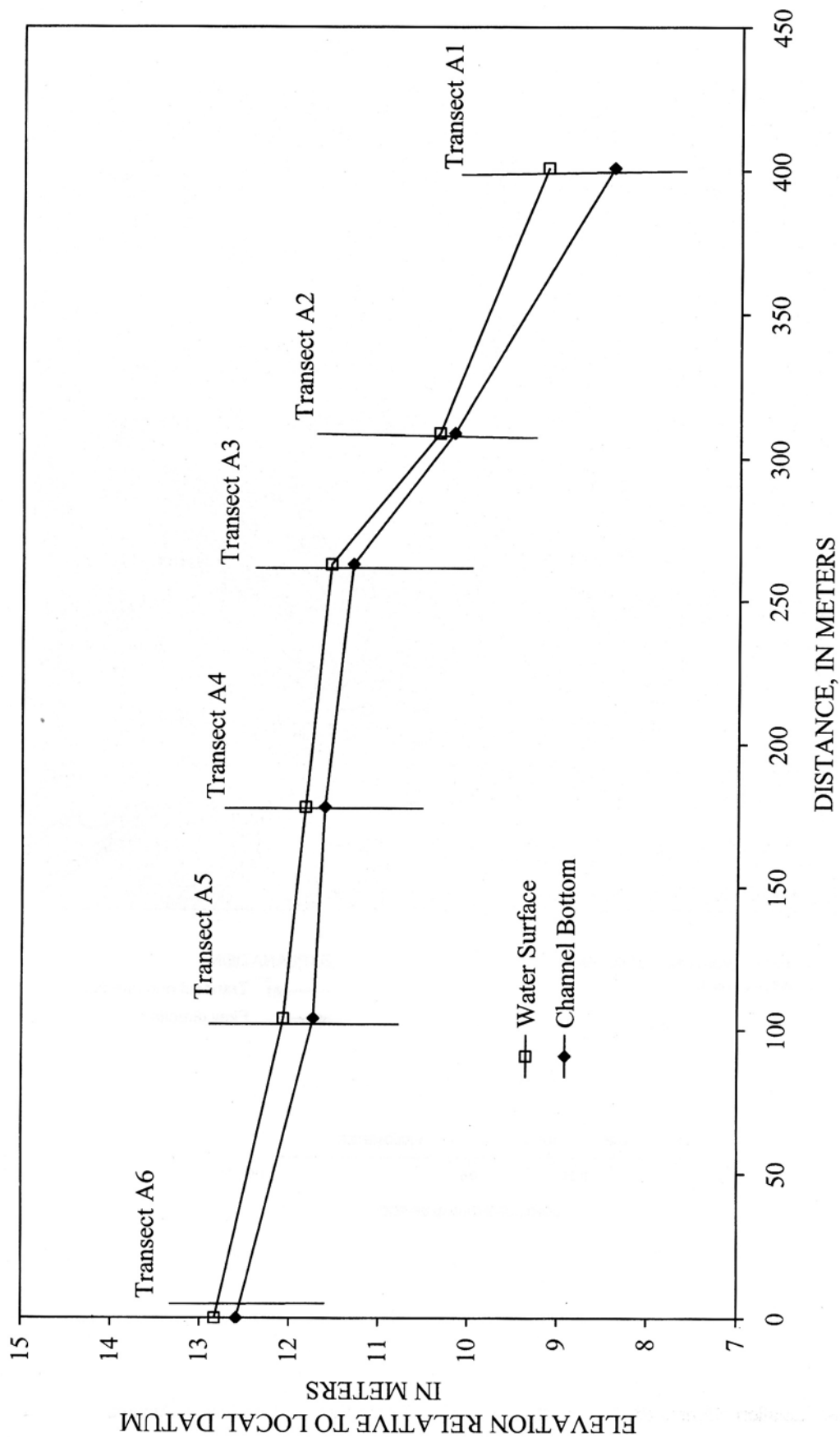
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**San Pedro River at Charleston, Arizona**  
**(USGS station number: 09471000)**

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**Figure 16.** Location of transects 1–6, reaches A–C, San Pedro River at Charleston, Arizona.

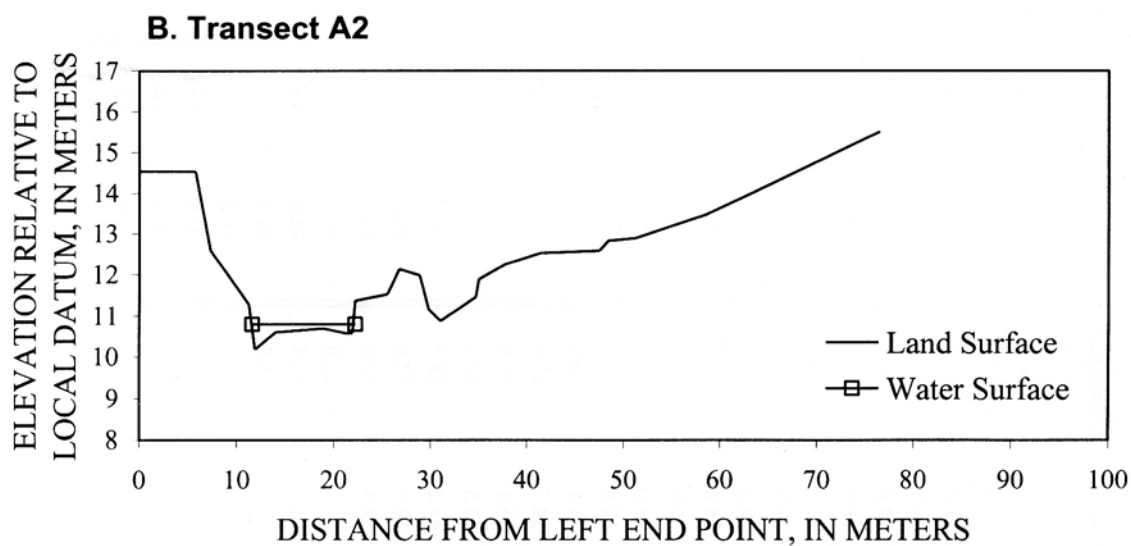
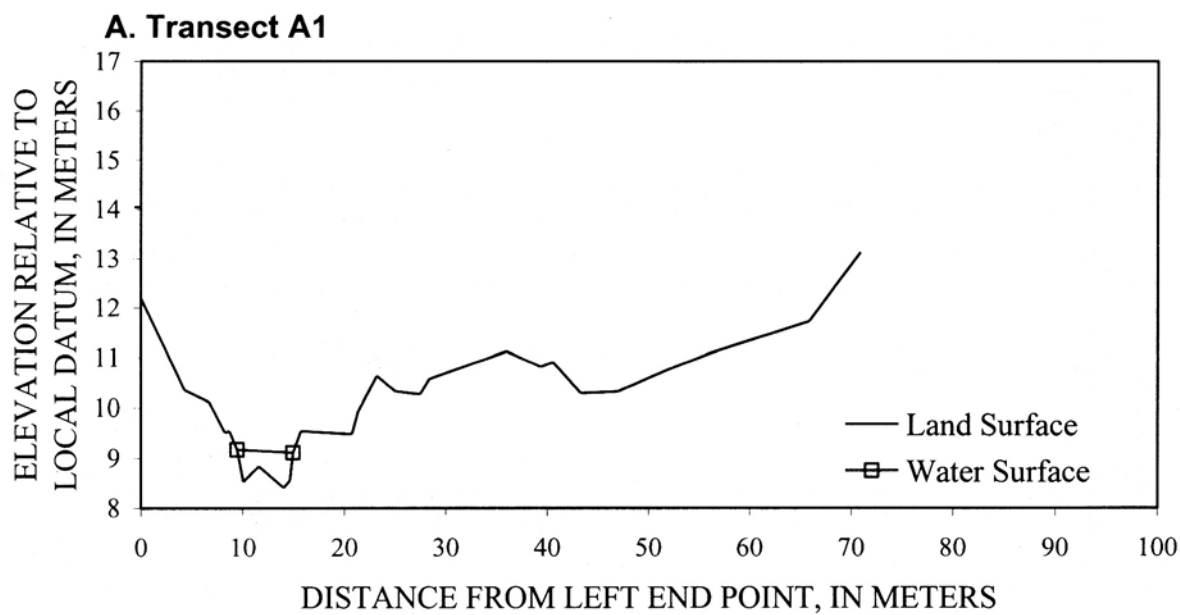


**Figure 17.** Longitudinal profile, reach A, San Pedro River at Charleston, Arizona, January 28 and 29, 1998. Local datum established using arbitrary elevation.

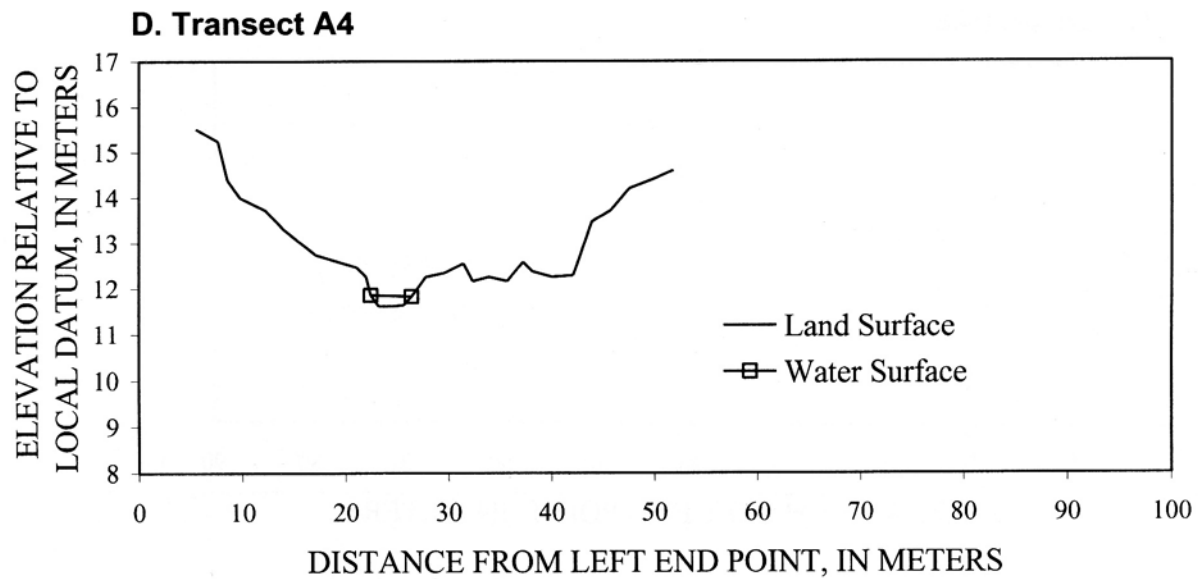
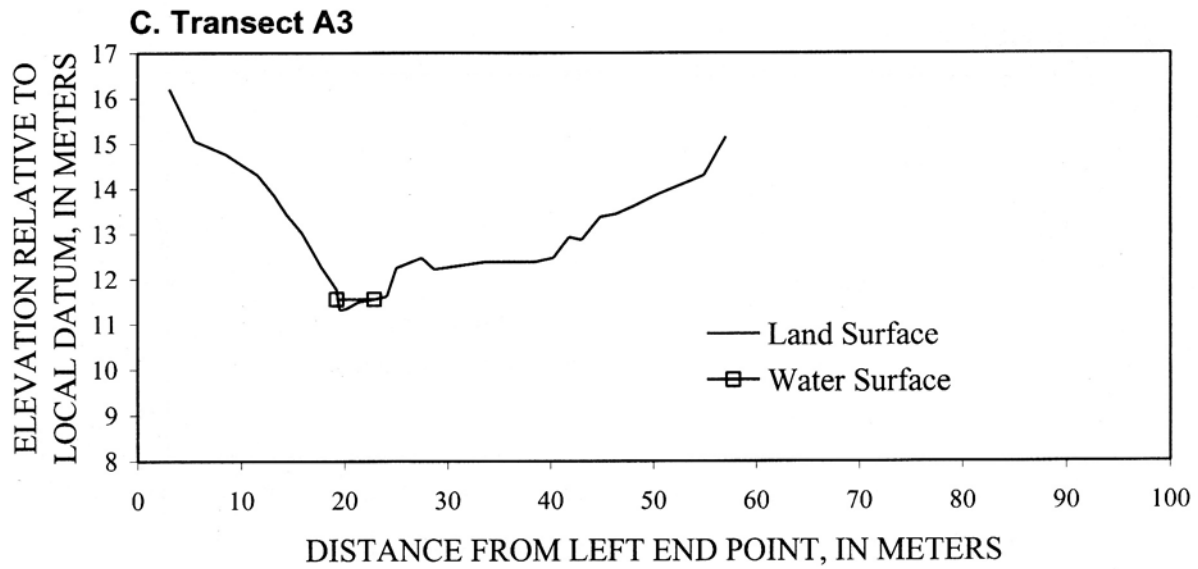
**Table 15.** Cross-sectional survey data for reach A, San Pedro River at Charleston, Arizona, January 28 and 29, 1998

[All values are in meters. Distance is from left end point]

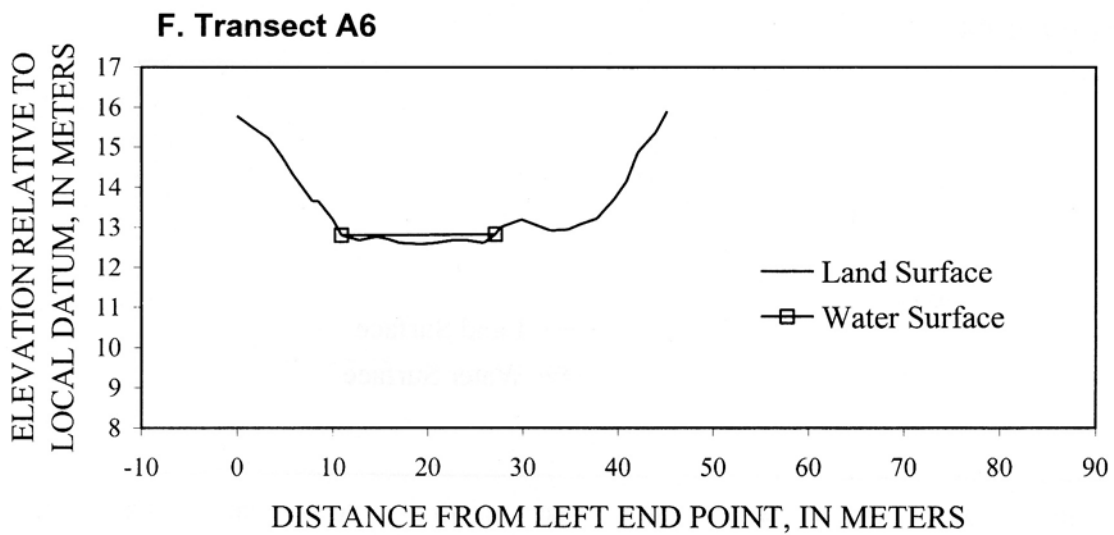
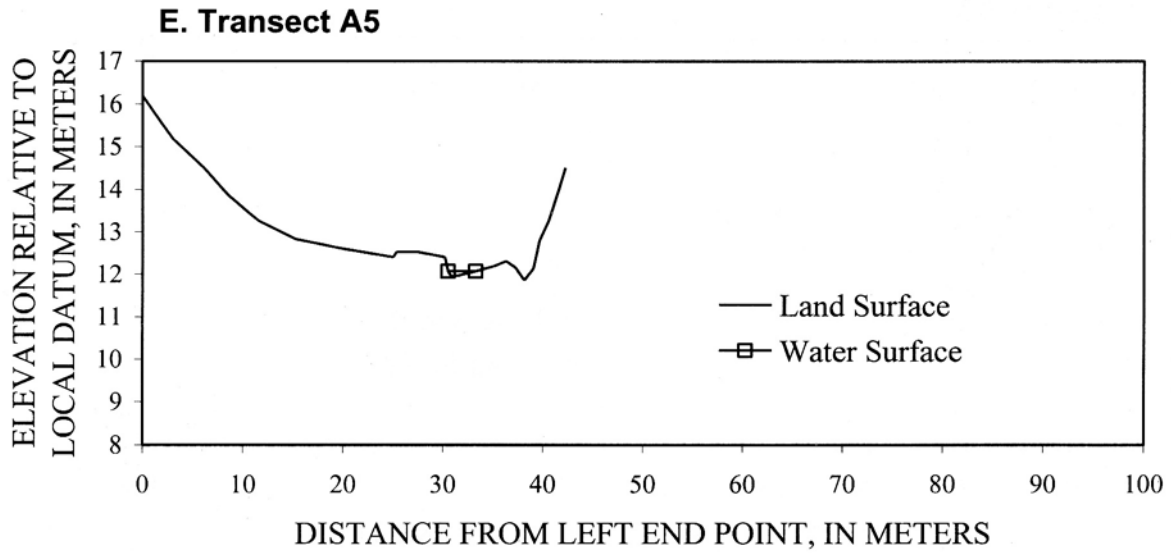
Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
-7.3	14.1	0.0	14.5	3.0	16.2	5.5	15.5	0.0	16.2	0.0	15.8
0.0	14.1	5.8	14.5	5.5	15.1	7.6	15.2	3.0	15.2	3.4	15.2
0.0	12.2	7.3	12.6	8.5	14.8	8.5	14.4	6.1	14.5	4.6	14.8
4.3	10.4	11.3	11.3	11.6	14.3	9.8	14.0	8.5	13.9	5.8	14.4
6.7	10.1	11.9	10.2	13.1	13.9	12.2	13.7	11.6	13.3	6.7	14.1
8.2	9.5	14.0	10.6	14.3	13.4	14.0	13.3	15.2	12.8	7.9	13.7
8.7	9.5	18.9	10.7	15.8	13.0	17.1	12.7	19.5	12.6	8.5	13.7
9.4	9.2	21.3	10.6	17.7	12.3	21.0	12.5	25.0	12.4	10.1	13.2
10.1	8.5	21.9	10.6	19.2	11.8	21.9	12.3	25.3	12.5	11.0	12.8
11.6	8.8	22.3	11.4	19.5	11.3	22.4	11.9	27.4	12.5	12.8	12.7
14.0	8.4	25.6	11.5	20.1	11.3	23.2	11.6	30.2	12.4	14.6	12.8
14.6	8.6	26.8	12.1	21.3	11.5	24.4	11.6	30.5	12.1	15.8	12.7
14.9	9.1	29.0	12.0	22.9	11.6	25.6	11.6	30.8	11.9	17.1	12.6
15.7	9.5	29.9	11.2	24.1	11.6	26.4	11.8	31.7	12.0	19.2	12.6
20.7	9.5	31.1	10.9	25.0	12.3	27.7	12.3	33.2	12.1	20.7	12.6
21.3	9.9	34.7	11.5	27.4	12.5	29.6	12.3	35.1	12.2	22.6	12.7
23.2	10.6	35.1	11.9	28.7	12.2	31.4	12.6	36.3	12.3	24.1	12.7
25.0	10.3	37.8	12.1	33.5	12.4	32.3	12.2	37.2	12.2	25.9	12.6
27.4	10.3	41.5	12.5	38.4	12.4	33.8	12.3	38.1	11.9	27.1	12.8
28.3	10.6	47.5	12.6	40.2	12.5	35.7	12.2	39.0	12.1	27.7	13.0
36.0	11.1	48.5	12.8	41.8	12.9	37.2	12.6	39.6	12.8	29.9	13.2
39.3	10.8	51.2	12.9	43.0	12.9	38.1	12.4	40.5	13.3	32.9	12.9
40.5	10.9	58.5	13.5	44.8	13.4	39.9	12.3	41.5	13.9	34.7	13.0
43.3	10.3	76.5	15.5	46.3	13.4	42.1	12.3	42.2	14.5	36.0	13.1
46.9	10.3			48.2	13.6	43.9	13.5			37.8	13.2
51.8	10.8			50.6	13.9	45.7	13.7			39.6	13.7
56.1	11.1			54.9	14.3	47.5	14.2			40.8	14.1
65.8	11.7			57.0	15.1	50.0	14.4			42.1	14.9
70.9	13.1					51.8	14.6				



**Figure 18A–F.** Cross sections of channel reach, reach A, San Pedro River at Charleston, Arizona, January 28 and 29, 1998. A, Transect A1. B, Transect A2. C, Transect A3. D, Transect A4. E, Transect A5. F, Transect A6. Local datum established using arbitrary elevation.



**Figure 18A–F.** Continued



**Figure 18A–F.** Continued.



**Table 16.** Description and location of semipermanent monuments for reach A, San Pedro River at Charleston, Arizona, January 28 and 29, 1998

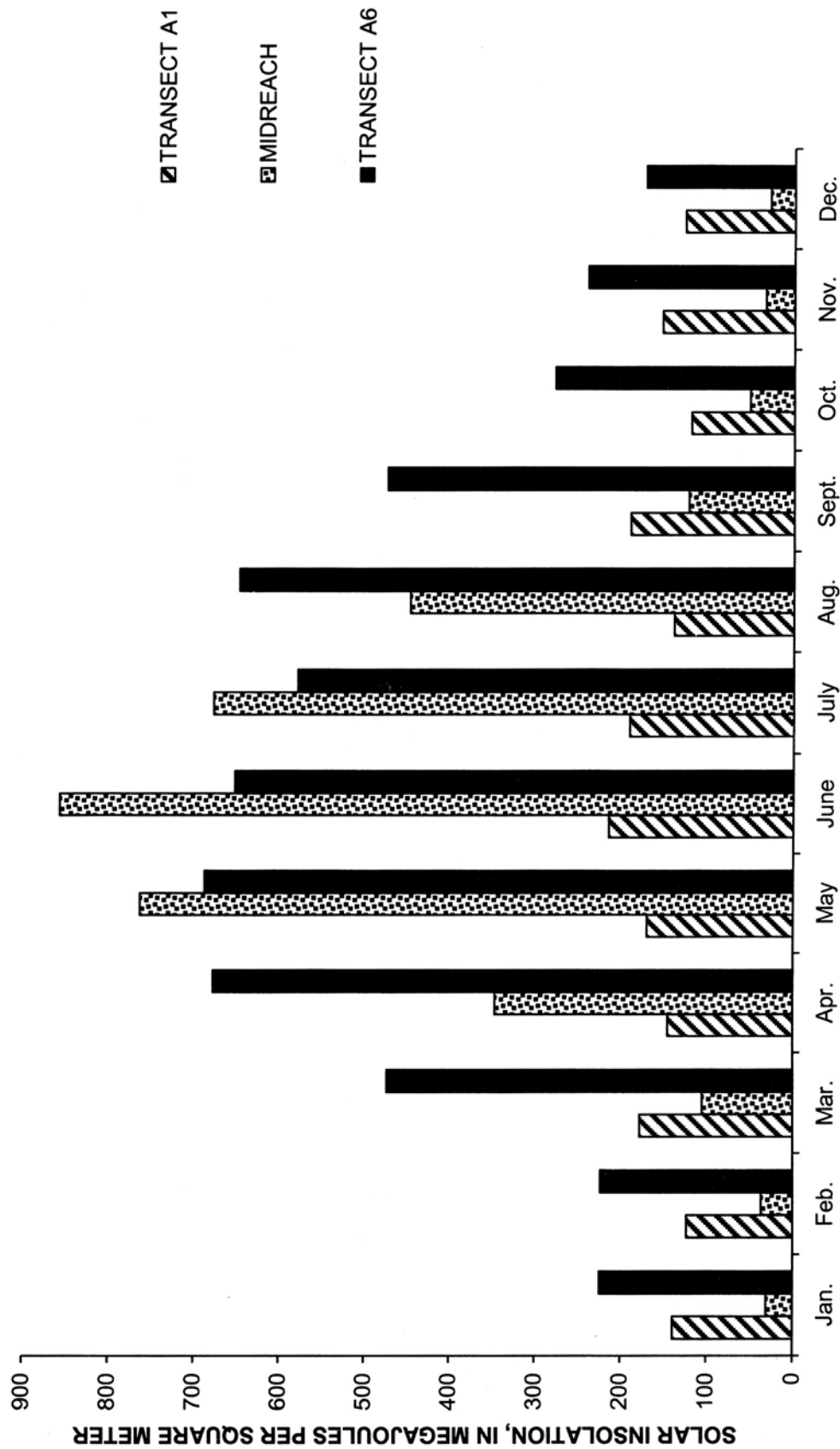
Transect	Type	Description of location and reference marks
A1	Left	Rebar. Transect is under cableway. Reference mark, RM-1, is spike in downstream side of large cottonwood tree, at tributary mouth upstream from transect 2. Elevation 15.24 meters.
A1	Right	Rebar, transect is under cableway.
A2	Left	Rebar, 56 meters upstream from transect A1.
A2	Right	Rebar, 56 meters upstream from transect A1.
A3	Left	Rebar, 70 meters upstream from transect A2.
A3	Right	Rebar, 70 meters upstream from transect A2.
A4	Left	Rebar, 88 meters upstream from transect A3.
A4	Right	Rebar, 88 meters upstream from transect A3.
A5	Left	Rebar, 75 meters upstream from transect A4.
A5	Right	Rebar, 75 meters upstream from transect A4.
A6	Left	Rebar, 99 meters upstream from transect A5.
A6	Right	Rebar, 99 meters upstream from transect A5.

**Table 17.** Habitat characteristics of reach A, San Pedro River at Charleston, Arizona, December 8, 1995

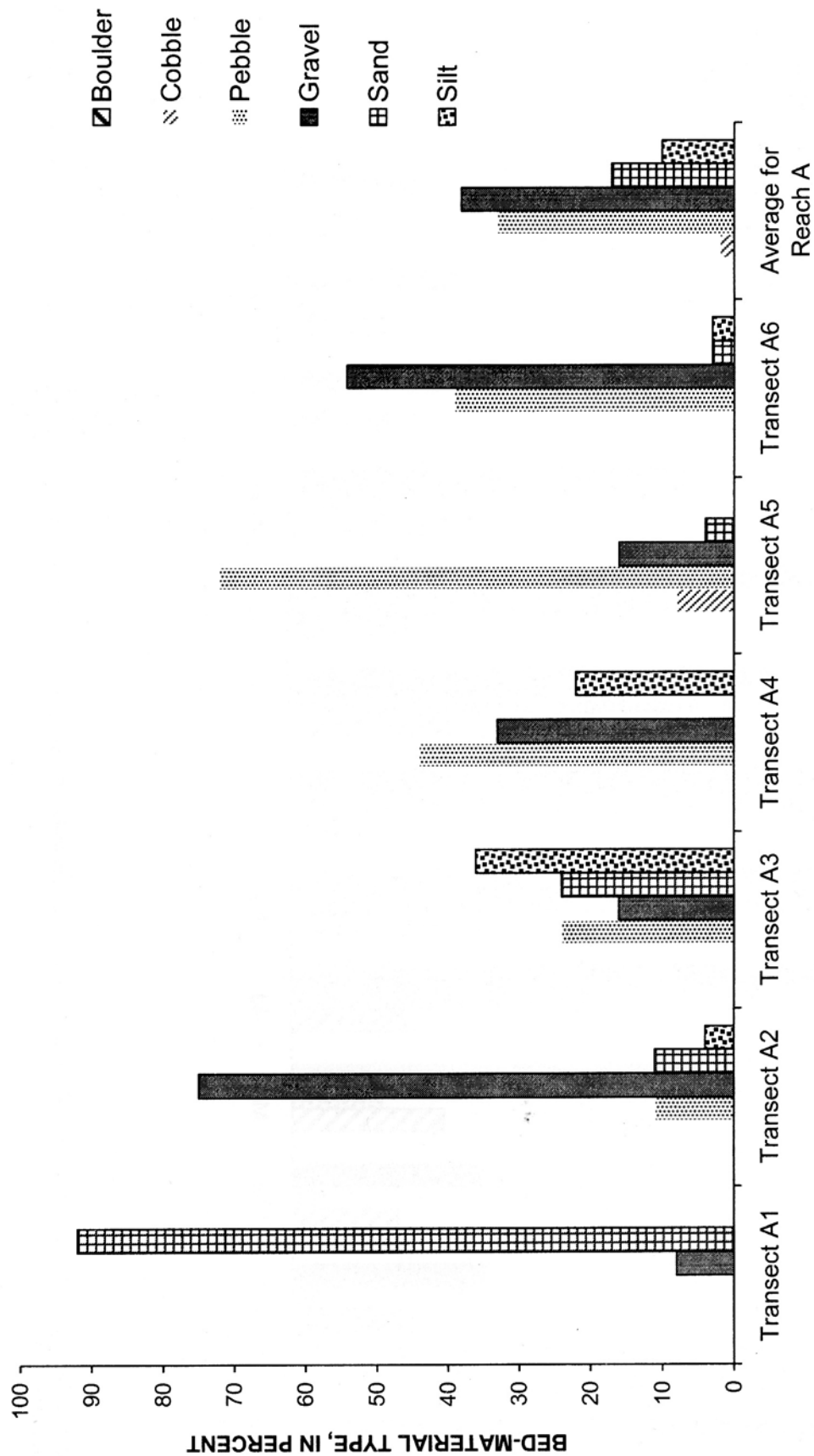
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. NA, not applicable]

Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Run)									
3.5	355	76	44	0.5	<sup>1</sup> 0.50	0.24	Sand	Gravel	5
				1.5	.28	.34	Sand	NA	0
				2.5	.15	.08	Sand	NA	0
Transect 2 (Riffle)									
13.6	307	78	42	.8	.07	.20	Gravel	Sand	5
				10.9	<sup>1</sup> .12	.48	Sand	Gravel	5
				12.7	.11	.43	Sand	Gravel	5
Transect 3 (Run)									
7.0	296	67	25	.8	<sup>1</sup> .43	.31	Gravel	NA	5
				2.5	.23	.21	Silt	Sand	0
				4.0	.21	.05	Silt	Sand	0
Transect 4 (Run)									
2.5	276	76	4	.8	<sup>1</sup> .23	.62	Gravel	Cobble	4
				1.4	.18	.53	Gravel	Cobble	4
Transect 5 (Riffle)									
6.9	348	67	19	1.2	.08	.11	Gravel	Cobble	3
				3.1	.10	.22	Gravel	Sand	3
				6.2	<sup>1</sup> .14	.53	Sand	Gravel	3
Transect 6 (Riffle)									
14.5	318	68	24	1.0	<sup>1</sup> .20	.57	Gravel	Cobble	4
				1.9	.14	.53	Gravel	NA	4
				11.5	.06	.22	Gravel	Sand	4

<sup>1</sup>Thalweg.



**Figure 19.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, San Pedro River at Charleston, Arizona, based on measurements made December 8, 1995.



**Figure 20.** Bed-material types at transects 1–6 and average for reach A, San Pedro River at Charleston, Arizona, December 8, 1995.

**Table 18.** Density and dominance of woody vegetation for reach A, San Pedro River at Charleston, Arizona, December 8, 1995

[Length of reach, 388 meters]

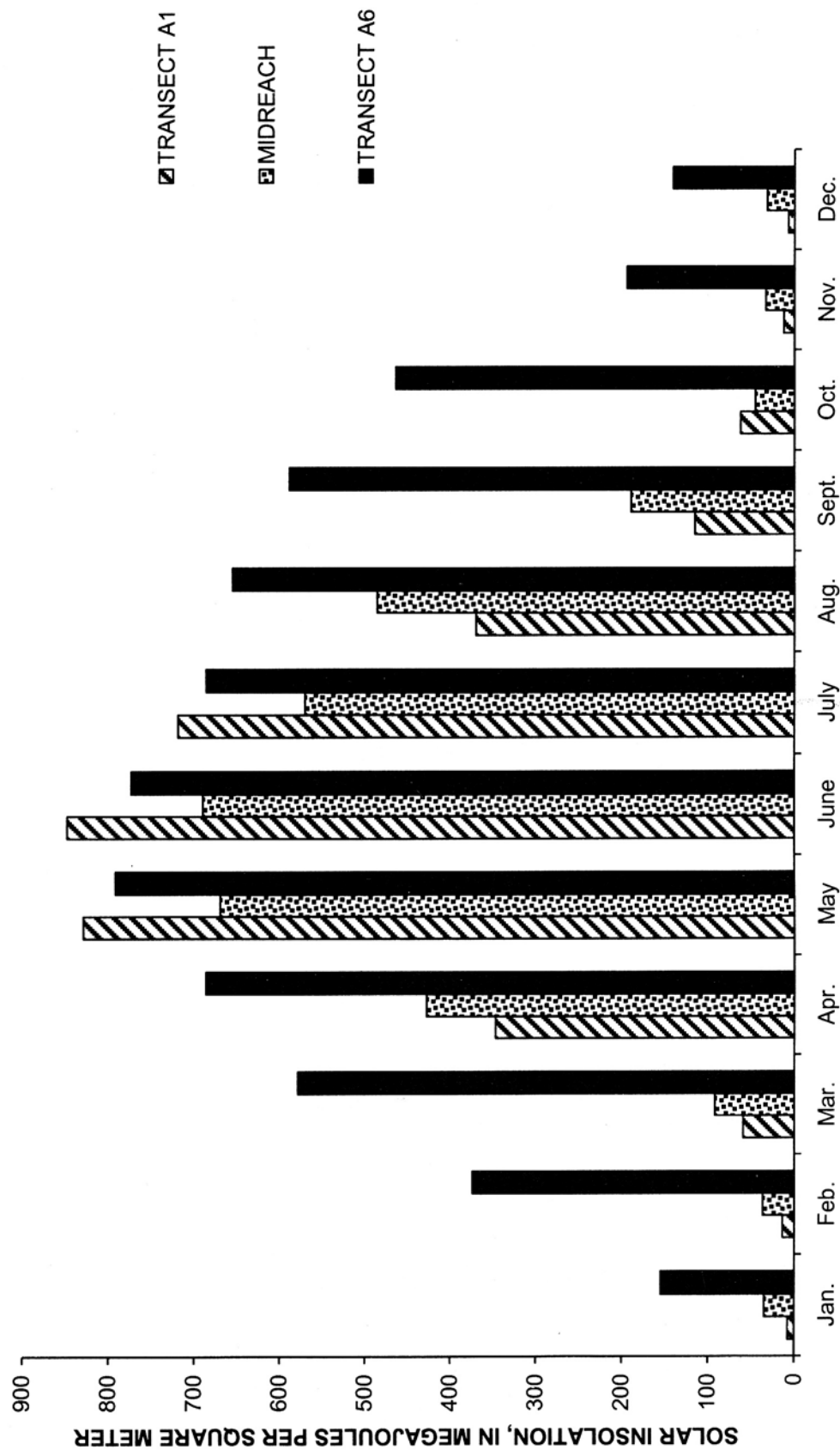
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	2,285	845	50	31
Mesquite ( <i>Prosopis sp.</i> )	50	2	8	4
Willow ( <i>Salix sp.</i> )	426	328	83	65

**Table 19.** Habitat characteristics of reach A, San Pedro River at Charleston, Arizona, November 13, 1996

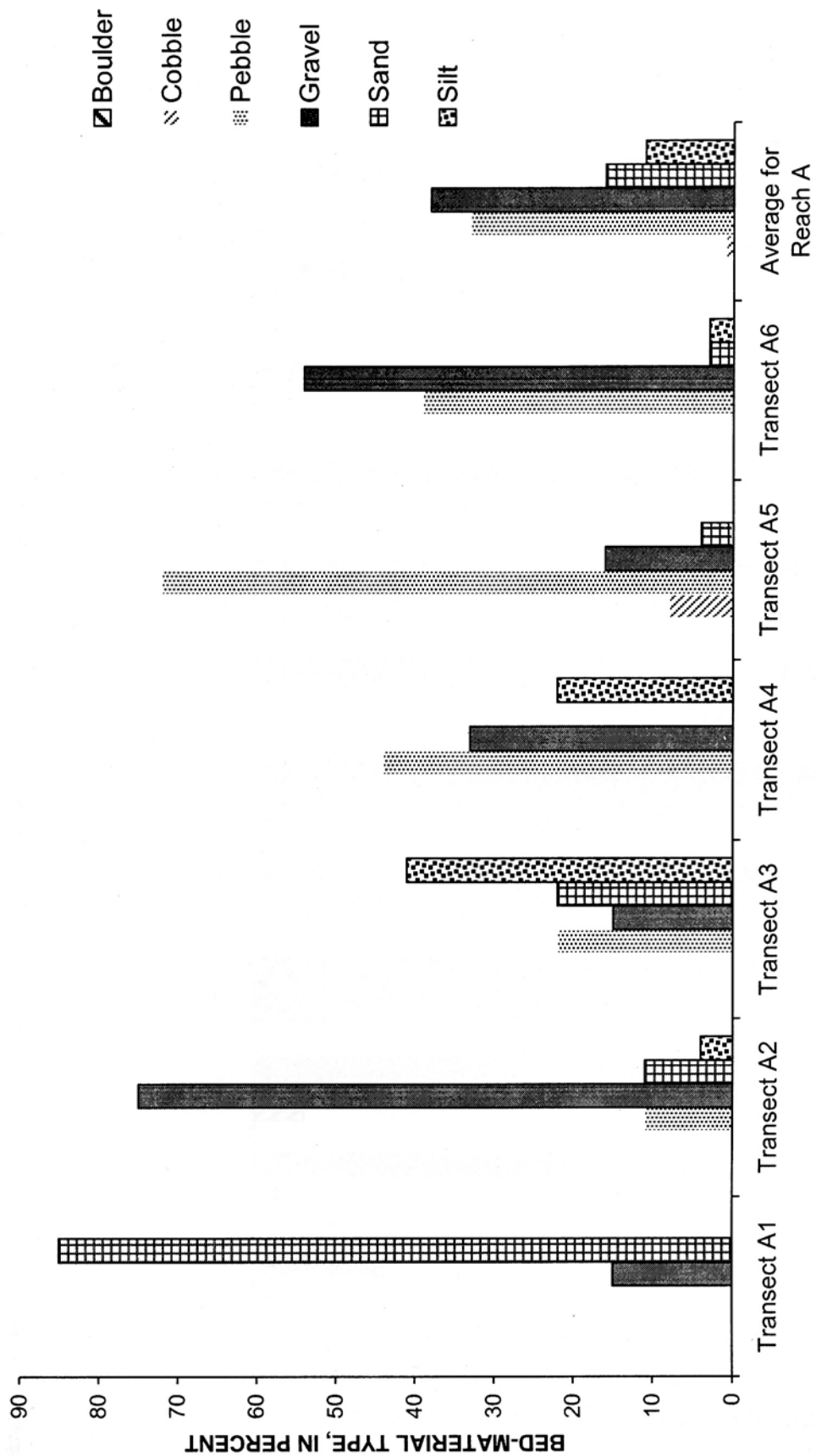
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. Dashes indicate no data]

Width of wetted channel, in meters	Aspect, in degrees	Canopy		Velocity			Substrate		
		Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Run)									
9.2	343	105	28	0.4	<sup>1</sup> 0.46	0.33	Gravel	Sand	5
				1.5	.27	.30	Gravel	Sand	5
				8.0	.20	0	Sand	Silt	0
Transect 2 (Riffle)									
13.1	300	77	65	1.4	.15	.76	Gravel	Sand	5
				8.8	<sup>1</sup> .21	.46	Sand	Gravel	5
				12.4	.09	.10	Sand	Gravel	5
Transect 3 (Run)									
7.0	295	71	15	.7	<sup>1</sup> .55	.22	Sand	Gravel	---
				4.0	.27	.20	Sand	Gravel	---
				6.0	.18	.17	Sand	Gravel	---
Transect 4 (Run)									
3.3	276	76	3	.5	<sup>1</sup> .27	.37	Gravel	Sand	3
				1.5	.21	.46	Gravel	Sand	3
				2.5	.15	.23	Gravel	Sand	3
Transect 5 (Riffle)									
8.1	276	63	34	1.3	<sup>1</sup> .24	.43	Cobble	Gravel	4
				2.5	.12	.37	Cobble	Gravel	4
				7.5	.12	.54	Cobble	Gravel	4
Transect 6 (Riffle)									
11.9	312	75	15	1.0	.06	.16	Gravel	Sand	5
				8.4	.18	.51	Gravel	Sand	4
				9.4	<sup>1</sup> .24	.24	Gravel	Sand	4

<sup>1</sup>Thalweg.



**Figure 21.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, San Pedro River at Charleston, Arizona, based on measurements made December 8, 1995.



**Figure 22.** Bed-material types at transects 1–6 and average for reach A, San Pedro River at Charleston, Arizona, December 8, 1995.

**Table 20.** Density and dominance of woody vegetation for reach A, San Pedro River at Charleston, Arizona, November 13, 1996  
[Length of reach, 394 meters]

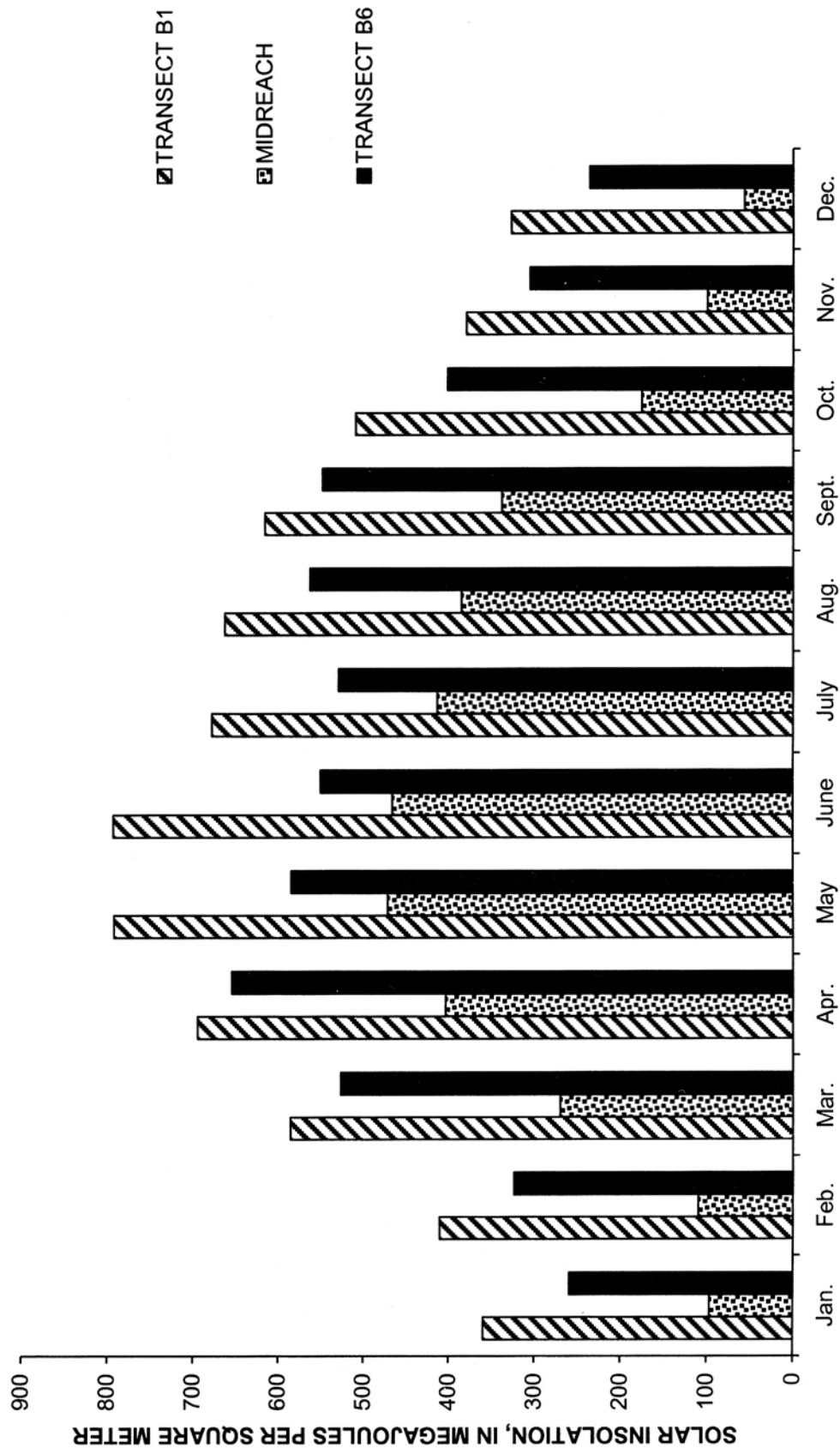
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	242	58	25	16
Mesquite ( <i>Prosopis sp.</i> )	66	19	33	20
Willow ( <i>Salix sp.</i> )	419	394	92	64

**Table 21.** Habitat characteristics of reach B, San Pedro River at Charleston, Arizona, November 18, 1996

[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. NA, not applicable]

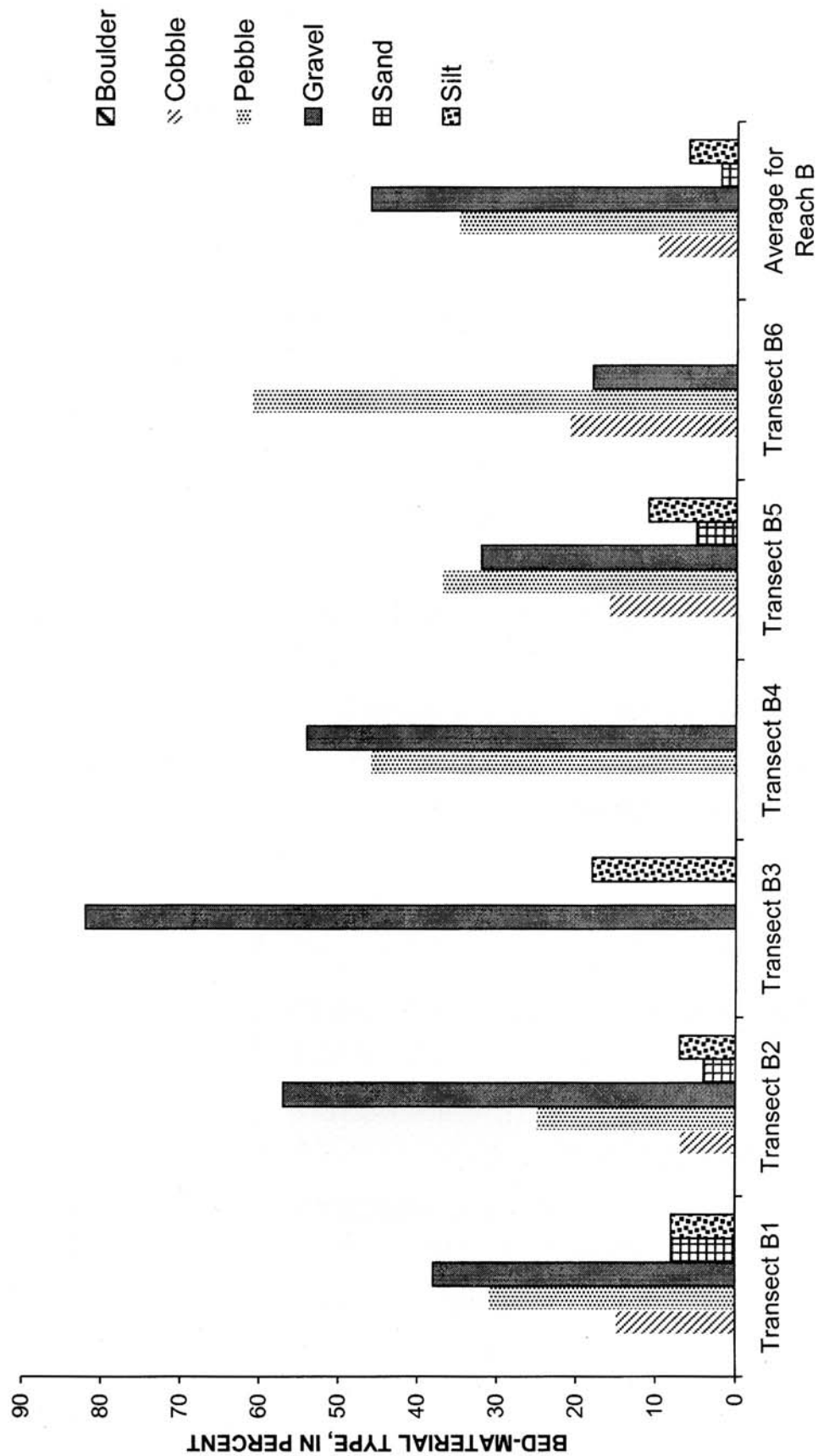
Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
12.8	336	137	35	1.4	0.06	0.02	Silt	Gravel	5
				9.0	.12	.25	Gravel	Sand	5
				10.7	.30	.30	Gravel	Sand	5
				12.2	<sup>1</sup> .43	.16	Sand	Gravel	5
Transect 2 (Pool)									
8.5	349	46	43	1.5	.36	.07	Gravel	NA	5
				3.2	<sup>1</sup> .43	.13	Gravel	Silt	5
				5.5	.30	.13	Sand	NA	0
Transect 3 (Pool)									
8.7	332	50	35	1.7	<sup>1</sup> .43	.12	Gravel	Silt	5
				3.5	.40	.16	Sand	Gravel	5
				5.2	.21	.08	Sand	Gravel	5
Transect 4 (Riffle)									
11.0	327	100	25	.5	<sup>1</sup> .43	.59	Gravel	NA	5
				1.6	.37	.04	Gravel	NA	5
				2.0	.21	.30	Gravel	Sand	5
				7.1	.03	.30	Gravel	Cobble	4
Transect 5 (Pool)									
5.3	301	72	66	1.8	.30	.03	Gravel	NA	5
				3.5	<sup>1</sup> .36	.35	Cobble	Gravel	2
				4.4	.30	.29	Gravel	NA	5
Transect 6 (Riffle)									
10.6	333	114	40	3.5	.12	.34	Cobble	Gravel	3
				5.5	<sup>1</sup> .21	.65	Cobble	Gravel	3
				7.4	.19	.19	Cobble	Sand	3

<sup>1</sup>Thalweg.



**Figure 23.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach B, San Pedro River at Charleston, Arizona, based on measurements made November 18, 1996.





**Figure 24.** Bed-material at transects 1–6 and average for reach B, San Pedro River at Charleston, Arizona, November 18, 1996.

**Table 22.** Density and dominance of woody vegetation for reach B, San Pedro River at Charleston, Arizona, November 18, 1996

[Length of reach, 208 meters]

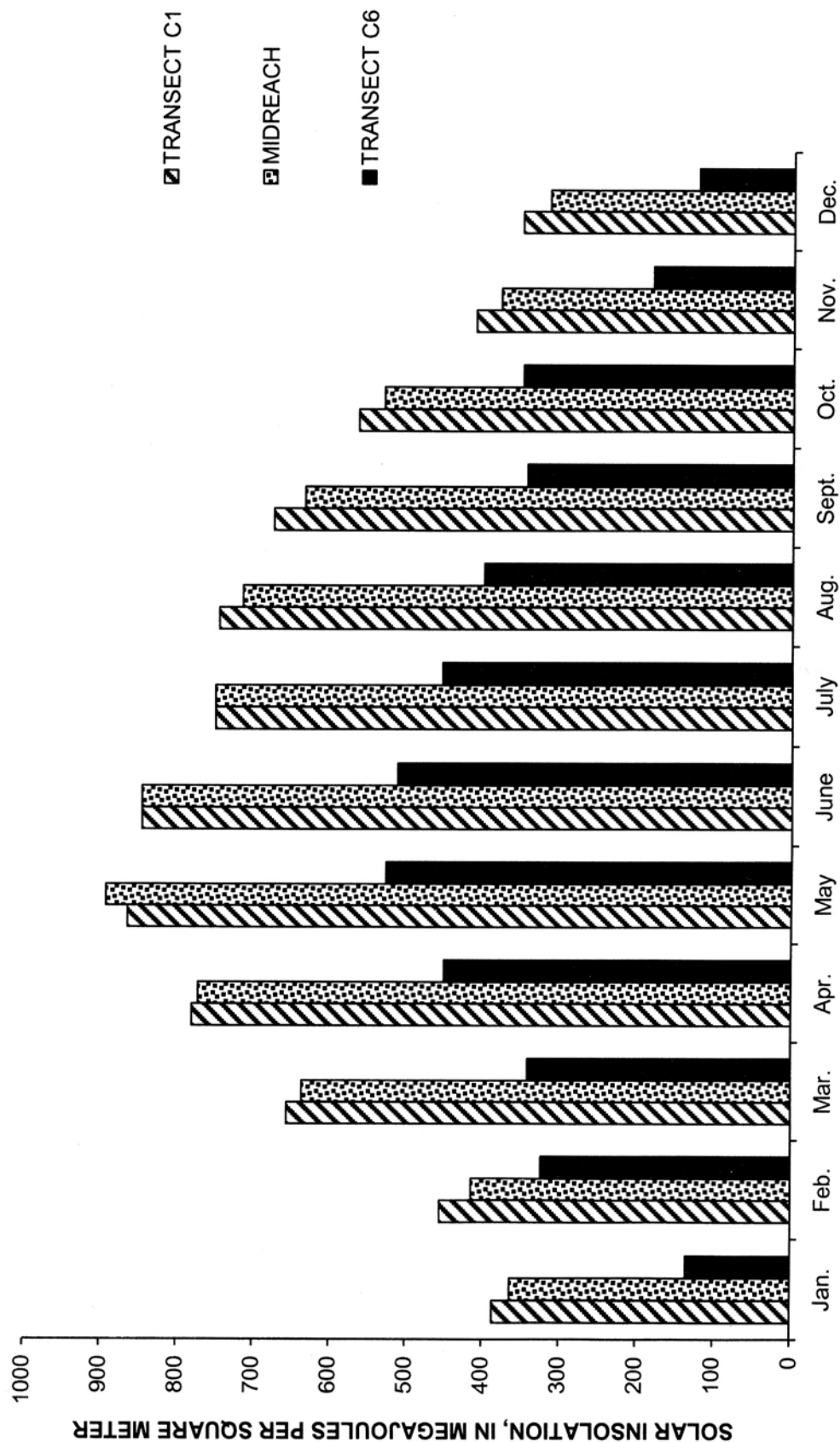
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	1,420	2,059	42	24
Mesquite ( <i>Prosopis sp.</i> )	83	131	50	26
Willow ( <i>Salix sp.</i> )	136	412	58	50

**Table 23.** Habitat characteristics of reach C, San Pedro River at Charleston, Arizona, November 22, 1996

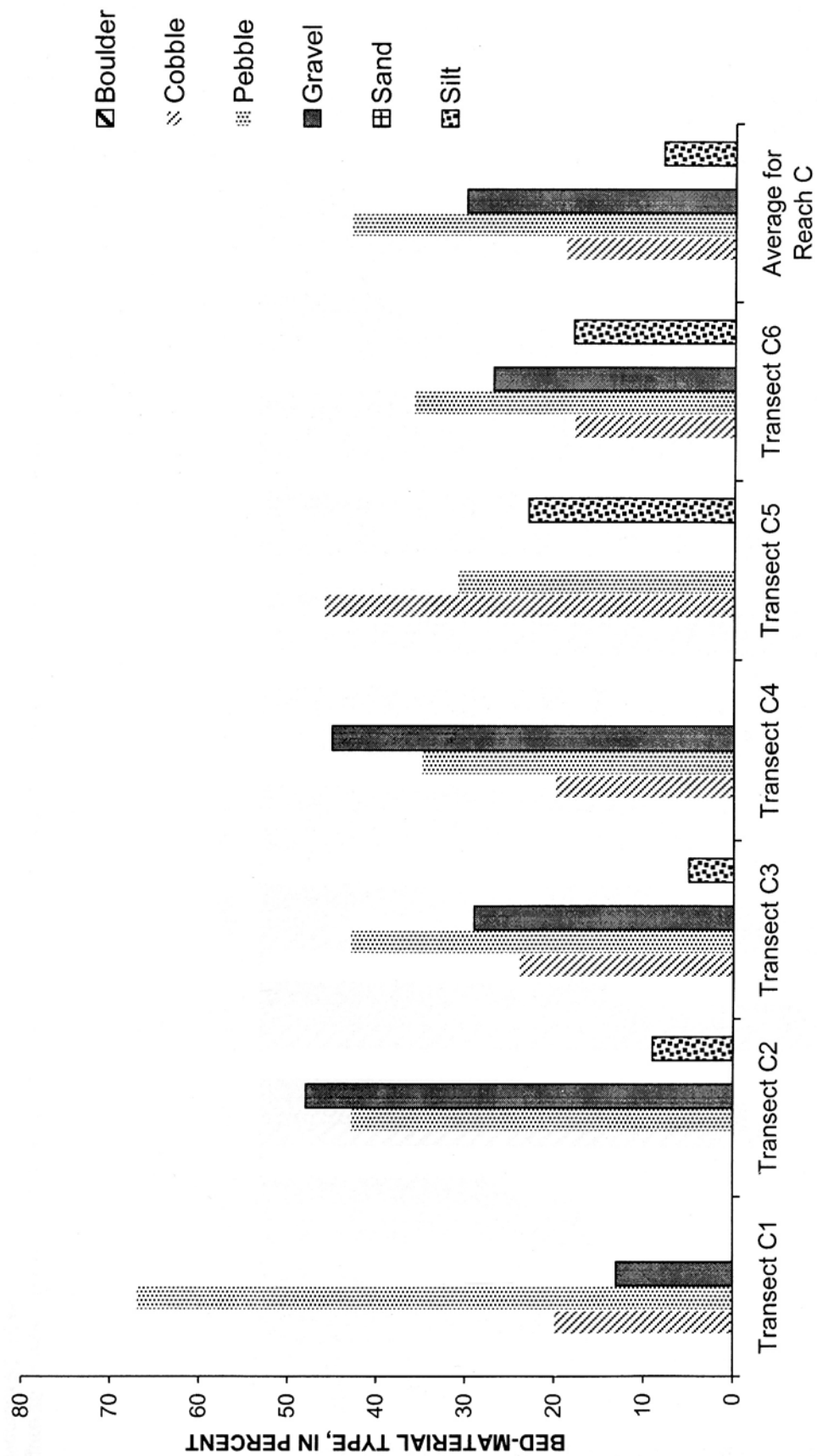
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment]

Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
4.2	318	106	7	1.1	<sup>1</sup> 0.8	0.86	Cobble	Gravel	3
				1.7	.15	.85	Cobble	Gravel	3
				2.8	.12	.47	Cobble	Gravel	3
Transect 2 (Pool)									
8.0	318	98	29	1.0	<sup>1</sup> .43	.04	Sand	Gravel	5
				3.0	.26	.04	Sand	Gravel	5
				5.0	.24	.14	Sand	Gravel	5
Transect 3 (Pool)									
5.8	337	75	44	2.0	.12	.31	Gravel	Cobble	3
				3.5	.15	.39	Gravel	Cobble	3
				5.0	<sup>1</sup> .27	.51	Gravel	Cobble	3
Transect 4 (Run/Pool)									
6.4	4	80	48	1.9	.49	.11	Gravel	Cobble	2
				3.3	<sup>1</sup> .64	.16	Cobble	Gravel	2
				4.0	.61	.15	Cobble	Gravel	5
Transect 5 (Run)									
3.1	43	98	40	1.3	.21	.52	Gravel	Cobble	3
				2.0	.27	.58	Gravel	Cobble	3
				2.6	<sup>1</sup> .30	.48	Gravel	Cobble	3
Transect 6 (Riffle)									
3.1	53	88	13	1.2	<sup>1</sup> .24	.96	Gravel	Cobble	2
				1.7	.18	.82	Gravel	Cobble	2
				2.4	.12	.54	Gravel	Cobble	2

<sup>1</sup>Thalweg.



**Figure 25.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach C, San Pedro River at Charleston, Arizona, based on measurements made November 22, 1996.



**Figure 26.** Bed-material at transects 1–6 and average for reach C, San Pedro River at Charleston, Arizona, November 22, 1996.

**Table 24.** Density and dominance of woody vegetation for reach C, San Pedro River at Charleston, Arizona, November 22, 1996  
[Length of reach, 311 meters]

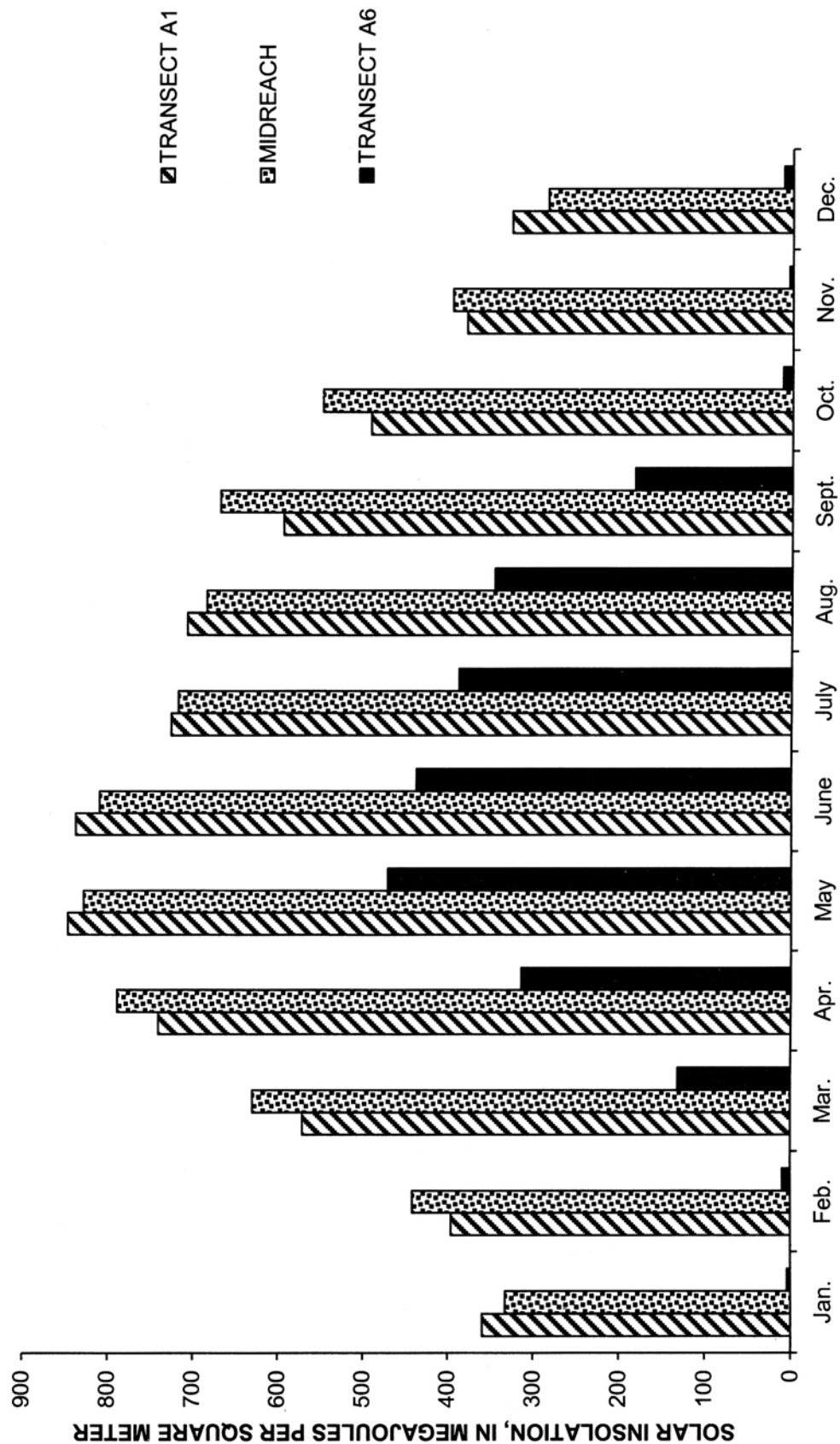
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	2,215	886	33	22
Mesquite ( <i>Prosopis sp.</i> )	20	31	7	9
Willow ( <i>Salix sp.</i> )	55	70	75	70

**Table 25.** Habitat characteristics of reach A, San Pedro River at Charleston, Arizona, November 20, 1997

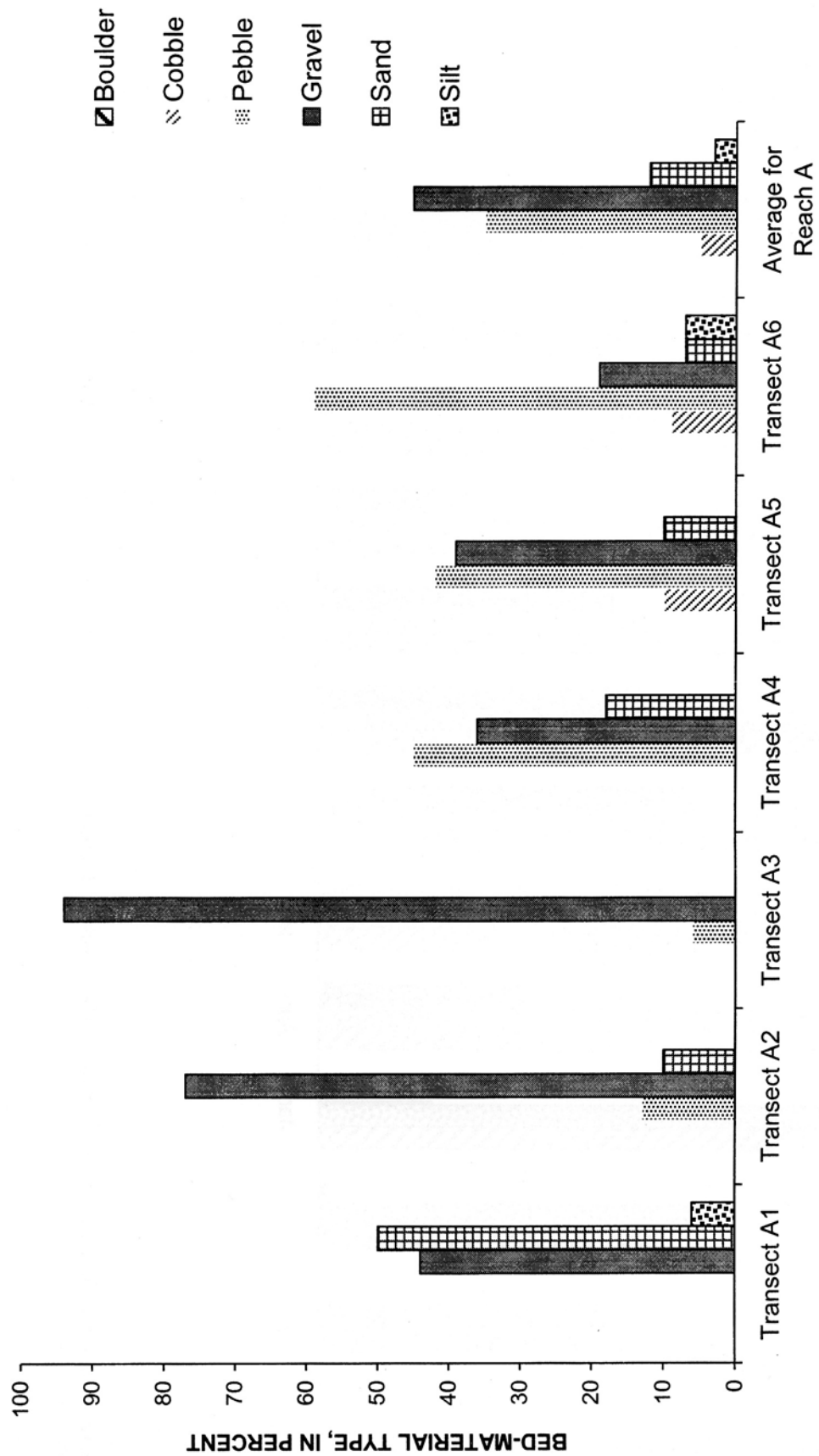
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. NA, not applicable]

Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
5.2	1	96	7	1.9	<sup>1</sup> 0.88	0.08	Gravel	Sand	5
				2.6	.82	.06	Gravel	Muck	5
				3.7	.73	.06	Gravel	Muck	5
Transect 2 (Pool)									
9.1	293	88	28	.2	<sup>1</sup> 1.55	.01	Sand	NA	0
				5.4	.09	.34	Gravel	NA	5
				7.3	.21	.50	Gravel	NA	5
Transect 3 (Pool)									
5.0	295	73	32	.3	<sup>1</sup> 1.40	.47	Gravel	NA	5
				2.0	.09	.25	Gravel	NA	5
				4.0	.06	.31	Gravel	NA	5
Transect 4 (Run/Pool)									
3.1	276	72	16	.5	.20	.24	Gravel	Sand	5
				1.0	<sup>1</sup> 1.26	.46	Gravel	Cobble	5
				2.1	.23	.32	Gravel	Cobble	5
Transect 5 (Run)									
17.5	348	110	13	2.1	.06	.02	Gravel	Cobble	3
				11.0	<sup>1</sup> 1.21	.93	Cobble	Gravel	4
				11.9	.09	.56	Gravel	Cobble	3
Transect 6 (Riffle)									
16.1	273	79	50	3.5	.12	.14	Cobble	Gravel	4
				7.4	<sup>1</sup> 1.29	.11	Gravel	Cobble	3
				11.5	.09	.01	Gravel	Sand	4

<sup>1</sup>Thalweg.



**Figure 27.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, San Pedro River at Charleston, Arizona, based on measurements made November 2, 1997.



**Figure 28.** Bed-material types at transects 1–6 and average for reach A, San Pedro River at Charleston, Arizona, November 20, 1997.

**Table 26.** Density and dominance of woody vegetation for reach A, San Pedro River at Charleston, Arizona, November 20, 1997  
[Length of reach, 401 meters]

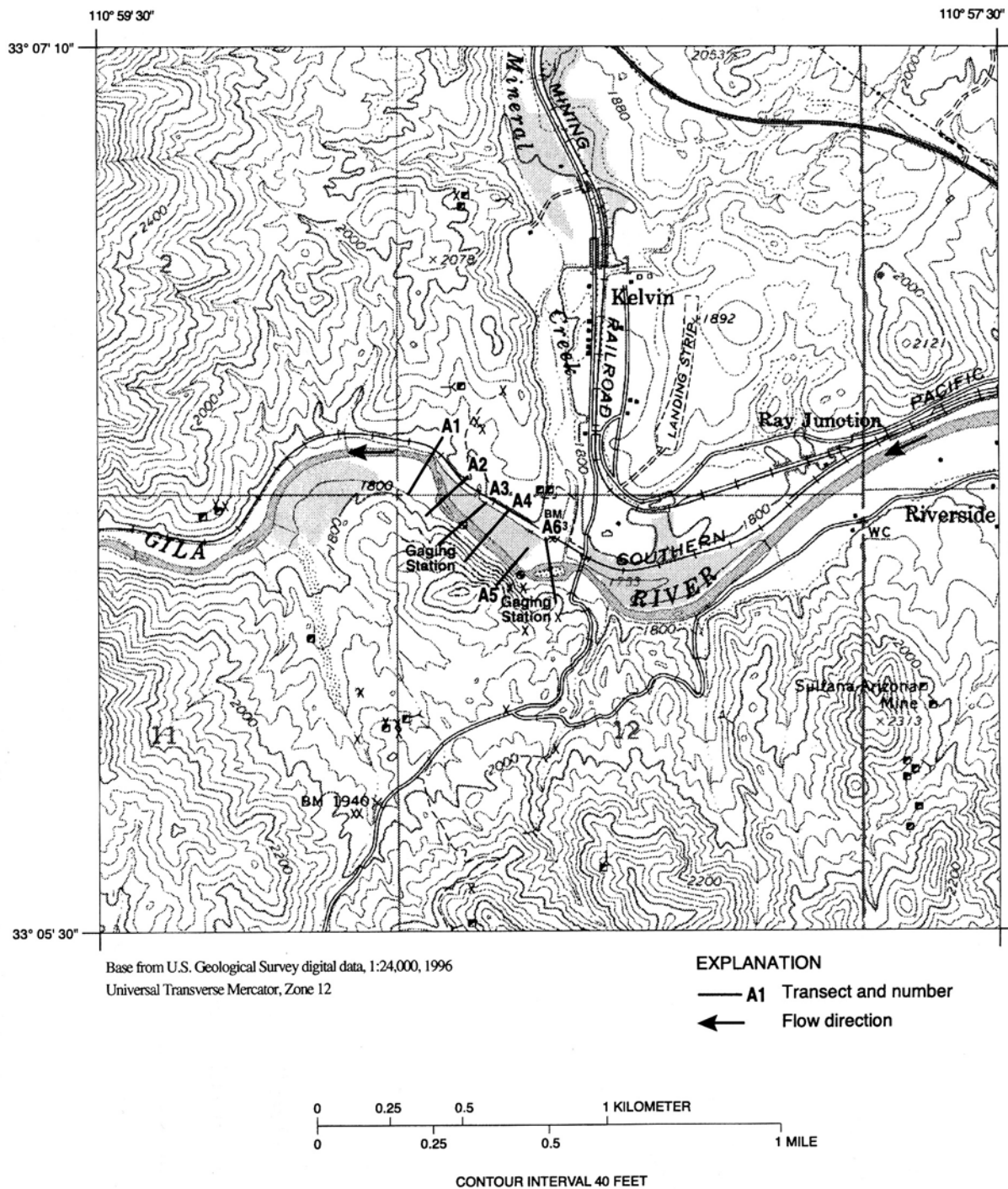
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	1,462	556	58	28
Mesquite ( <i>Prosopis sp.</i> )	60	16	33	19
Willow ( <i>Salix sp.</i> )	358	261	92	53



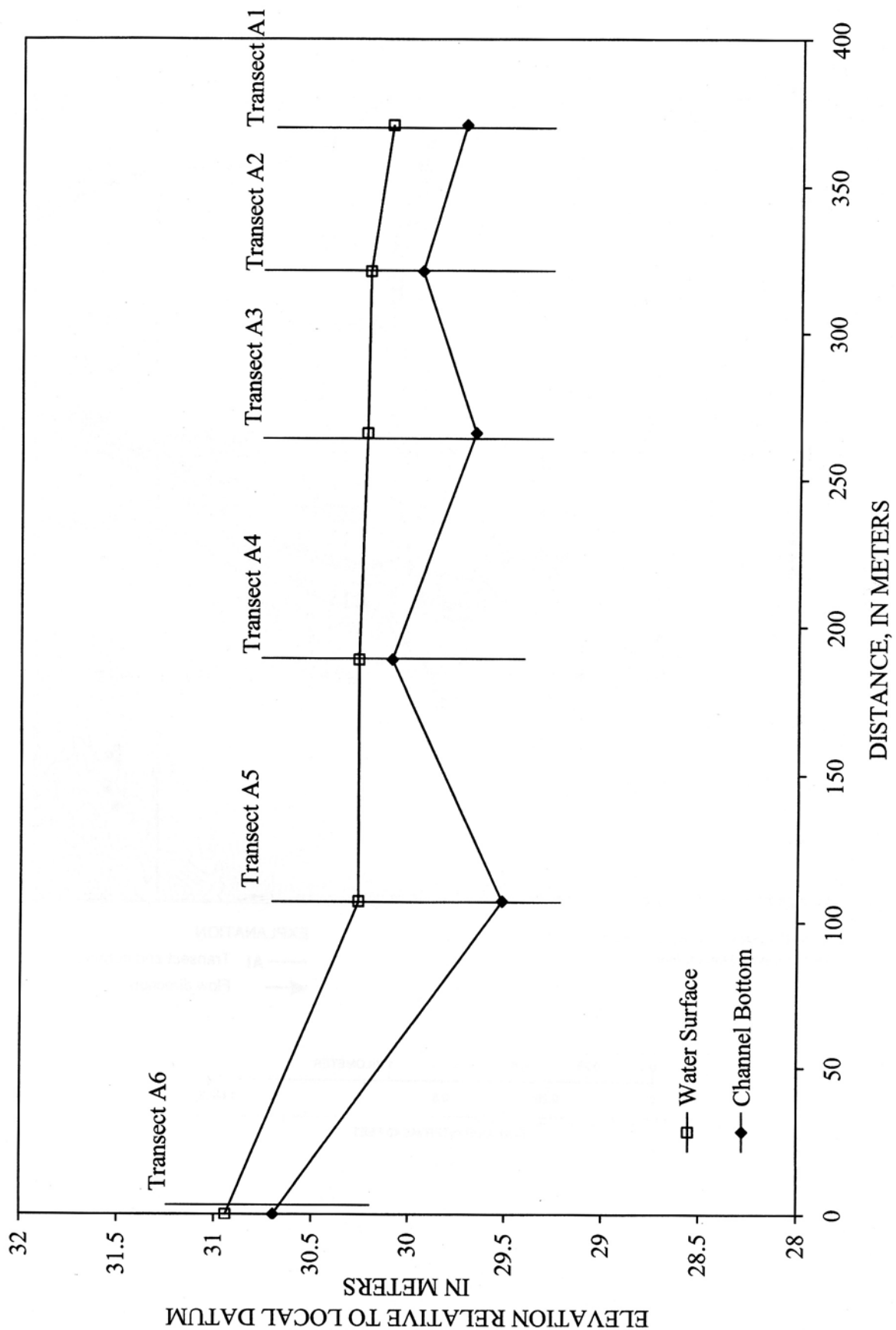
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**Gila River at Kelvin, Arizona**  
**(USGS station number: 09474000)**

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**Figure 29.** Location of transects 1–6, reach A, Gila River at Kelvin, Arizona.

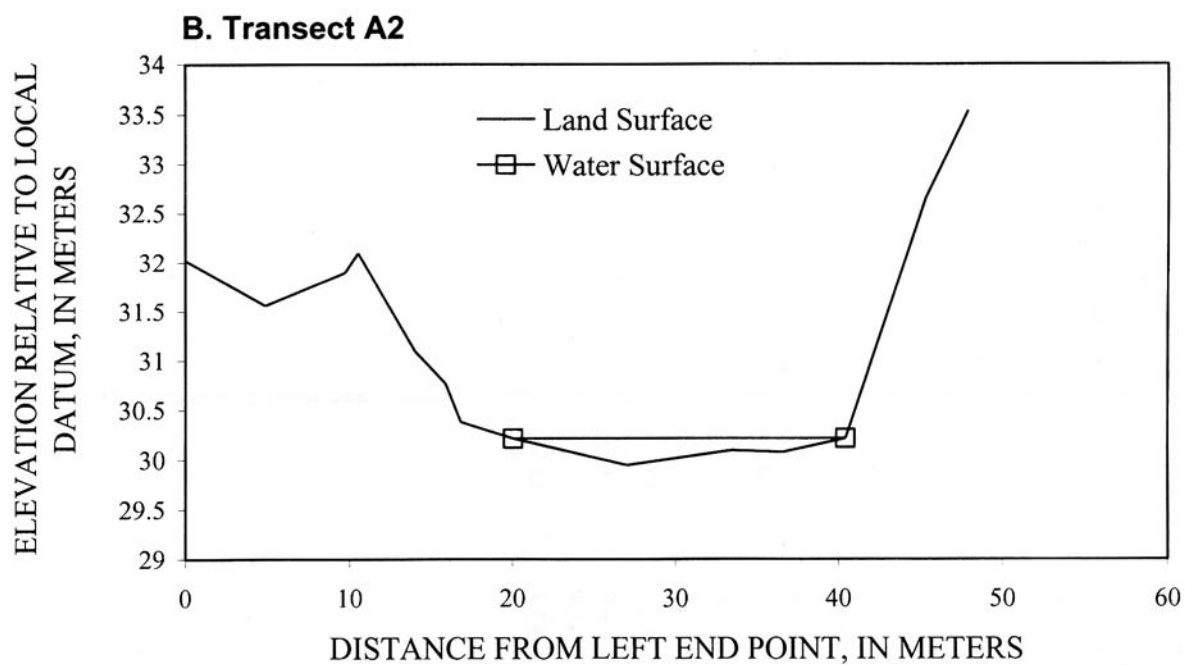
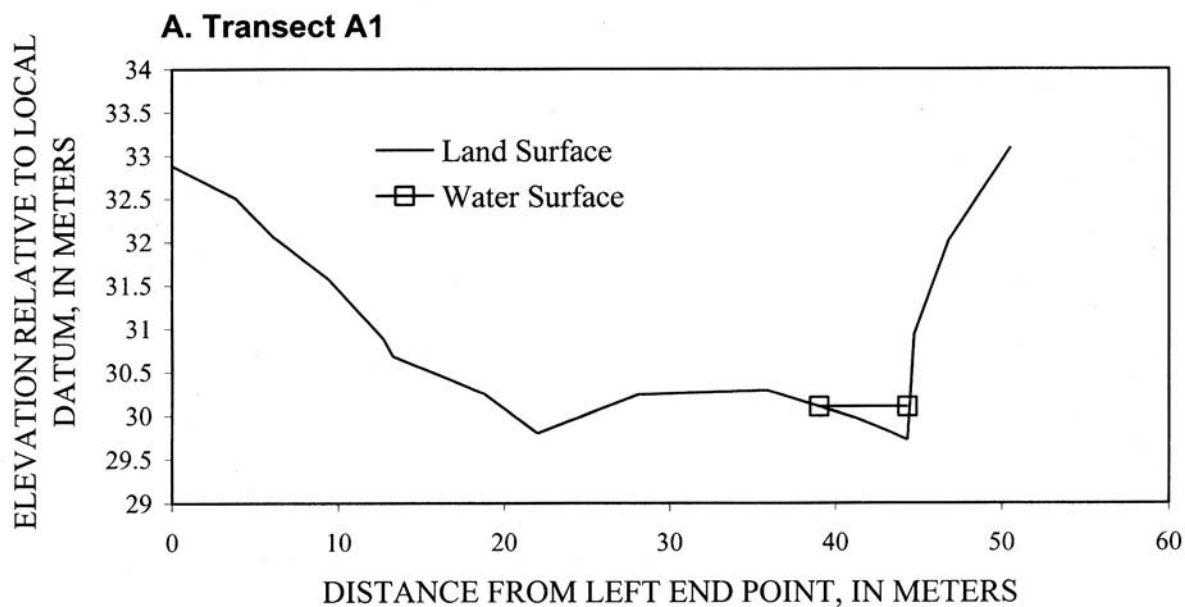


**Figure 30.** Longitudinal profile, reach A, Gila River at Kelvin, Arizona, November 3 and 4, 1998. Local datum is the zero point of the reference gage at streamflow-gaging station, Gila River at Kelvin (09474000).

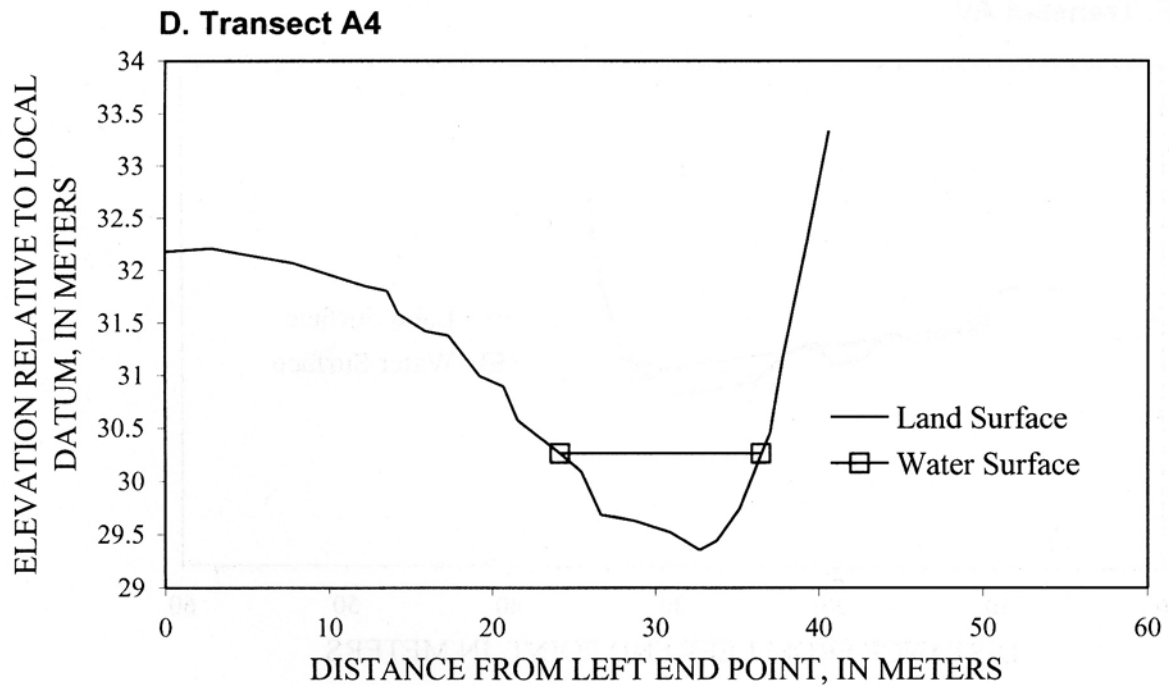
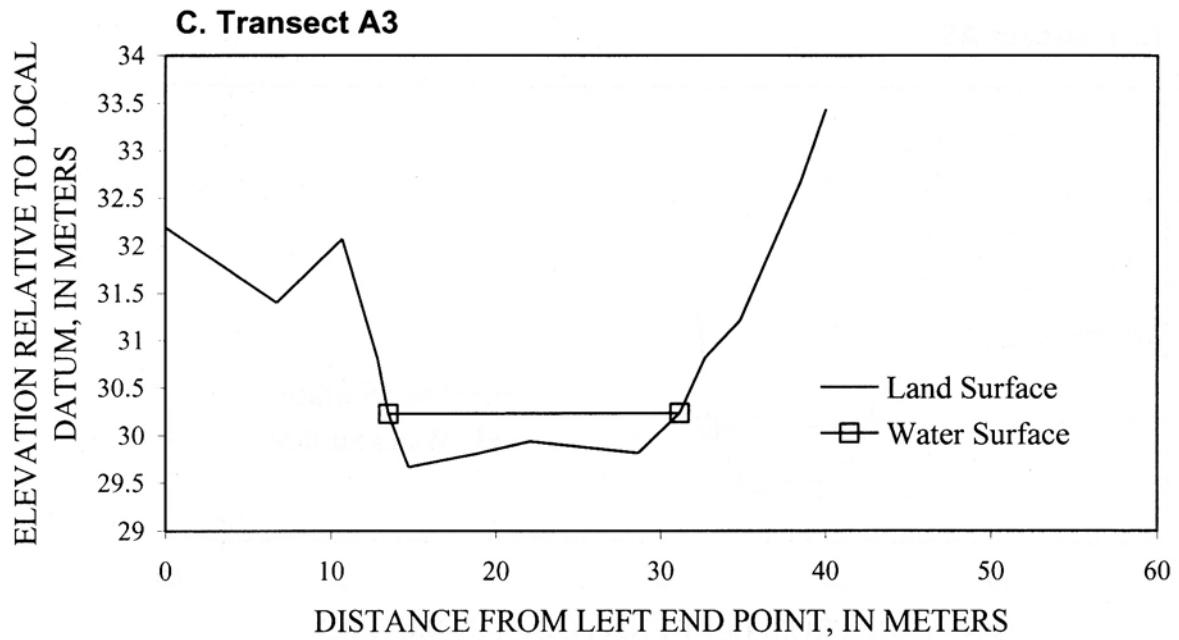
**Table 27.** Cross-sectional survey data for reach A, Gila River at Kelvin, Arizona, November 3 and 4, 1998

[All values are in meters. Distance is from left end point]

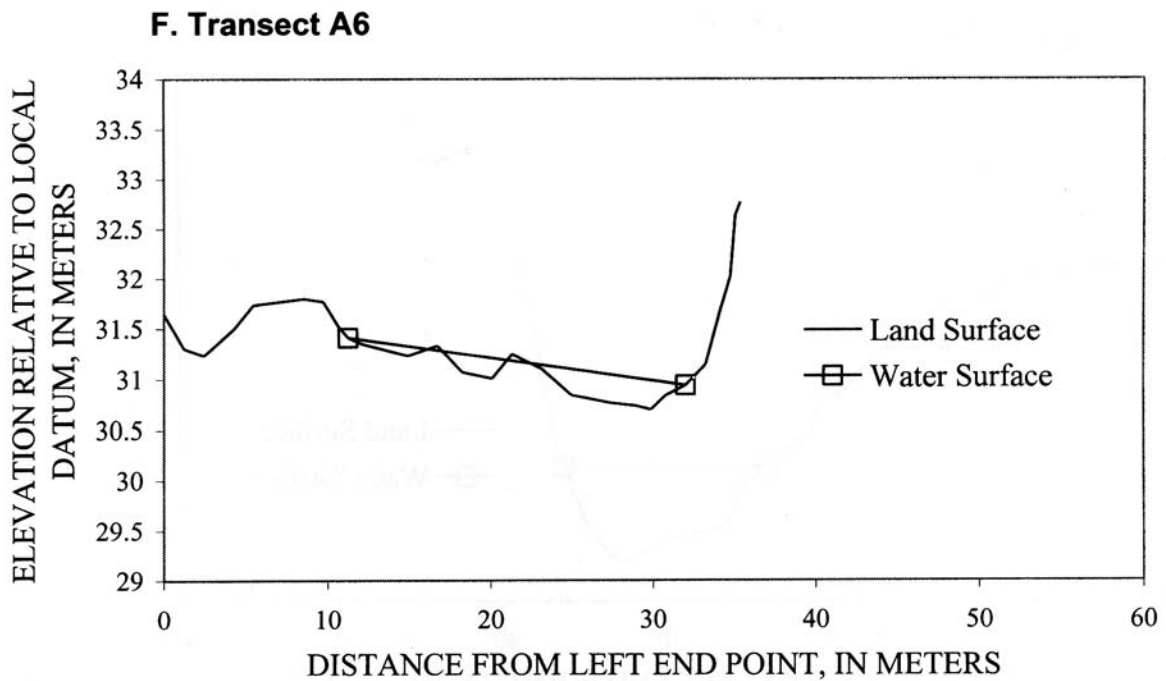
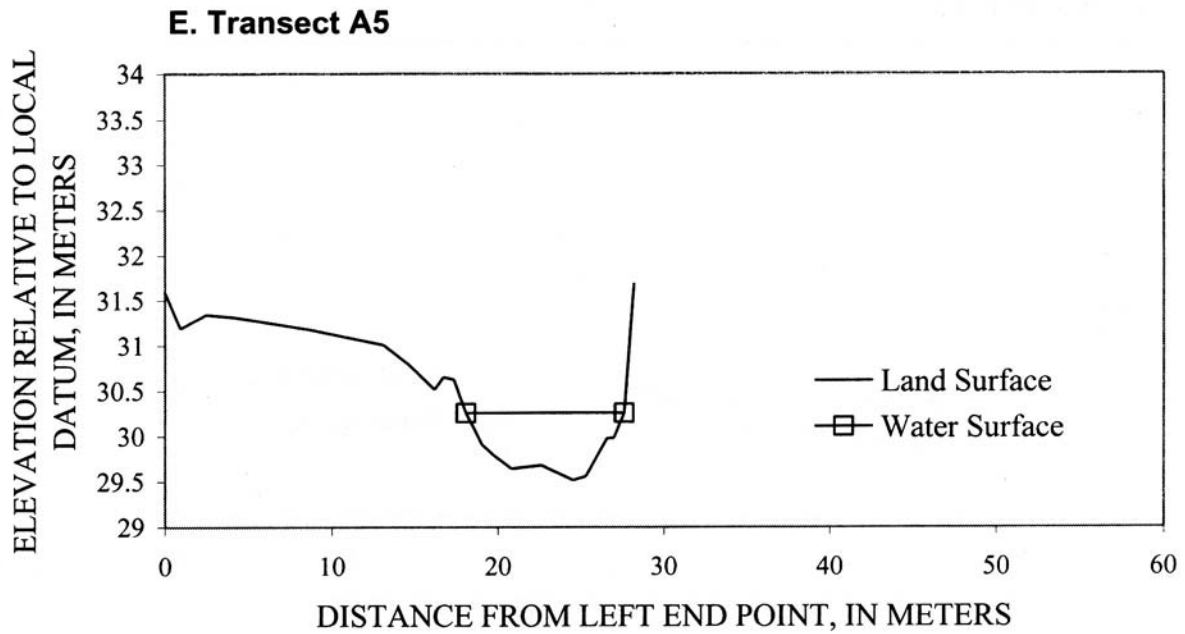
Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
0.0	32.9	0.0	32.0	0.0	32.2	0.0	32.2	0.0	31.6	0.0	31.6
3.8	32.5	4.9	31.6	6.7	31.4	2.8	32.2	0.9	31.2	1.2	31.3
6.1	32.1	9.8	31.9	10.7	32.1	7.8	32.1	2.4	31.3	2.4	31.2
9.4	31.6	10.5	32.1	12.8	30.8	12.2	31.8	4.1	31.3	4.3	31.5
12.7	30.9	14.0	31.1	13.5	30.2	13.6	31.8	8.7	31.2	5.5	31.7
13.3	30.7	15.9	30.8	14.7	29.7	14.2	31.6	13.1	31.0	8.5	31.8
18.8	30.2	16.8	30.4	18.8	29.8	15.9	31.4	14.6	30.8	9.8	31.8
22.0	29.8	20.0	30.2	22.0	29.9	17.3	31.4	16.2	30.5	10.7	31.5
28.1	30.2	27.0	29.9	28.6	29.8	19.2	31.0	16.7	30.7	11.3	31.4
35.8	30.3	33.4	30.1	31.1	30.2	20.7	30.9	17.3	30.6	12.2	31.3
39.0	30.1	36.5	30.1	32.7	30.8	21.5	30.6	18.1	30.3	14.9	31.2
41.2	30.0	40.4	30.2	34.8	31.2	24.1	30.3	19.0	29.9	16.8	31.3
43.3	29.8	42.8	31.4	38.5	32.7	25.5	30.1	19.7	29.8	18.3	31.1
44.3	29.7	45.3	32.7	40.0	33.4	26.7	29.7	20.8	29.6	20.1	31.0
44.7	30.9	47.9	33.5			28.7	29.6	22.6	29.7	21.3	31.2
46.8	32.0					30.9	29.5	24.5	29.5	23.2	31.1
50.5	33.1					32.7	29.4	25.3	29.6	25.0	30.8
						33.7	29.4	26.6	30.0	27.4	30.8
						35.1	29.7	27.0	30.0	29.0	30.7
						36.5	30.2	27.6	30.3	29.9	30.7
						37.0	30.5	28.2	31.7	30.8	30.8
						37.8	31.2			32.0	30.9
						39.2	32.3			33.2	31.1
						40.5	33.3			34.1	31.7
										34.7	32.0
										35.1	32.6
										35.4	32.8



**Figure 31 A–F.** Cross sections of channel, reach A, Gila River at Kelvin, Arizona, November 3 and 4, 1998. A, Transect A1. B, Transect A2. C, Transect A3. D, Transect A4. E, Transect A5. F, Transect A6. Local datum is the zero point of the reference gage at streamflow-gaging station, Gila River at Kelvin, Arizona (09474000).



**Figure 31 A–F.** Continued.



**Figure 31 A–F.** Continued.

**Table 28.** Description and location of semipermanent monuments for reach A, Gila River at Kelvin, Arizona, November 3 and 4, 1998

Transect	Type	Description of location and reference marks
A1	Left	Rebar. Reference mark, RM-6, is well; brass tablet at gaging station, 1.5 meters downstream from upper gaging station. Elevation, 32.63 meters, datum of survey.
A1	Right	No marker.
A2	Left	Rebar, 50 meters upstream from transect A1.
A2	Right	Rebar, 50 meters upstream from transect A1.
A3	Left	Rebar, 55 meters upstream from transect A2.
A3	Right	Rebar, 55 meters upstream from transect A2.
A4	Left	Rebar, 77 meters upstream from transect A3.
A4	Right	Rebar, 77 meters upstream from transect A3.
A5	Left	Rebar, 82 meters upstream from transect A4.
A5	Right	Rebar, 82 meters upstream from transect A4.
A6	Left	Rebar, 107 meters upstream from transect A5.
A6	Right	Rebar, 107 meters upstream from transect A5.

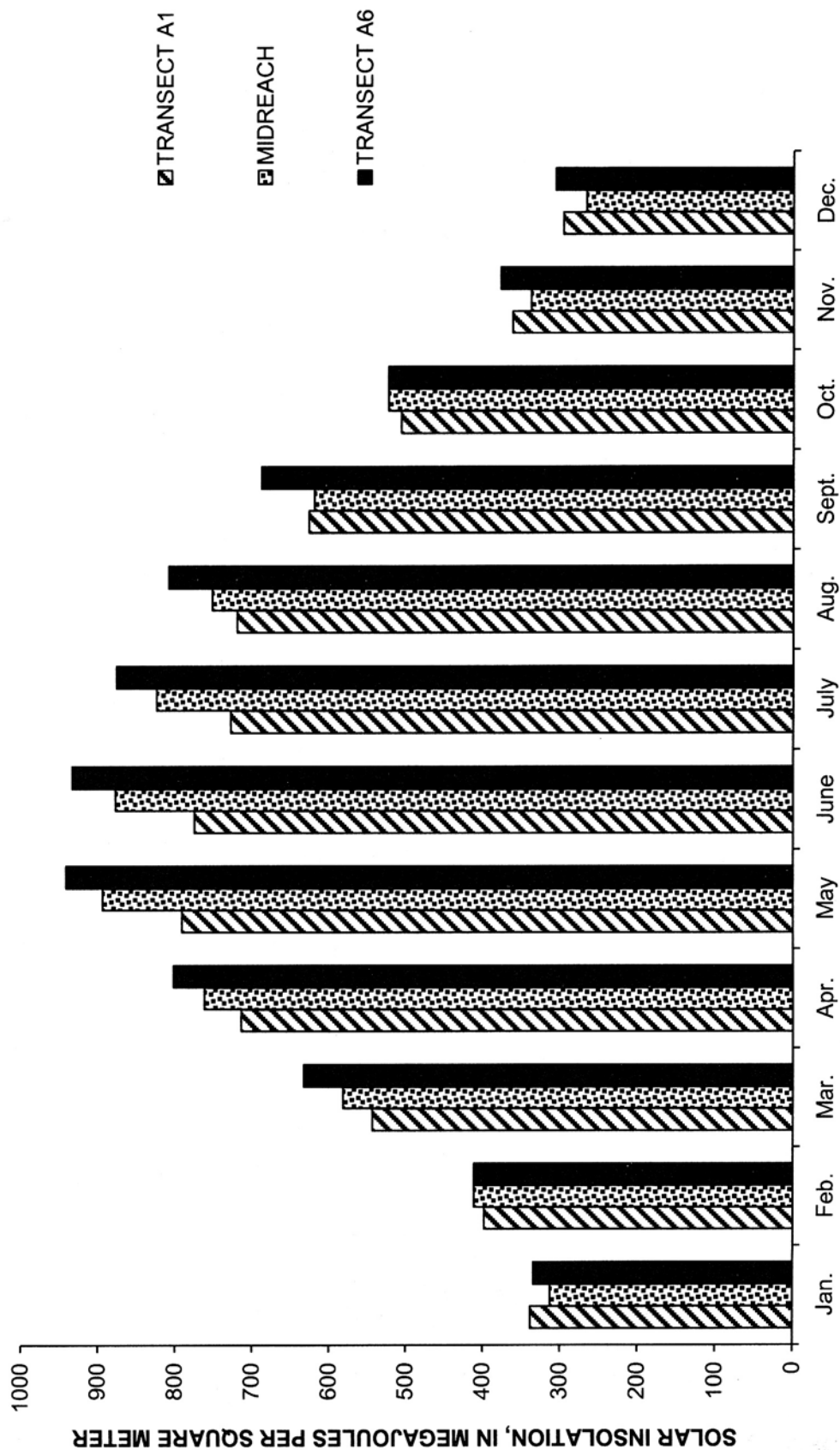
**Table 29.** Habitat characteristics of reach A, Gila River at Kelvin, Arizona, November 27, 1995

[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment. Dashes indicate no data. NA, not applicable]

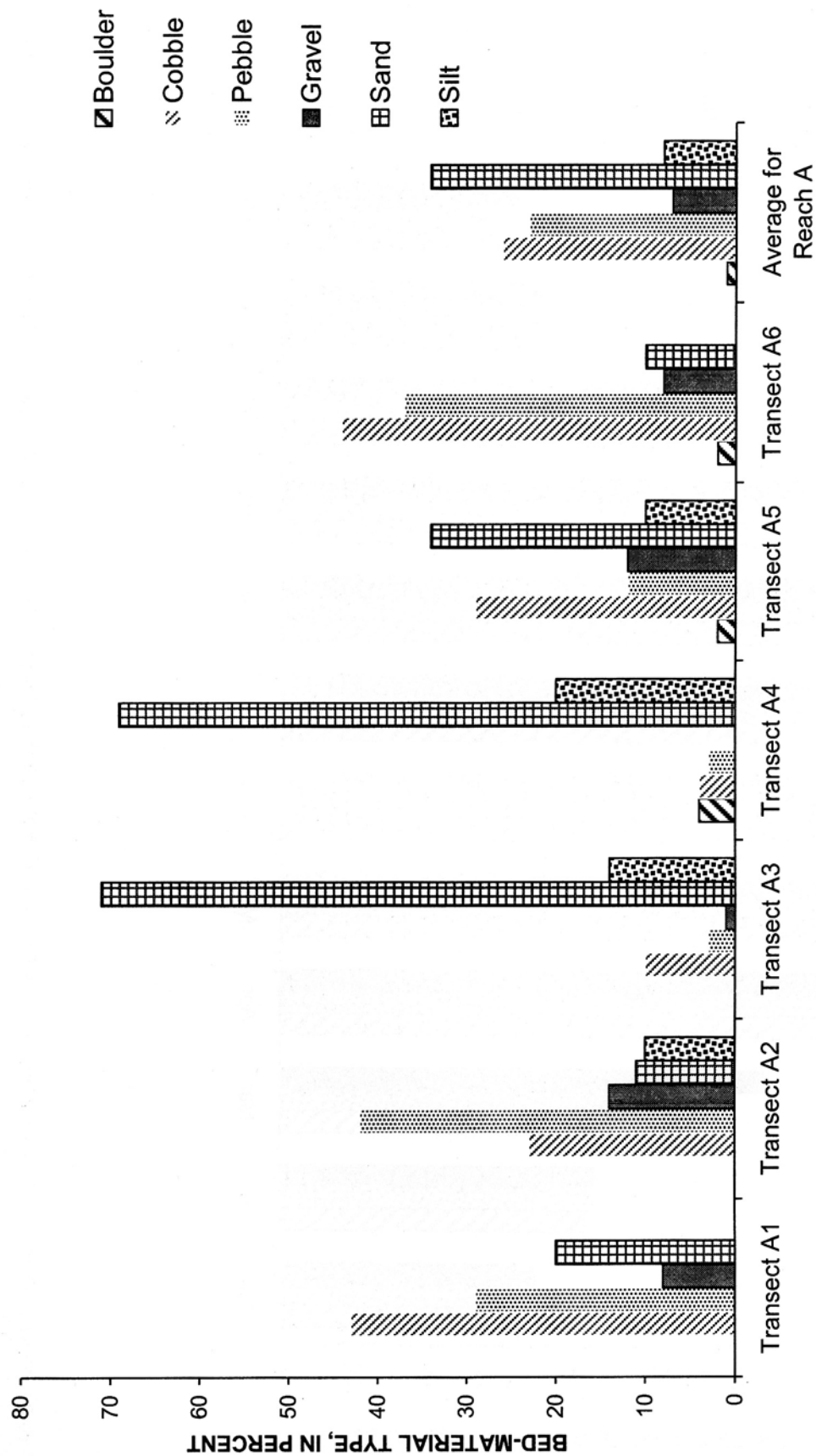
Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
26.5	319	132	43	5.0	0.24	0.60	Cobble	Gravel	4
				15.1	.18	.60	Cobble	Gravel	4
				22.0	<sup>1</sup> .72	.94	Cobble	Boulder	4
Transect 2 (Run)									
28.7	329	140	26	9.0	.29	.29	Gravel	Sand	2
				17.0	.34	.49	Cobble	Sand	2
				25.3	<sup>1</sup> .63	.70	Gravel	Cobble	3
Transect 3 (Pool)									
24.5	319	121	32	3.9	<sup>1</sup> .71	.36	Sand	Cobble	3
				9.0	.43	.38	Sand	NA	0
				17.0	.40	.35	Sand	NA	0
Transect 4 (Run)									
16.1	315	112	25	4.0	.62	.25	Sand	Cobble	2
				8.0	.75	.45	Sand	NA	0
				12.6	<sup>1</sup> 1.09	.46	Sand	NA	0
Transect 5 (Run)									
15.6	344	98	26	3.3	.30	.32	---	---	---
				6.7	.45	.35	Sand	Gravel	4
				10.0	<sup>1</sup> .86	.86	Gravel	Sand	4
Transect 6 (Riffle)									
32.5	281	141	19	2.0	<sup>1</sup> .46	.44	Gravel	Cobble	4
				12.5	.25	.18	Cobble	Sand	4
				22.5	.18	.66	Cobble	Gravel	4

<sup>1</sup>Thalweg.





**Figure 32.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, Gila River at Kelvin, Arizona, based on measurements made November 27, 1995.



**Figure 33.** Bed-material types at transects 1–6 and average for reach A, Gila River at Kelvin, Arizona, November 27, 1995.

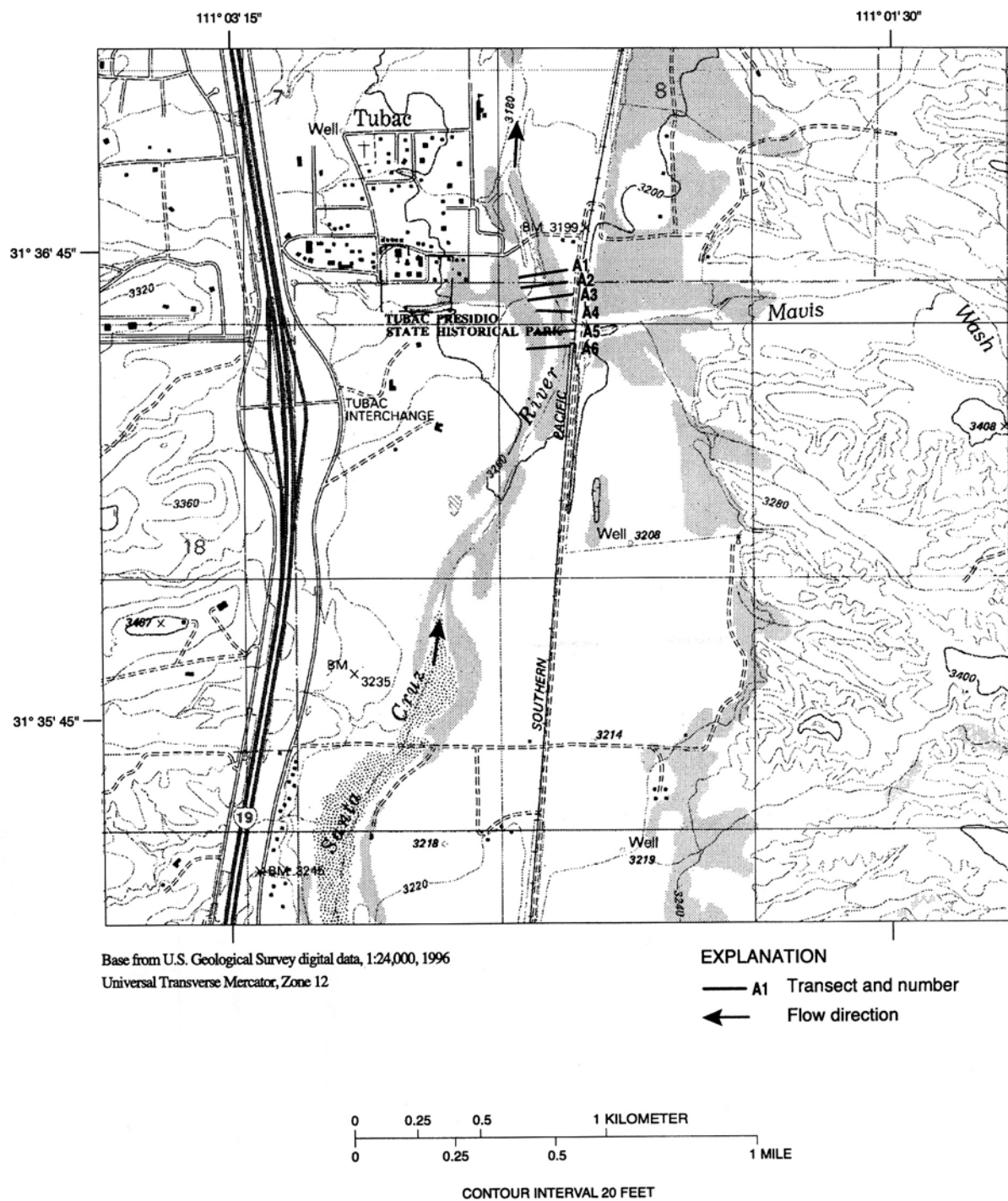
**Table 30.** Density and dominance of woody vegetation for reach A, Gila River at Kelvin, Arizona, November 27, 1995  
[Length of reach, 371 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Mesquite ( <i>Prosopis sp.</i> )	50	50	8	3
Tamarisk ( <i>Tamarix sp.</i> )	25	61	92	71
Willow ( <i>Salix sp.</i> )	346	308	42	26

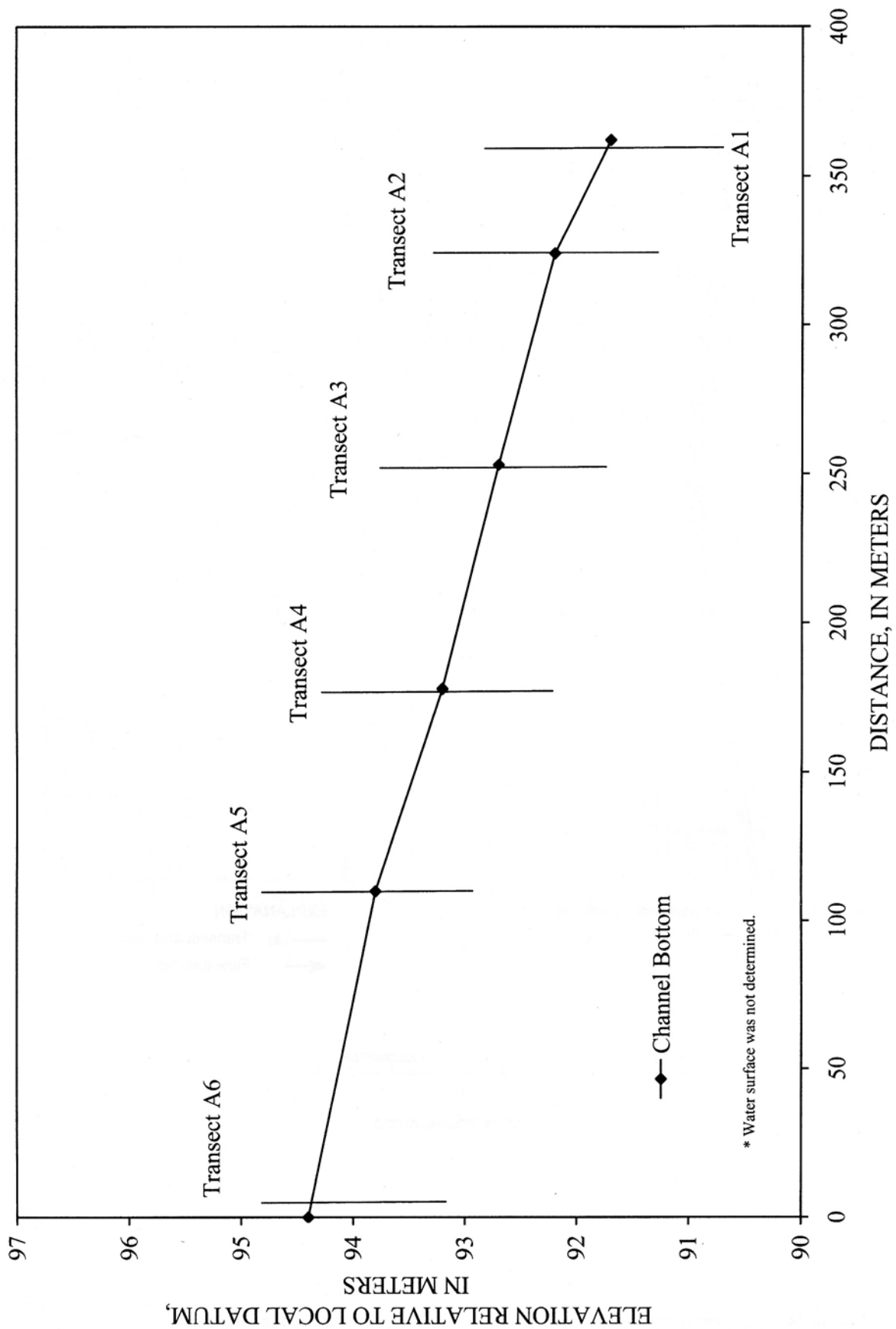
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**Santa Cruz River at Tubac, Arizona**  
**(USGS station number: 09481740)**

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**Figure 34.** Location of transects 1–6, reach A, Santa Cruz River at Tubac, Arizona.

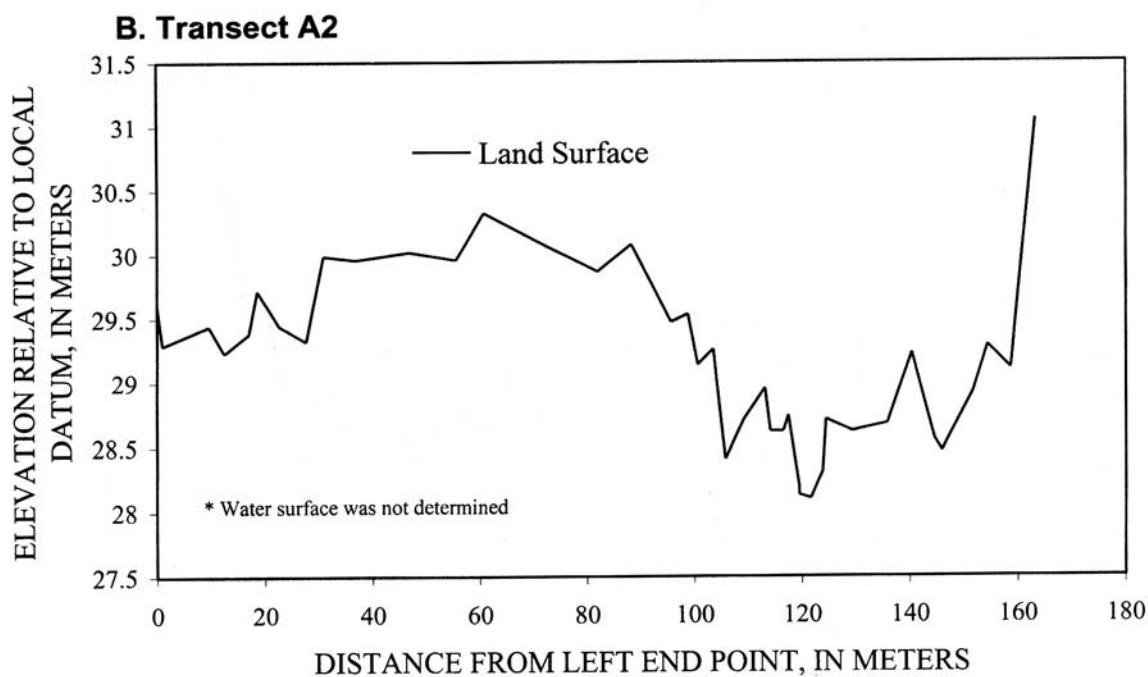
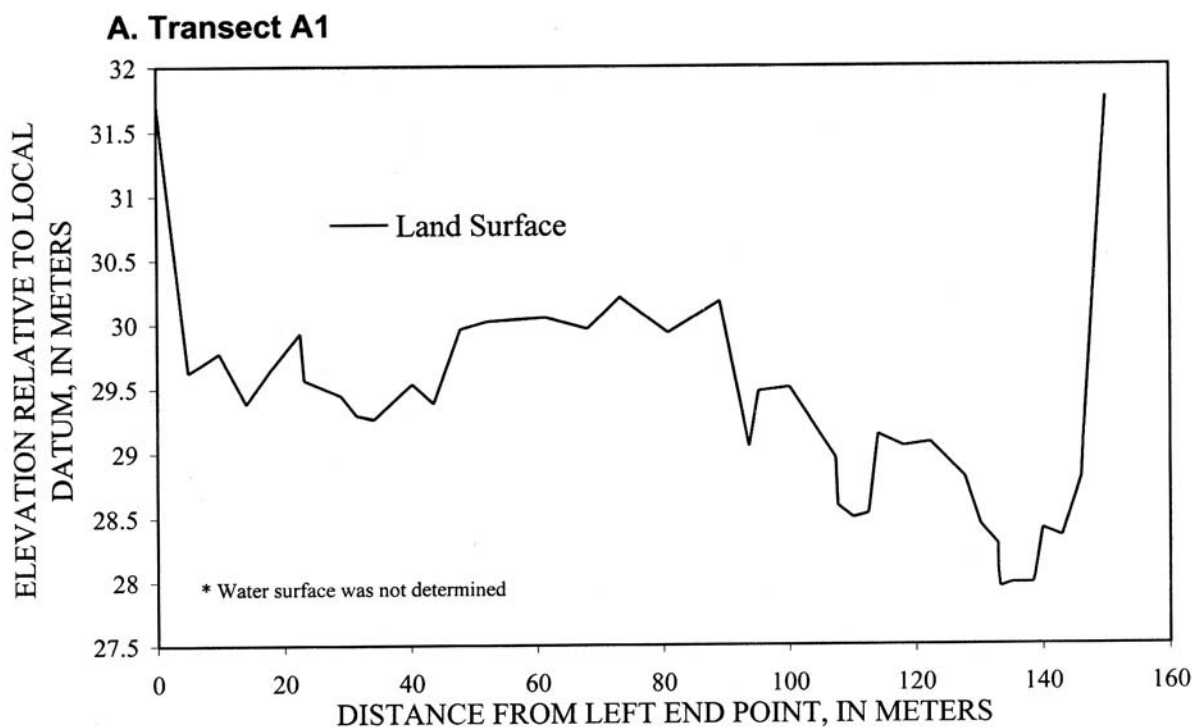


**Figure 35.** Longitudinal profile, reach A, Santa Cruz River at Tubac, Arizona, January 7 and 12, 1998. Local datum established by using arbitrary elevation.

**Table 31.** Cross-sectional survey data for reach A, Santa Cruz River at Tubac, Arizona, January 7 and 12, 1998

[All values are in meters. Distance is from left end point]

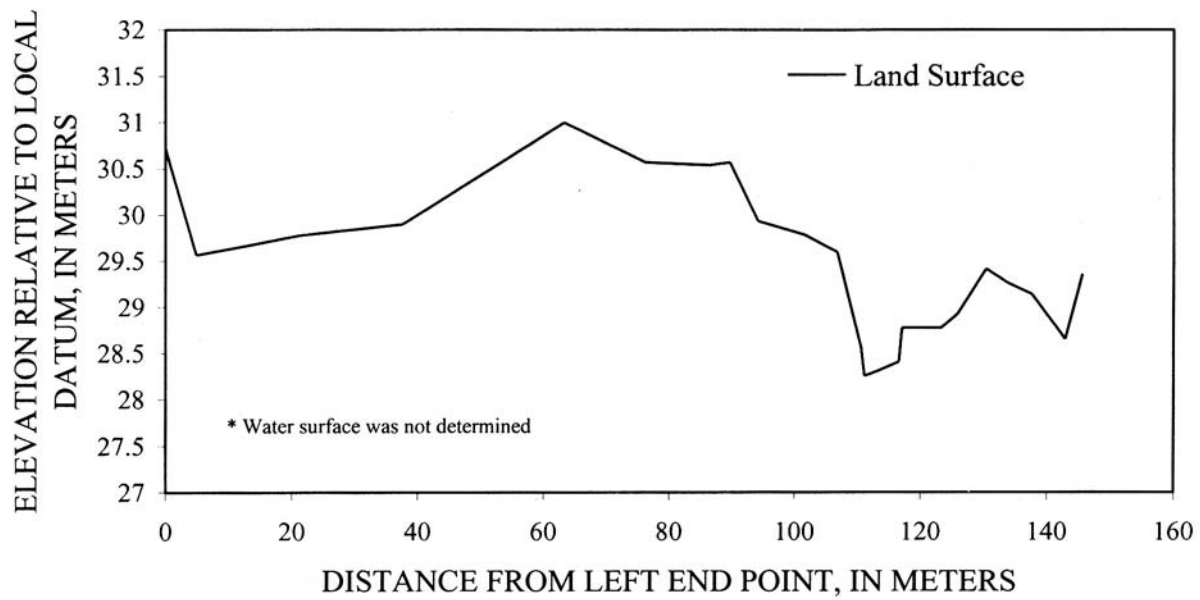
Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
0	31.7	0	29.6	0	30.7	0	30.9	0	31.6	0	31.4
4.9	29.6	1	29.3	4.9	29.6	4.8	29.3	0	31.4	0	31.3
9.8	29.8	9.6	29.4	21.2	29.8	13.6	29.3	1.4	31.2	.3	31.2
14.0	29.4	12.4	29.2	32.5	29.9	22.5	29.4	3.9	30.7	1.5	30.7
18	29.7	17	29.4	63.3	31	35.3	29.8	16.5	31	8.4	30.7
22.6	29.9	18.6	29.7	76.2	30.6	37.9	30.4	18.9	30.2	8.9	29.6
23.2	29.6	22.7	29.4	86.3	30.5	46.3	30.2	27	30.2	10.1	29.4
29	29.4	27.7	29.3	89.7	30.6	57.2	30	39.6	29.4	15.6	29.8
31.4	29.3	31	30	94.2	29.9	59.6	30.7	42.2	30.1	19.5	30.3
34.2	29.3	36.8	30	101.6	29.8	69.3	30.8	45.6	30.1	23.8	30.4
40.3	29.5	46.8	30	106.8	29.6	78.2	31.1	50	30.8	28	30.6
43.6	29.4	55.6	30	110.6	28.6	86.9	30.9	55	30.9	30.8	30.8
47.9	30	60.8	30.3	111.1	28.3	103.5	30.7	62.3	31.1	33.8	31
52.2	30	73.3	30.1	113.4	28.3	108.5	29.2	74.3	30.9	35.1	30.7
61.3	30.1	82	29.9	116.6	28.4	110.4	28.9	81.3	30.7	36.3	30.6
68	30	88.3	30.1	117	28.8	116.6	29.2	92.6	30.9	38.8	30.8
73.2	30.2	95.7	29.5	120.8	28.8	120.2	29.0	95.3	31.1	40.6	30.6
80.8	29.9	98.9	29.5	123.3	28.8	120.9	28.4	103.8	29.5	42.7	30.6
89	30.2	100.7	29.1	125.9	28.9	122.8	28.4	104.7	28.9	46.1	30.7
93.6	29.0	103.6	29.3	130.4	29.4	125.3	28.4	105	28.6	47.3	30.9
95.1	29.5	105.8	28.4	133.8	29.3	125.9	29.0	107.6	28.7	55.5	30.8
100	29.5	109.3	28.7	137.6	29.1	129.7	29.2	110.9	28.8	60.2	30.9
107.3	29.0	113.3	29.0	142.9	28.6	131.8	29.4	111.8	29.3	64.5	30.7
107.6	28.6	114.2	28.6	145.6	29.4	136.6	29.4	116.9	29.3	69.4	30.7
110.1	28.5	116.7	28.6			140.5	29.5	125	29.3	76.4	30.8
112.5	28.5	117.6	28.7			143.4	29.3	131.6	29.3	77.9	30.2
114	29.1	119.6	28.2			145.7	29.1	135.5	30.2	82.7	30.1
118	29	119.6	28.1			147.6	29.1	138.9	30.4	86.8	29.9
122.3	29.1	121.7	28.1			148.8	29.8	147.2	34	90.9	29.2
127.7	28.8	124	28.3			151.3	31.1	156	34.4	95.5	28.8
130.2	28.4	124.6	28.7			155.1	30.8			95.8	28.8
132.9	28.3	129.4	28.6			160.2	34.1			97.7	28.8
132.9	28.1	136	28.7			161.8	34.3			98.9	28.8
133.2	28	140.6	29.2							101.8	29
135.1	28	144.7	28.6							104.5	29
138.4	28	146	28.5							105.1	29.4
138.7	28.0	151.8	28.9							110.1	29.5
139.9	28.4	154.5	29.3							119.6	30.1
143	28.3	158.8	29.1							120.1	31
146	28.8	163.3	31.1								
146.3	29.1										
150	31.8										



**Figure 36A–F.** Cross sections of channel, reach A, Santa Cruz River at Tubac, Arizona, January 7 and 12, 1998. A, Transect A1. B, Transect A2. C, Transect A3. D, Transect A4. E, Transect A5. F, Transect A6. Local datum established using arbitrary elevation.



### C. Transect A3



### D. Transect A4

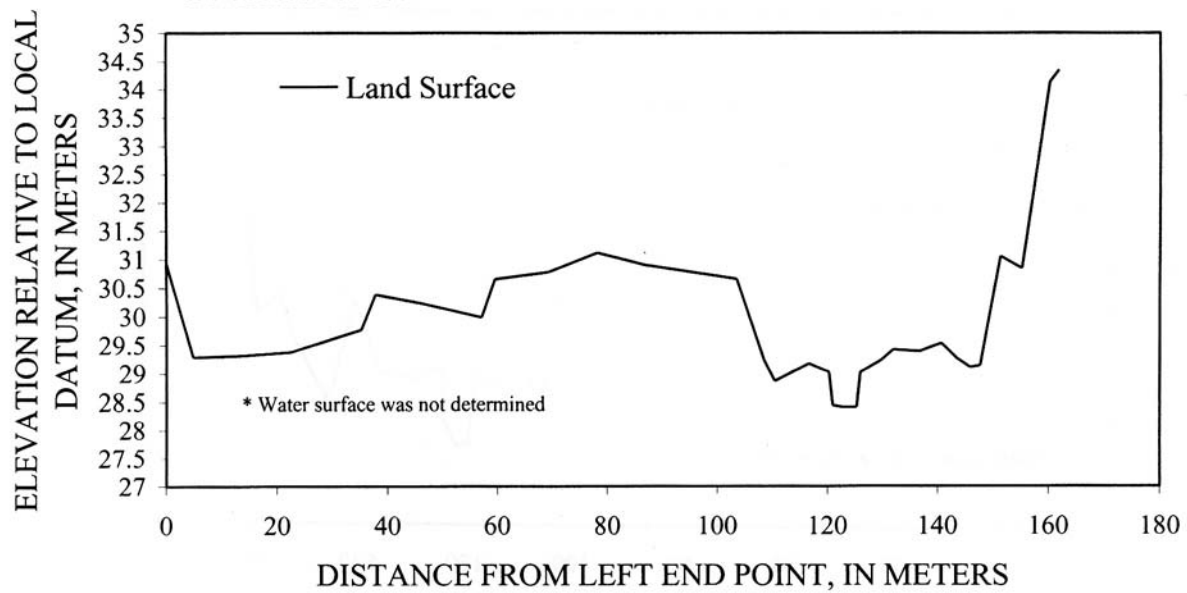
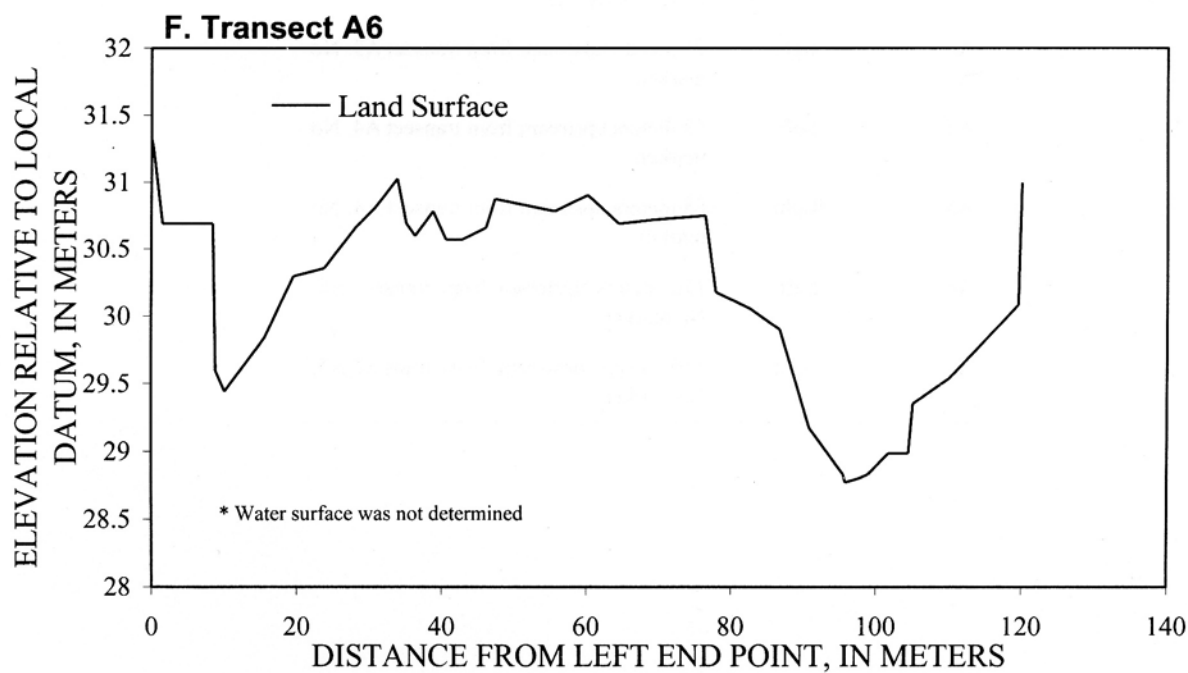
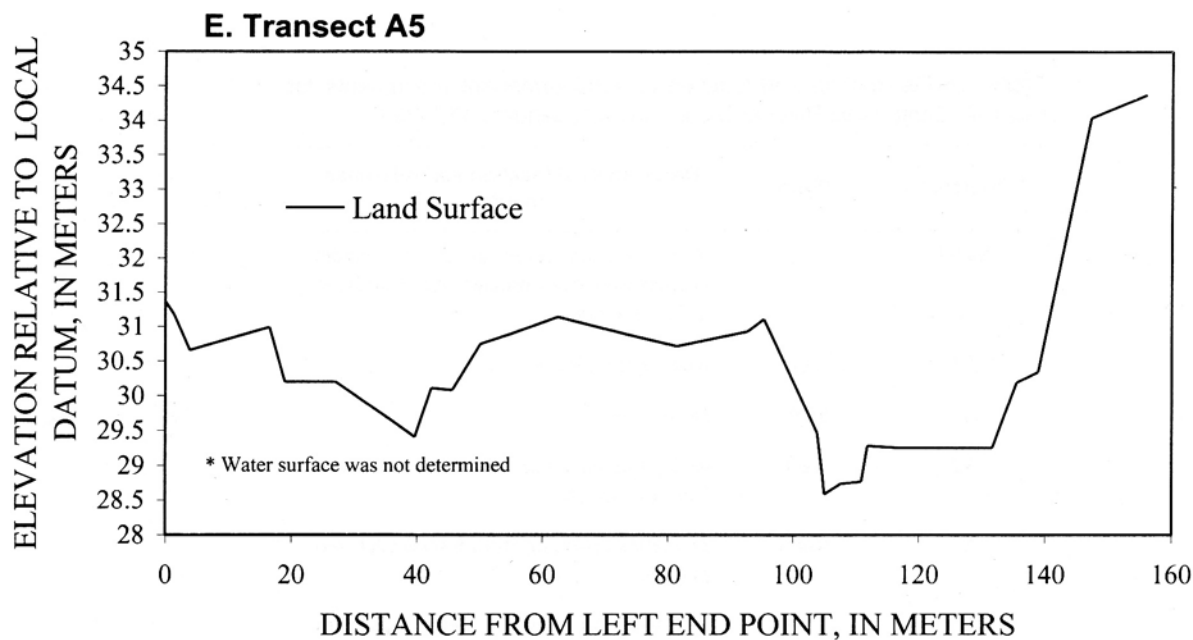


Figure 36A–F. Continued.



**Figure 36A–F.** Continued.

**Table 32.** Description and location of semipermanent monuments for reach A, Santa Cruz River at Tubac, Arizona, January 12, 1998

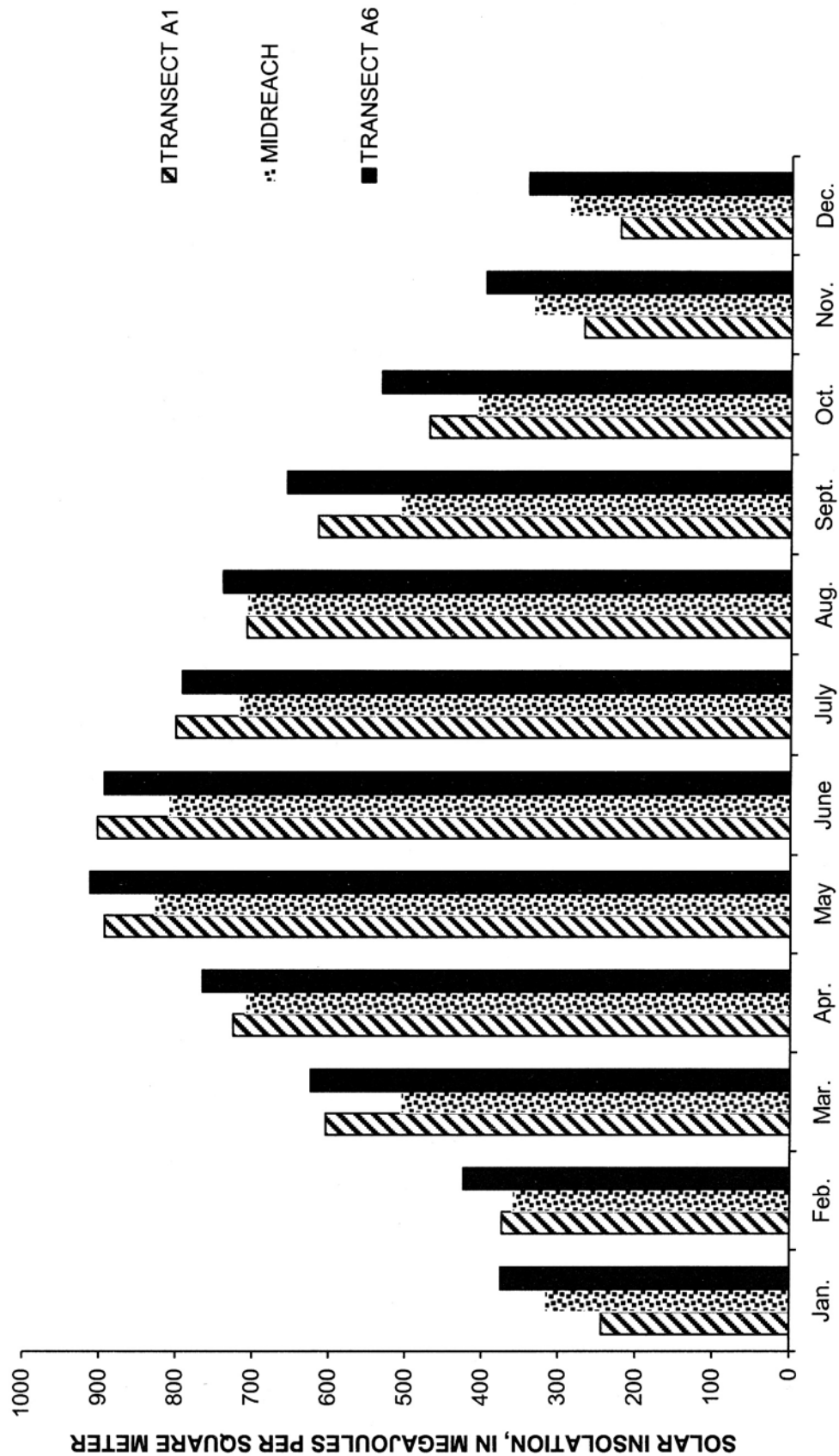
Transect	Type	Description of location and reference marks
RM-1		Red paint on levee about 20 meters downstream from transect A1. Elevation is 31.7 meters.
A1	Left	Red paint on levee.
A1	Right	No marker.
A2	Left	Red paint on levee 38 meters upstream from transect A1.
A2	Right	38 meters upstream from transect A1. No marker.
A3	Left	Red paint on levee 71 meters upstream from transect A2.
A3	Right	71 meters upstream from transect A2. No marker.
A4	Left	Red paint on levee 75 meters upstream from transect A3.
A4	Right	75 meters upstream from transect A3. No marker.
A5	Left	68 meters upstream from transect A4. No marker.
A5	Right	68 meters upstream from transect A4. No marker.
A6	Left	110 meters upstream from transect A5. No marker.
A6	Right	110 meters upstream from transect A5. No marker.

**Table 33.** Habitat characteristics of reach A, Santa Cruz River at Tubac, Arizona, January 19, 1996

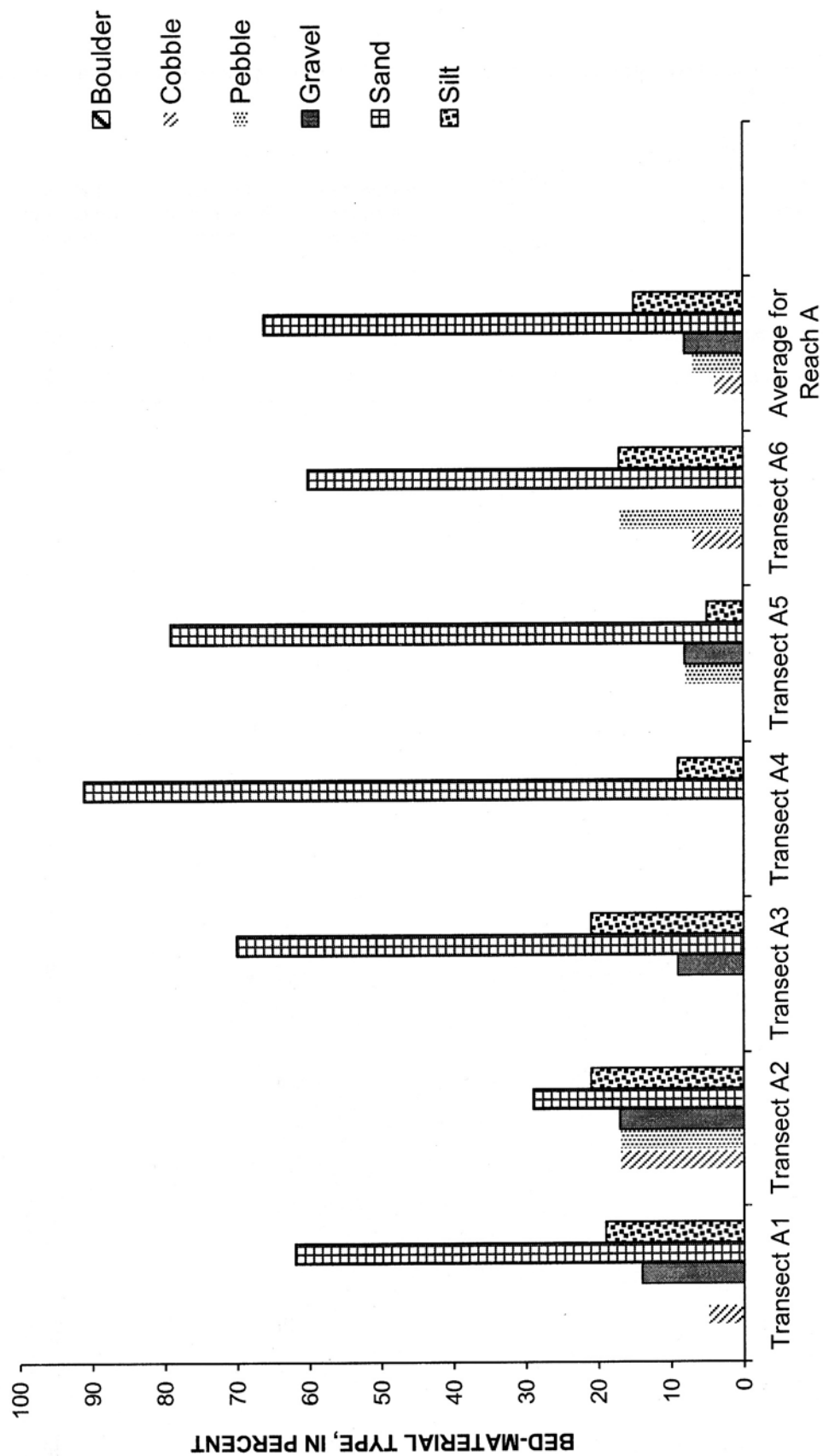
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment. NA, not applicable]

Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Run)									
6.7	10	128	9	1.7	0.26	0.48	Sand	NA	0
				2.8	<sup>1</sup> .27	.64	Sand	Gravel	5
				4.2	.21	.55	Sand	NA	0
Transect 2 (Riffle)									
8.4	18	149	0	2.9	.18	.07	Sand	Gravel	4
				5.0	<sup>1</sup> .24	1.05	Sand	Cobble	3
				6.3	.18	.75	Sand	Cobble	3
Transect 3 (Run)									
14.6	352	118	12	3.4	.21	.63	Sand	NA	0
				6.5	.08	.06	Sand	NA	0
				10.6	<sup>1</sup> .27	.71	Sand	NA	0
Transect 4 (Run)									
7.5	4	85	38	.9	<sup>1</sup> .24	.63	Sand	NA	0
				3.0	.18	.66	Sand	NA	0
				5.0	.12	.51	Sand	NA	0
Transect 5 (Run)									
15.2	350	144	31	3.8	<sup>1</sup> .24	.50	Sand	NA	0
				5.7	.15	.57	Sand	NA	0
				7.8	.18	.57	Sand	NA	0
Transect 6 (Riffle)									
17.5	26	153	0	1.6	.24	.88	Gravel	Cobble	4
				2.0	<sup>1</sup> .27	.82	Gravel	Cobble	4
				2.8	.27	.76	Gravel	Cobble	4
				6.6	.12	.08	Silt	NA	0

<sup>1</sup>Thalweg.



**Figure 37.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, Santa Cruz River at Tubac, Arizona, based on measurements made January 19, 1996.



**Figure 38.** Bed-material types at transects 1–6 and average for reach A, Santa Cruz River at Tubac, Arizona, January 19, 1996.

**Table 34.** Density and dominance of woody vegetation for reach A, Santa Cruz River at Tubac, Arizona, January 19, 1996

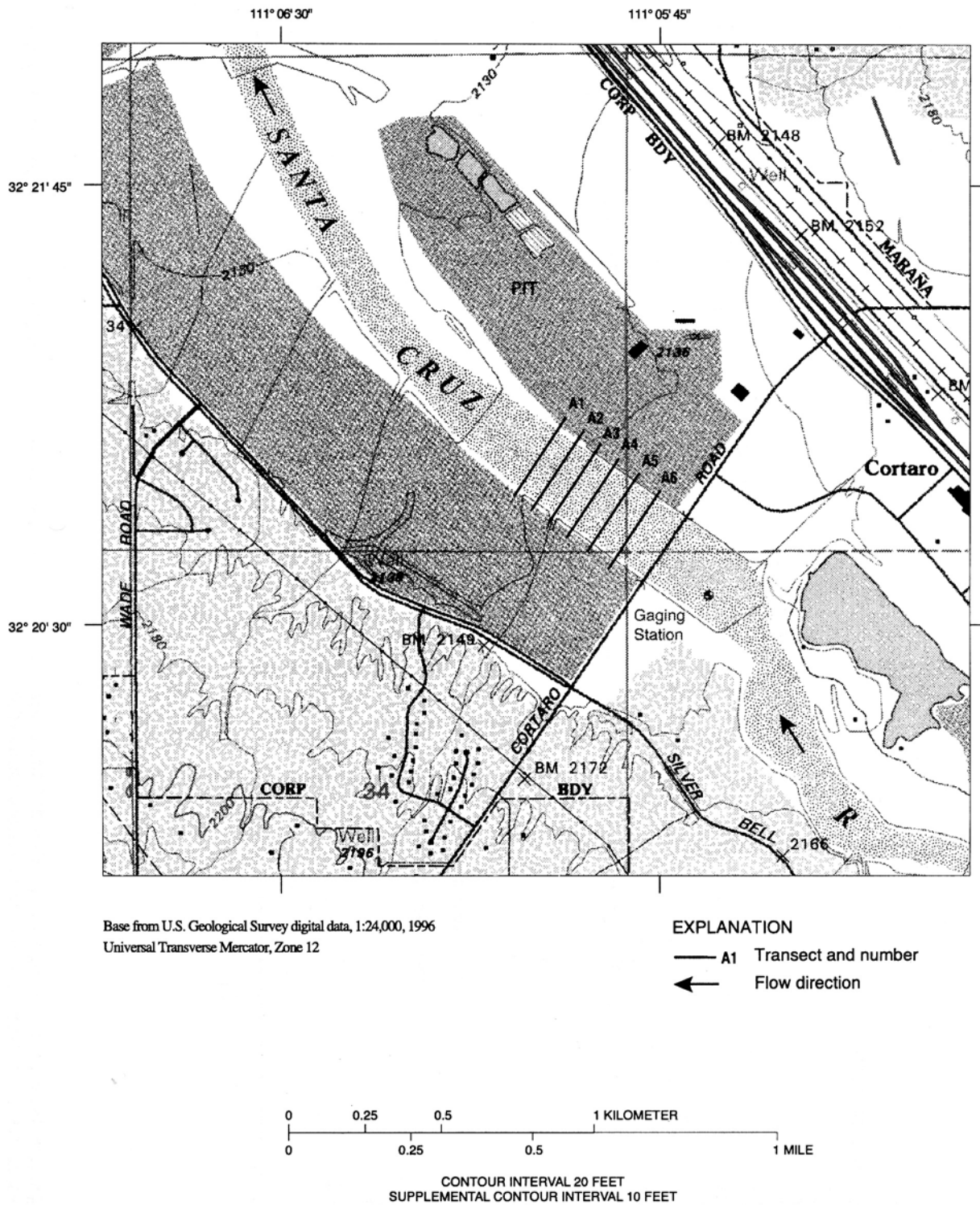
[Length of reach, 371 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Willow ( <i>Salix sp.</i> )	35	64	100	79
Freemont cottonwood ( <i>Populus fremontii</i> )	18	8	42	18
Desert broom ( <i>Baccharis sarothroides</i> )	38	3	8	4

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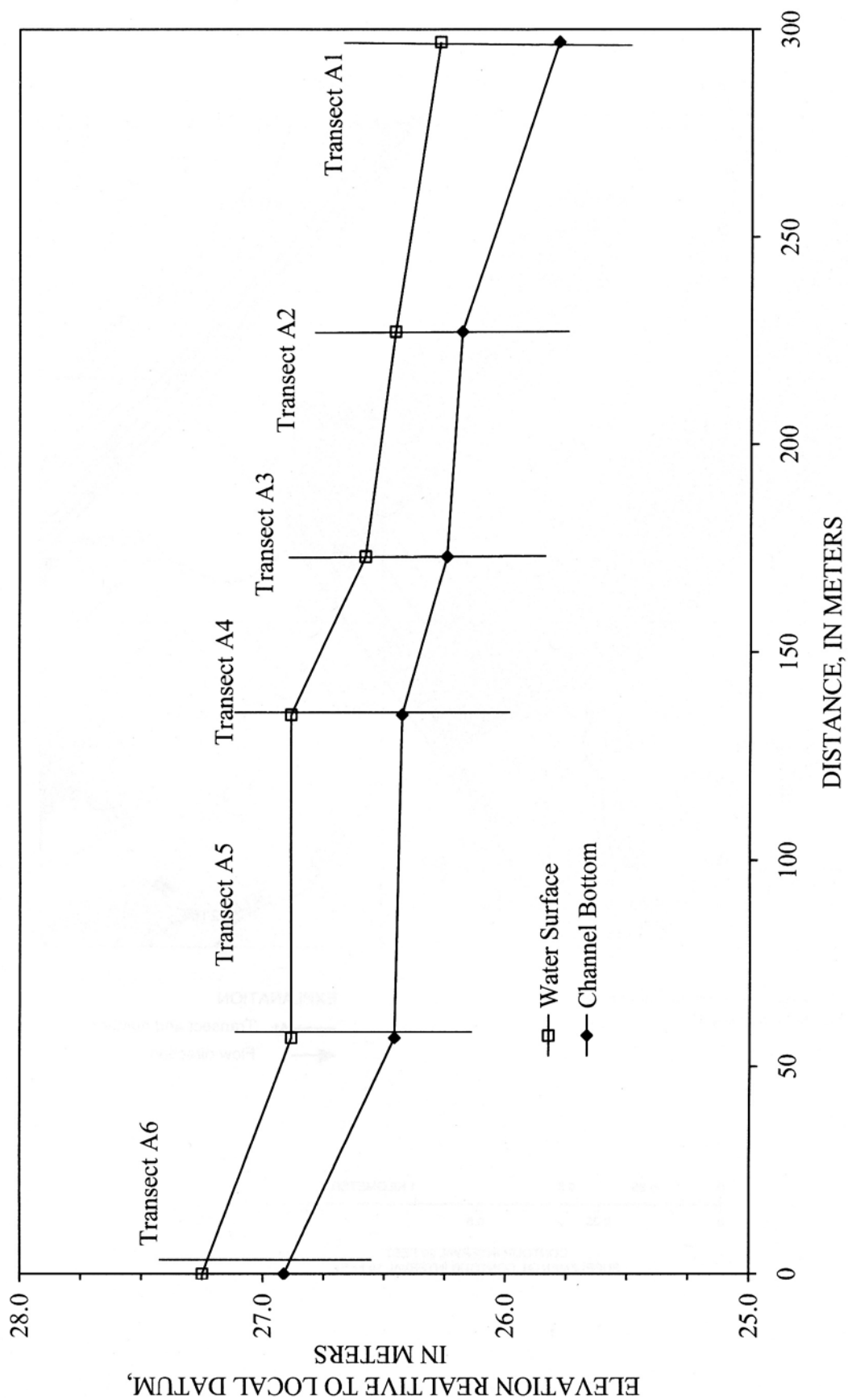
**Santa Cruz River at Cortaro, Arizona**  
**(USGS station number: 09486500)**

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**Figure 39.** Location of transects 1–6, reach A, Santa Cruz River at Cortaro, Arizona.



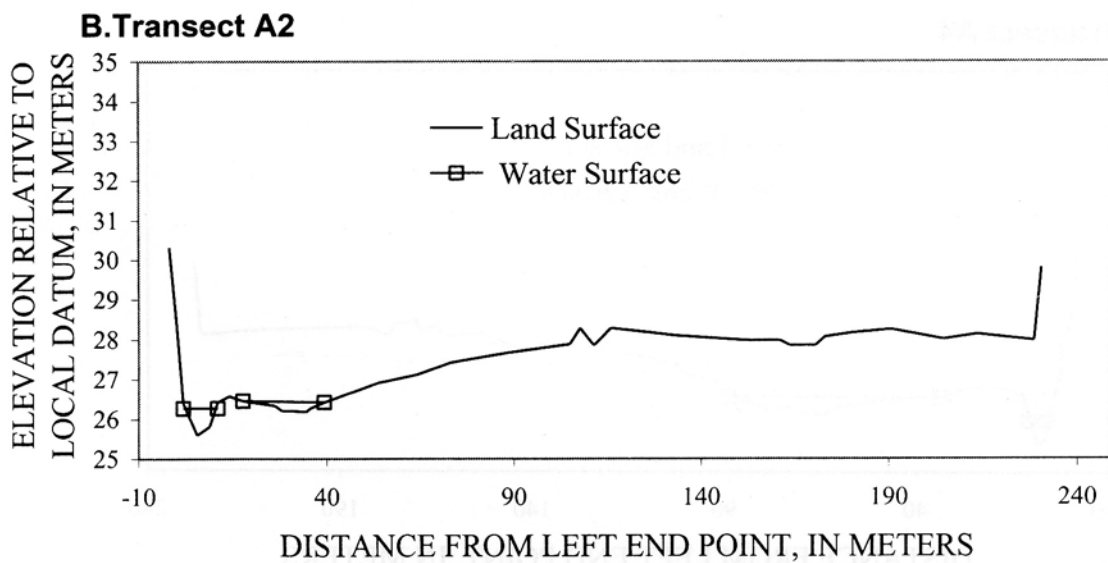
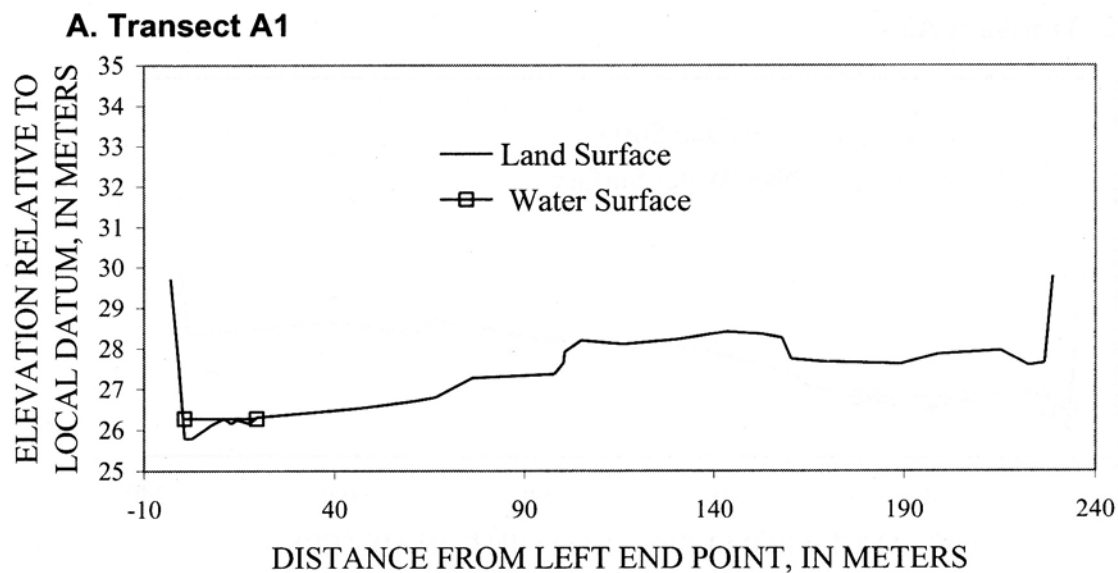


**Figure 40.** Longitudinal profile, reach A, Santa Cruz River at Cortaro, Arizona, January 26, 1998. Local elevation is the zero point of the reference gage at streamflow-gaging station, Santa Cruz River at Cortaro, Arizona (09486500).

**Table 35.** Cross-sectional survey data for reach A, Santa Cruz River at Cortaro, Arizona, January 26, 1998

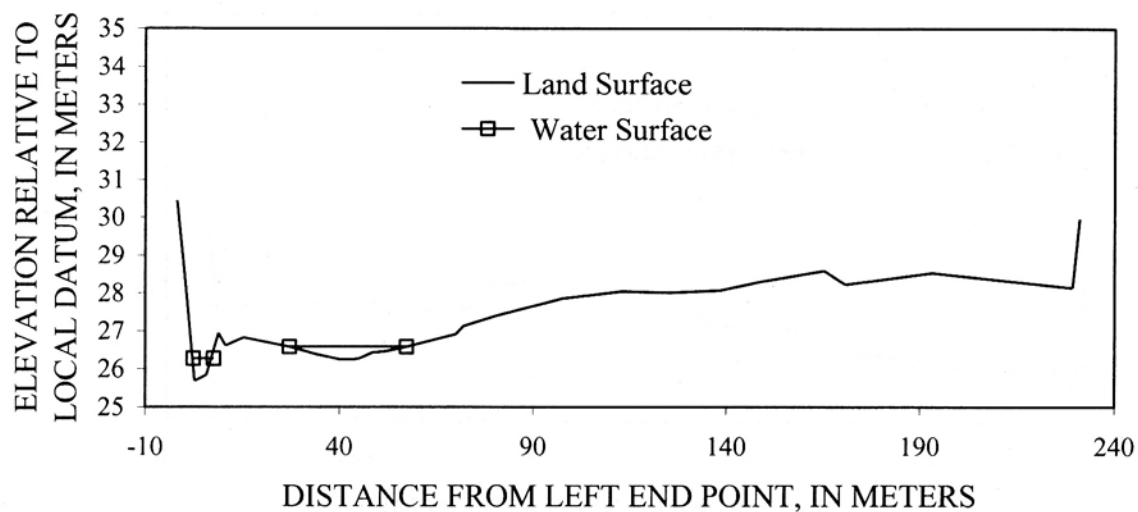
[All values are in meters. Distance is from left end point]

Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
-3.0	29.7	-1.8	30.3	-1.8	30.4	-1.8	30.4	0.0	29.4	2.1	31.7
-0.9	27.6	0.0	28.5	0.0	28.6	0.0	28.6	7.0	29.0	4.0	29.6
0.6	25.8	1.8	26.4	2.7	25.7	2.4	28.4	16.8	28.6	6.7	29.6
2.4	25.8	5.5	25.6	5.8	25.8	2.7	27.4	18.3	26.3	7.9	28.6
7.6	26.1	8.8	25.8	8.8	26.9	4.9	26.7	19.5	26.0	11.3	28.8
11.0	26.3	11.0	26.4	10.7	26.6	6.4	25.8	23.2	26.3	14.0	29.0
12.8	26.2	14.0	26.6	15.2	26.8	8.2	25.7	24.4	27.0	18.9	29.3
14.3	26.2	17.7	26.5	27.1	26.6	12.5	27.0	30.5	27.2	20.7	29.1
17.7	26.2	26.2	26.3	33.5	26.4	18.3	27.1	42.7	27.3	26.8	29.3
19.5	26.3	28.0	26.2	40.2	26.2	26.8	27.1	54.3	27.3	28.0	28.3
30.5	26.4	30.5	26.2	43.3	26.2	33.8	26.9	58.8	27.1	32.6	27.7
45.7	26.5	34.4	26.2	45.1	26.3	36.6	26.9	59.7	26.9	36.6	27.6
61.0	26.7	35.7	26.3	48.5	26.4	43.0	26.8	62.2	26.8	39.6	27.9
66.4	26.8	39.3	26.4	51.8	26.5	46.6	26.8	63.4	26.9	41.1	27.6
76.2	27.3	53.6	26.9	57.3	26.6	51.5	26.8	64.6	26.8	46.3	27.6
97.8	27.4	64.0	27.1	70.1	26.9	60.4	26.6	67.1	26.8	47.5	26.4
100.3	27.6	73.2	27.4	71.9	27.1	64.3	26.4	68.0	26.7	51.8	26.6
100.6	27.9	88.4	27.7	80.5	27.4	68.3	26.5	72.8	26.8	53.9	26.5
104.9	28.2	104.9	27.9	97.5	27.9	72.8	26.6	79.2	26.7	54.3	26.7
115.8	28.1	107.6	28.3	112.8	28.0	75.6	26.5	82.6	26.5	55.2	27.3
130.5	28.2	111.3	27.9	124.4	28.0	77.4	26.5	85.3	26.5	62.2	27.4
143.3	28.4	115.8	28.3	138.4	28.1	79.6	26.6	89.3	26.5	65.2	27.8
152.4	28.3	132.9	28.1	149.4	28.3	81.7	26.7	93.6	26.5	73.2	27.9
157.9	28.3	152.4	28.0	165.2	28.6	89.0	26.9	99.7	26.7	76.2	27.6
160.3	27.7	160.9	28.0	170.7	28.2	92.4	27.3	106.1	26.9	88.4	27.6
167.6	27.7	163.4	27.9	192.9	28.5	100.3	27.4	108.8	27.3	100.6	27.4
189.0	27.6	170.4	27.9	229.2	28.1	102.4	27.7	116.1	27.4	104.2	27.2
198.7	27.9	172.8	28.1	231.0	30.0	112.8	27.9	118.3	27.7	108.5	27.0
215.2	28.0	179.8	28.2			137.2	28.2	132.6	28.0	110.6	27.2
222.5	27.6	190.2	28.3			139.0	28.0			112.8	27.2
226.8	27.6	204.2	28.0			146.3	28.2			114.9	27.1
228.9	29.8	213.1	28.1			152.4	28.4			115.8	27.2
		228.3	28.0			163.1	28.3			117.0	27.1
		230.1	29.8			164.6	28.6			118.6	27.1
						169.5	28.5			121.9	27.0
						170.1	28.7			123.7	26.9
						176.2	28.7			127.4	27.0
						177.1	28.4			130.5	26.9
						182.9	28.6			136.6	27.2
						204.2	28.5			137.2	27.3
						216.4	28.5			140.8	27.2
						226.2	28.4			146.3	27.1
						228.0	30.2			148.1	27.0
										150.3	27.2
										162.2	26.9
										173.4	27.8
										178.0	28.8



**Figure 41A–F.** Cross sections of channel, reach A, Santa Cruz River at Cortaro, Arizona, January 26, 1998. A, Transect A1. B, Transect A2. C, Transect A3. D, Transect A4. E, Transect A5. F, Transect A6. Local datum established as the zero point of the reference gage at streamflow-gaging station, Santa Cruz River at Cortaro, Arizona (09486500).

### C. Transect A3



### D. Transect A4

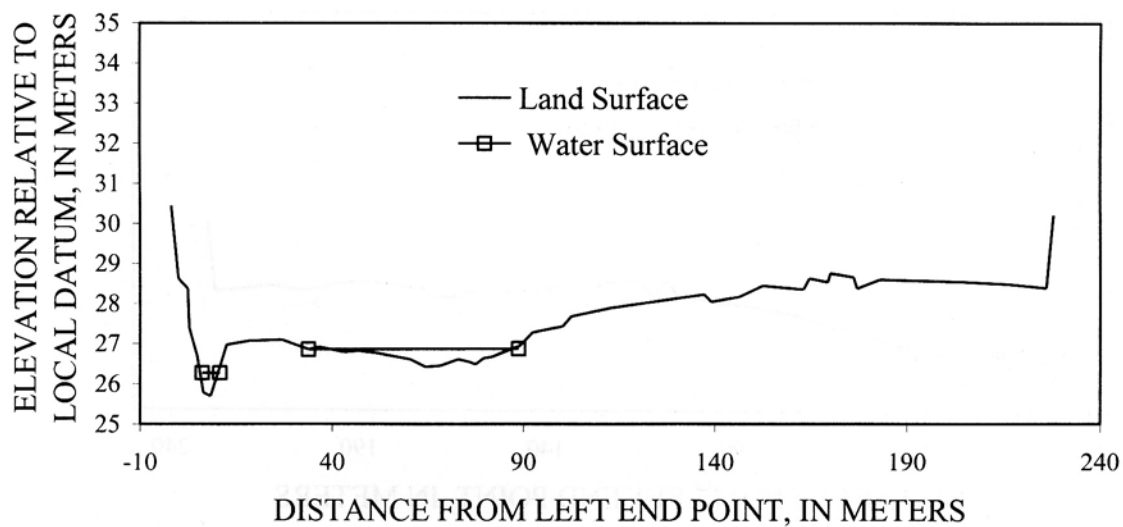
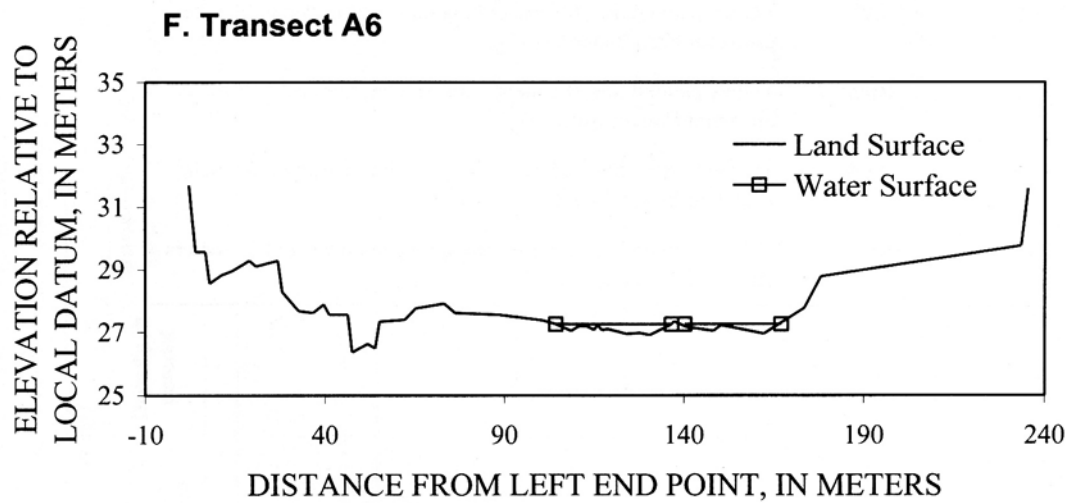
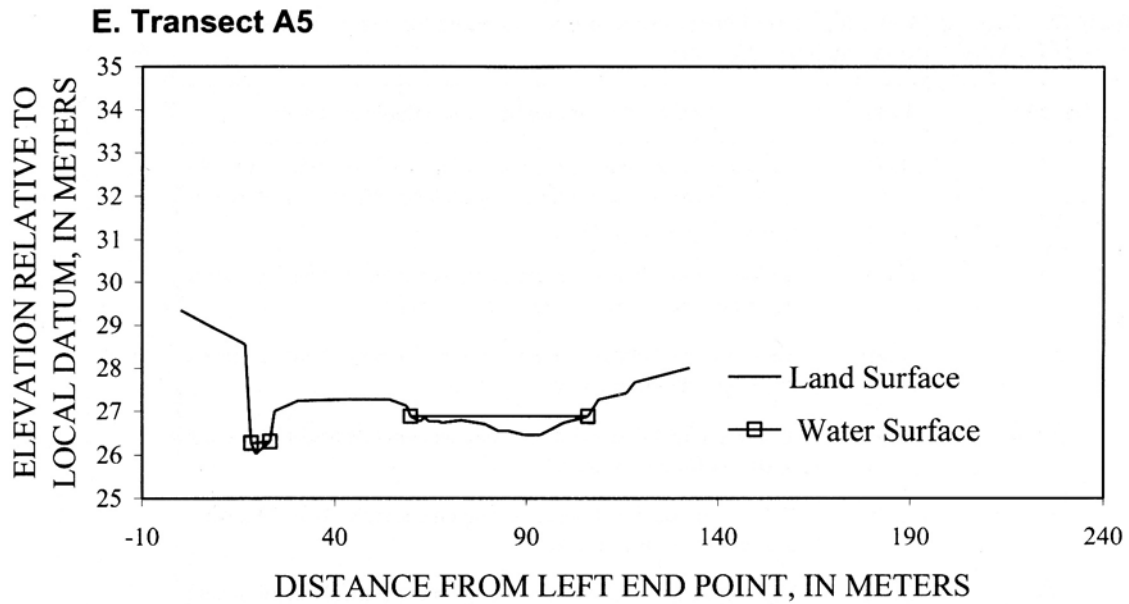


Figure 41A–F. Continued.



**Figure 41A–F.** Continued.

**Table 36.** Description and location of semipermanent monuments for reach A, Santa Cruz River at Cortaro, Arizona, January 26, 1996

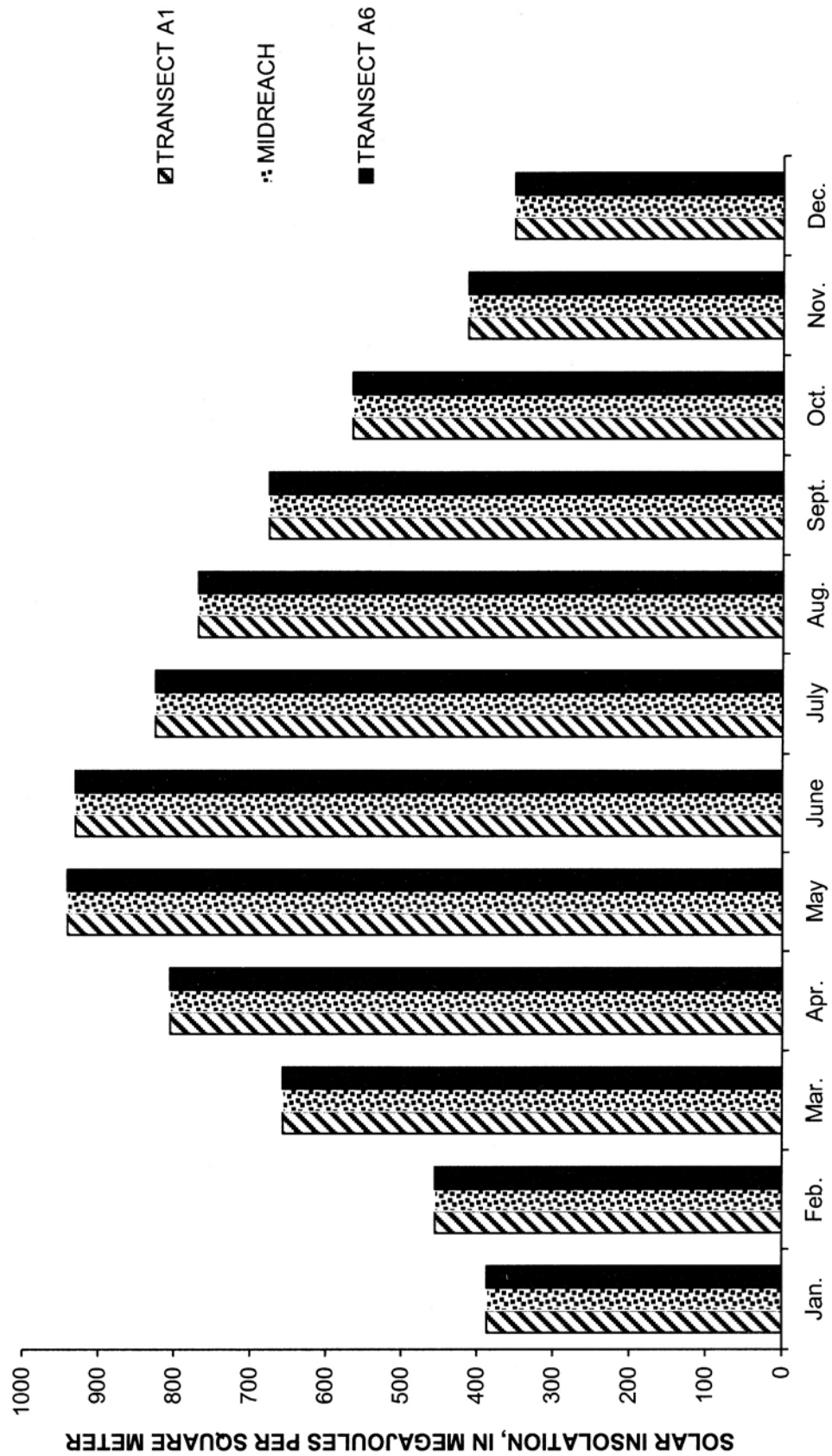
Transect	Type	Description of location and reference marks
A1	Left	Yellow painted line, 0.5 meter long on concrete about 18 meters upstream from tributary mouth on left bank. Reference-mark 1 is at gaging station.
A1	Right	Yellow painted line, 0.5 meter long on concrete about 18 meters upstream from tributary mouth on left bank.
A2	Left	Yellow painted line, 0.5 meter long on concrete about 70 meters upstream from transect A1.
A2	Right	Yellow painted line, 0.5 meter long on concrete about 70 meters upstream from transect A1.
A3	Left	Yellow painted line, 0.5 meter long on concrete about 54 meters upstream from transect A2.
A3	Right	Yellow painted line, 0.5 meter long on concrete about 54 meters upstream from transect A2.
A4	Left	Yellow painted line, 0.5 meter long on concrete about 38 meters upstream from transect A3.
A4	Right	Yellow painted line, 0.5 meter long on concrete about 38 meters upstream from transect A3.
A5	Left	Yellow painted line, 0.5 meter long on concrete about 78 meters upstream from transect A4.
A5	Right	Yellow painted line, 0.5 meter long on concrete about 78 meters upstream from transect A4.
A6	Left	Yellow painted line, 0.5 meter long on concrete about 57 meters upstream from transect A5.
A6	Right	Yellow painted line, 0.5 meter long on concrete about 57 meters upstream from transect A5.

**Table 37.** Habitat characteristics of reach A, Santa Cruz River at Cortaro, Arizona, January 23, 1996

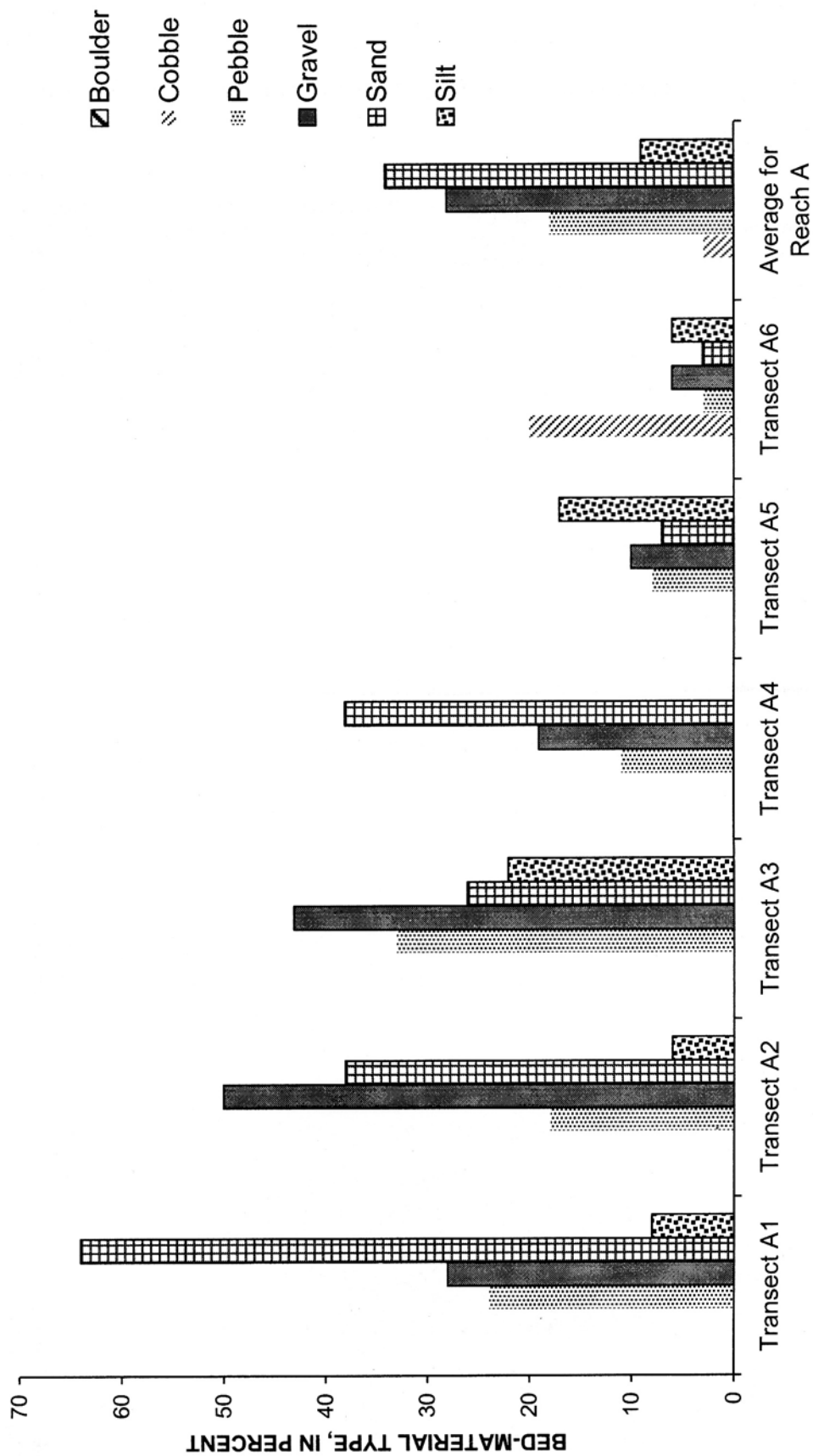
[Embeddedness categories: 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. NA, not applicable]

Width of wetted channel, in meters	Aspect, in degrees	Canopy		Velocity			Substrate		
		Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Run)									
21.5	310	166	0	7.1	<sup>1</sup> 0.34	0.72	Gravel	Sand	5
				3.5	.30	.54	Gravel	Sand	5
				14.0	.15	.45	Gravel	Sand	5
Transect 2 (Run)									
19.5	304	164	0	5.4	<sup>1</sup> .24	.81	Gravel	Sand	5
				10.0	.24	.59	Gravel	Sand	5
				15.0	.15	.73	Gravel	Sand	5
Transect 3 (Run)									
9.8	310	155	0	.4	.4	.49	Gravel	Sand	4
				3.4	<sup>1</sup> .37	.27	Gravel	Sand	4
				6.4	.34	.75	Gravel	Sand	4
Transect 4 (Riffle)									
7.7	312	151	0	.9	<sup>1</sup> .55	1.07	Gravel	NA	5
				3.0	.52	.95	Gravel	NA	5
				5.3	.18	.94	Gravel	Sand	4
Transect 5 (Riffle)									
7.8	276	170	3	6.6	<sup>1</sup> .64	1.05	Gravel	Sand	4
				4.4	.27	.84	Gravel	Sand	4
				2.2	.12	.45	Gravel	Sand	3
Transect 6 (Riffle)									
10.5	274	173	0	4.1	<sup>1</sup> .27	1.19	Gravel	Sand	5
				6.2	.21	1.16	Gravel	Sand	4
				7.3	.18	.86	Gravel	Sand	4

<sup>1</sup>Thalweg.



**Figure 42.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, Santa Cruz River at Cortaro, Arizona, based on measurements made January 23, 1996.



**Figure 43.** Bed-material types at transects 1–6 and average for reach A, Santa Cruz River at Cortaro, Arizona, January 23, 1996.



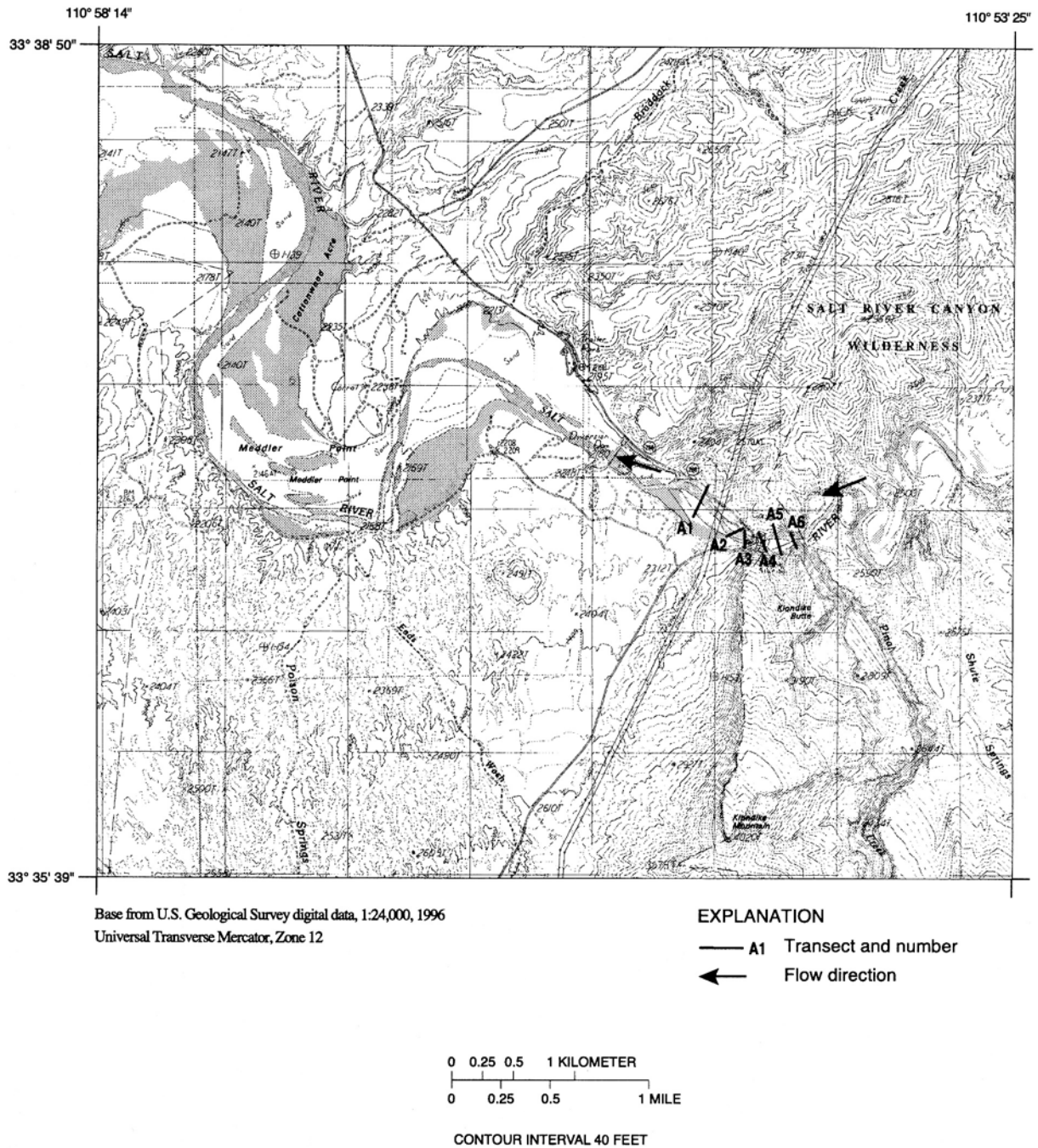
**Table 38.** Density and dominance of woody vegetation for reach A, Santa Cruz River at Cortaro, Arizona, January 23, 1996  
 [Length of reach, 297 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Tamarisk ( <i>Tamarix sp.</i> )	4	2	8	40
Willow ( <i>Salix sp.</i> )	3	2	25	60

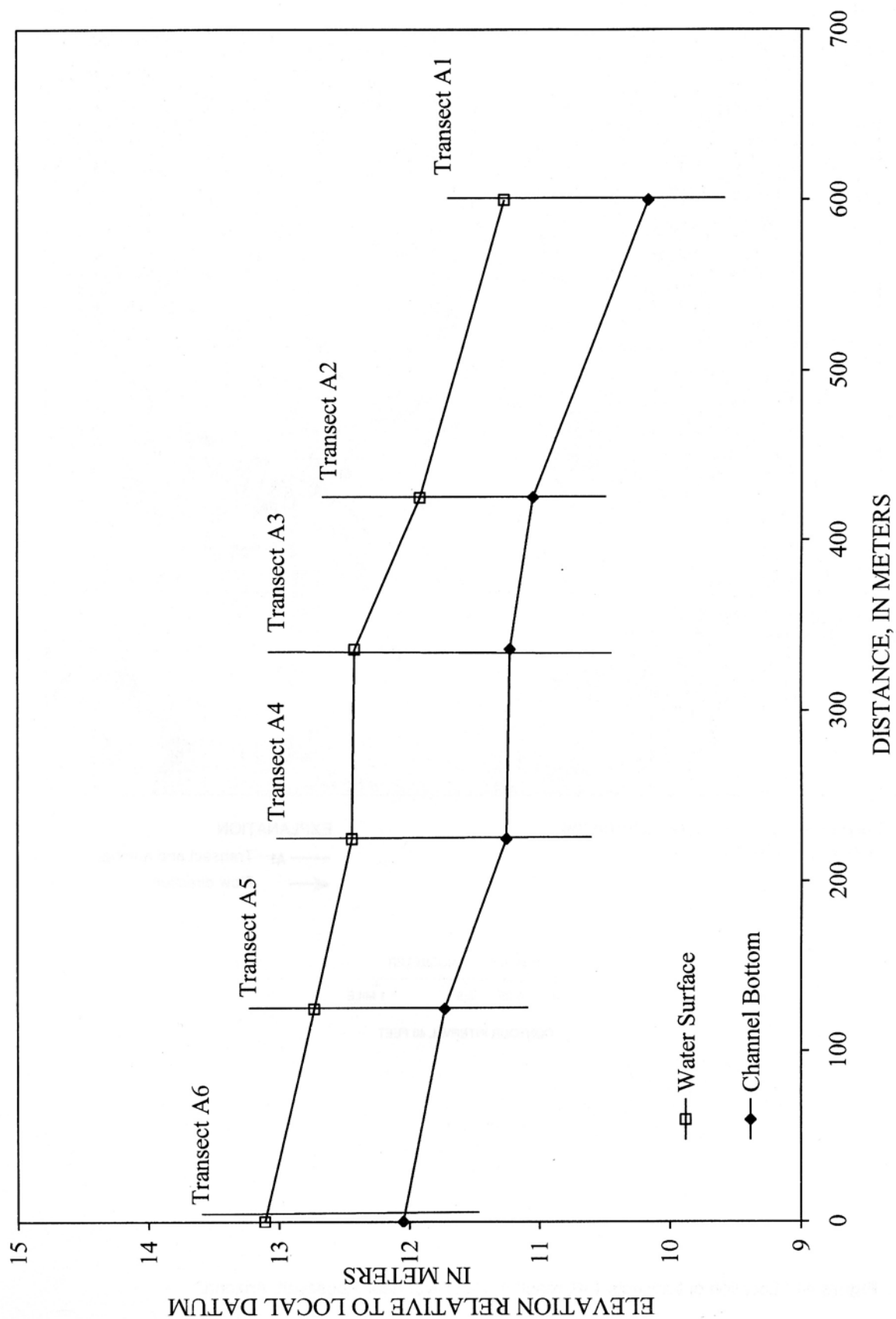
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**Salt River near Roosevelt, Arizona**  
**(USGS station number: 09498500)**

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**Figure 44.** Location of transects 1–6, reach A, Salt River near Roosevelt, Arizona.

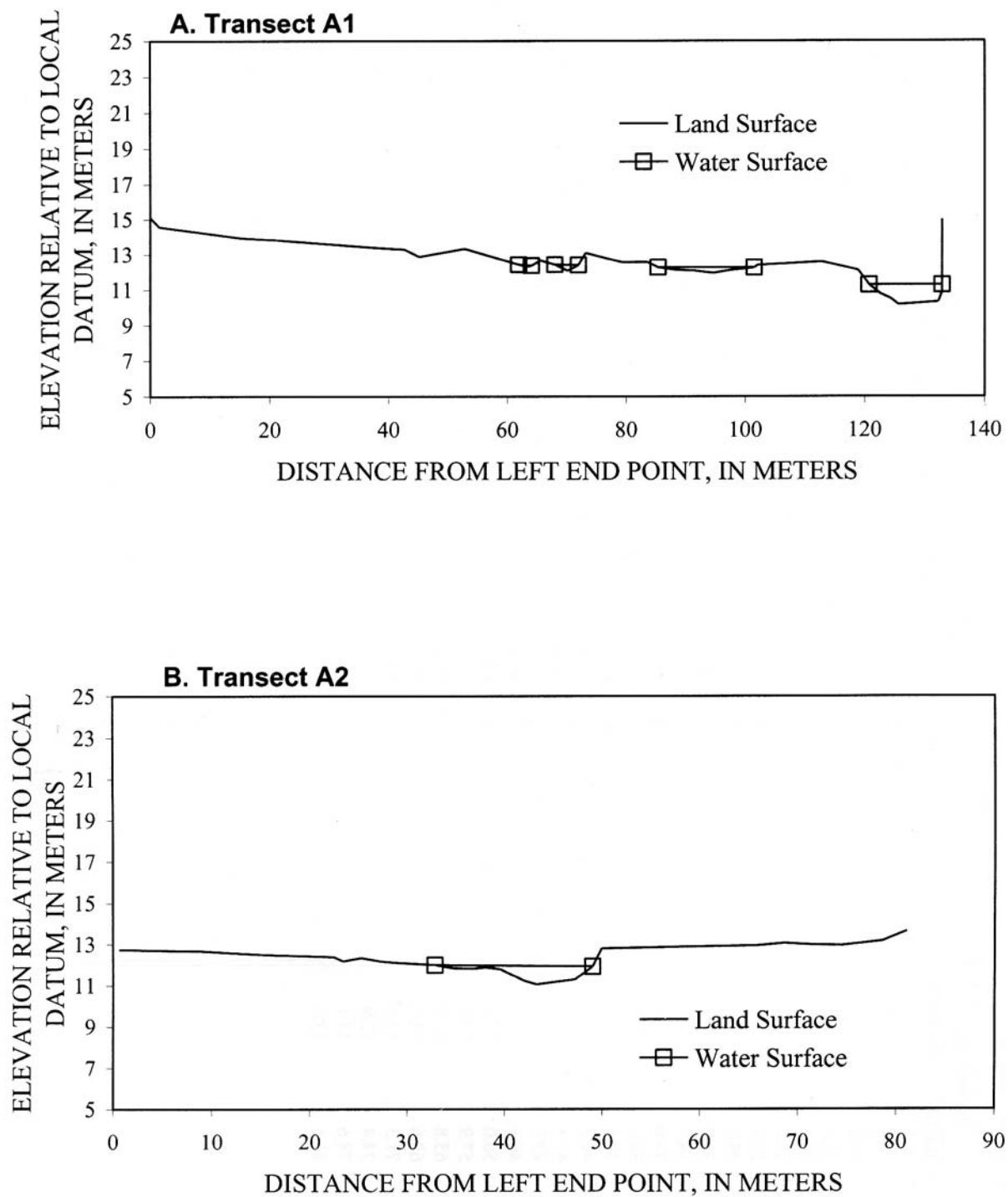


**Figure 45.** Longitudinal profile, reach A, Salt River near Roosevelt, Arizona, July 27 and 28, 1998. Local datum established using arbitrary elevation.

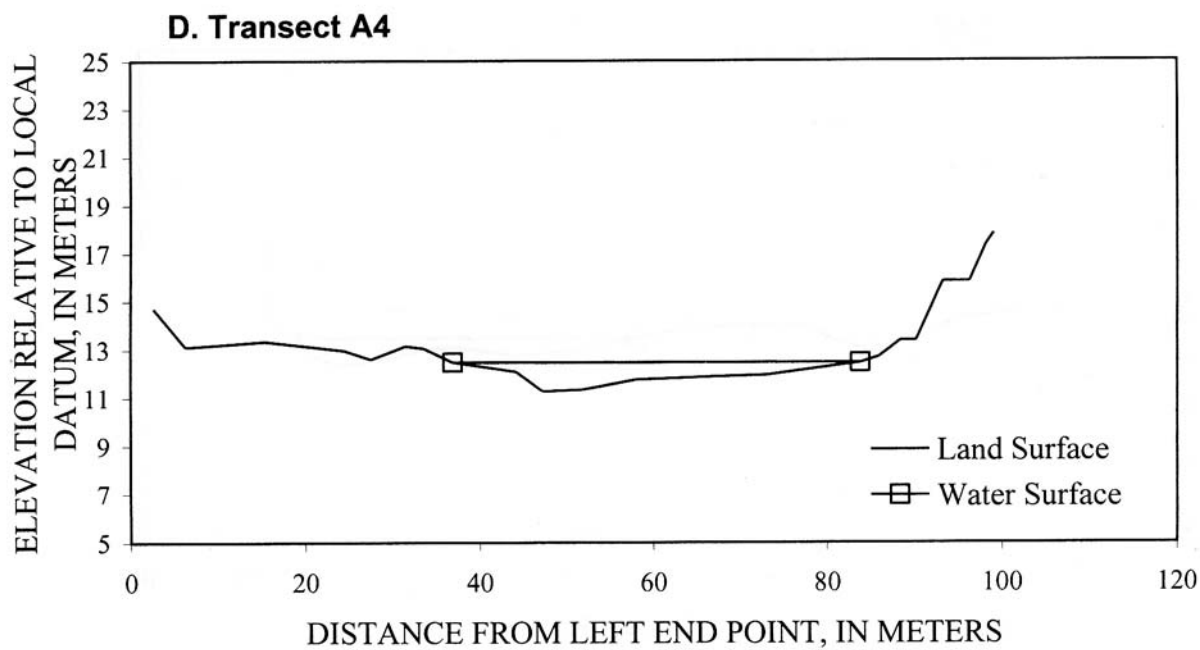
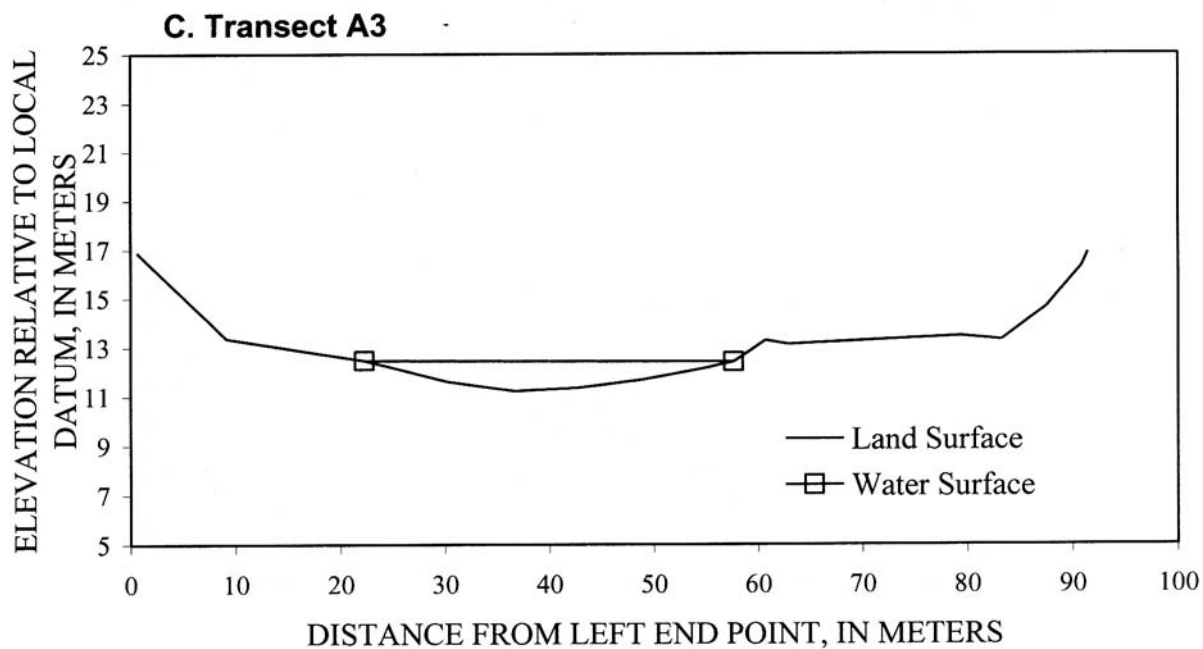
**Table 39.** Cross-sectional survey data for reach A, Salt River near Roosevelt, Arizona, July 27 and 28, 1998

[All values are in meters. Distance is from left end point]

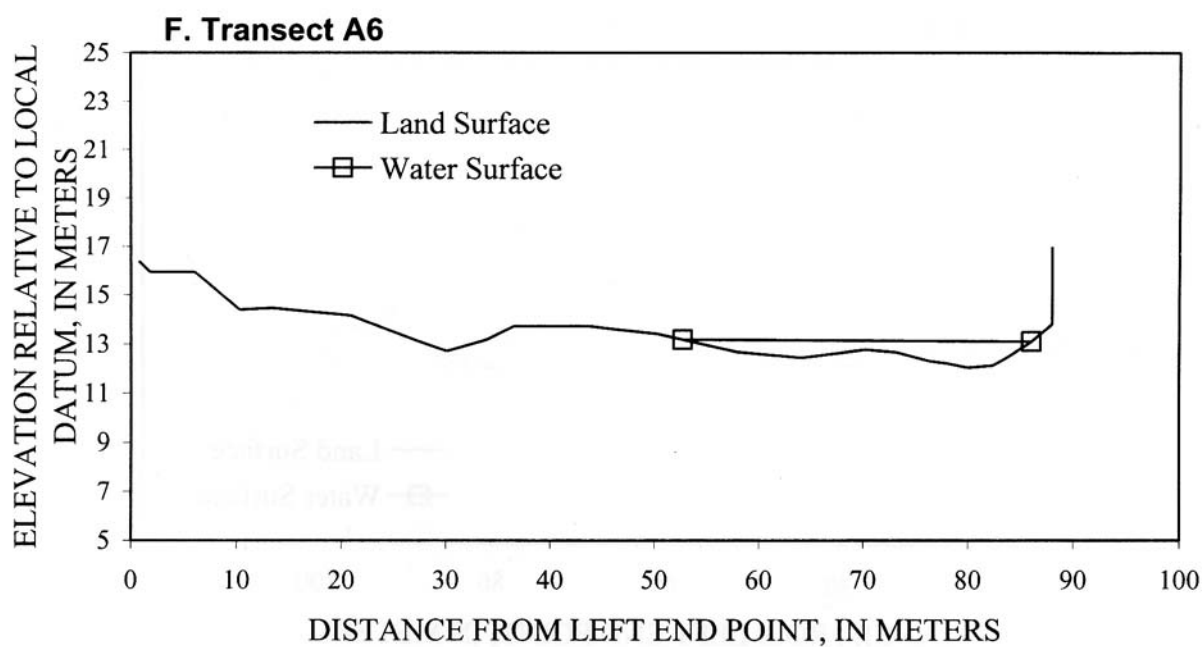
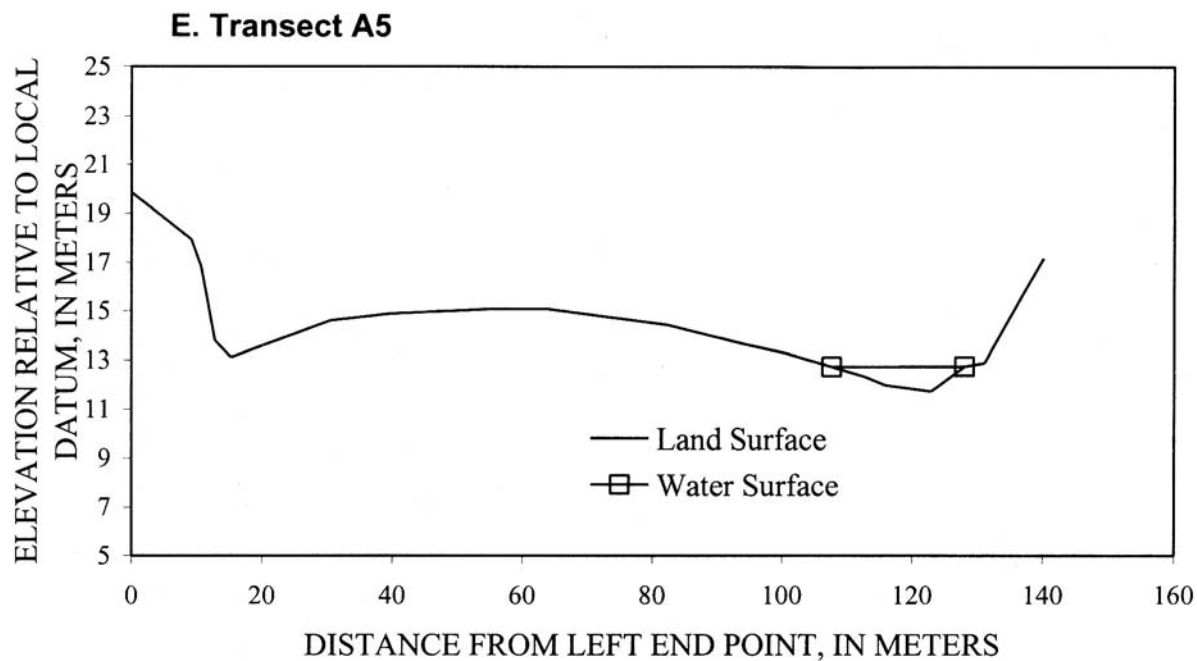
Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
0.0	15.1	0.6	12.7	0.6	16.9	2.6	14.7	0.0	19.9	87.9	17.0
1.5	14.6	9.1	12.7	9.1	13.4	6.2	13.1	9.1	18.0	87.9	13.8
15.2	13.9	15.2	12.5	22.3	12.5	15.2	13.4	10.7	16.8	86.0	13.1
21.3	13.8	22.6	12.4	30.2	11.6	24.4	13.0	12.8	13.8	83.5	12.4
36.6	13.4	23.5	12.2	36.6	11.2	27.4	12.6	15.2	13.1	82.3	12.1
42.7	13.3	25.3	12.3	42.7	11.4	31.4	13.2	30.5	14.6	79.9	12.0
45.1	12.9	27.4	12.1	48.8	11.7	33.5	13.1	39.6	14.9	78.0	12.2
52.7	13.3	29.3	12.1	54.9	12.1	36.9	12.5	54.9	15.1	76.2	12.3
61.9	12.4	32.9	12.0	57.6	12.4	44.2	12.1	64.0	15.1	73.2	12.7
63.4	12.3	34.7	11.8	60.7	13.3	47.2	11.3	82.3	14.4	70.1	12.8
64.0	12.4	36.6	11.8	62.8	13.1	51.8	11.3	94.5	13.6	64.0	12.5
65.5	12.7	38.1	11.9	79.2	13.5	57.9	11.7	100.6	13.3	57.9	12.7
68.0	12.4	39.6	11.8	83.2	13.3	67.1	11.9	107.6	12.7	52.7	13.2
70.1	12.1	42.1	11.2	87.5	14.6	73.2	11.9	112.8	12.3	50.3	13.4
71.9	12.4	43.3	11.0	90.8	16.3	83.8	12.4	115.8	12.0	46.3	13.6
73.2	13.1	47.2	11.3	91.4	16.9	86.0	12.7	122.8	11.7	43.9	13.7
76.2	12.8	49.1	11.9			88.4	13.4	128.0	12.7	36.6	13.7
79.2	12.6	50.0	12.8			90.2	13.4	131.1	12.9	34.0	13.2
83.5	12.6	57.9	12.9			93.3	15.8	140.1	17.2	30.2	12.7
85.3	12.3	65.8	12.9			96.3	15.8			27.1	13.2
88.4	12.1	68.6	13.0			98.1	17.3			21.0	14.2
91.4	12.1	71.3	13.0			99.1	17.8			21.0	14.2
94.5	11.9	74.4	12.9							17.1	14.3
97.5	12.1	78.6	13.1							13.4	14.5
101.5	12.3	81.1	13.6							10.4	14.4
102.1	12.4									6.1	16.0
112.8	12.6									1.8	16.0
118.9	12.1									.8	16.4
120.7	11.3										
122.5	10.8										
124.4	10.5										
125.6	10.2										
132.3	10.3										
132.9	10.9										
132.9	15.0										



**Figure 46A–F.** Cross sections of channel, reach A, Salt River near Roosevelt, Arizona, July 27 and 28, 1998. A, Transect A1. B, Transect A2. C, Transect A3. D, Transect A4. E, Transect A5. F, Transect A6. Local datum established using arbitrary elevation.



**Figure 46A–F.** Continued.



**Figure 46A–F.** Continued.



**Table 40.** Description and location of semipermanent monuments for reach A, Salt River near Roosevelt, Arizona, July 27 and 28, 1998

Transect	Type	Description of location and reference marks
A1	Left	Rebar.
A1	Right	Rebar at base of rock cliff.
A2	Left	Rebar, 175 meters upstream from transect A1.
A2	Right	Rebar, 175 meters upstream from transect A1.
A3	Left	Lone boulder about 20 meters upstream from boat ramp.
A3	Right	Chiseled square in boulder at base of bluff about 20 meters upstream from boat ramp.
A4	Left	Chiseled square in bedrock outcrop at base of cliff, 145 meters upstream from right bank of transect A3.
A4	Right	Large eyebolt in rock, 78 meters upstream from transect A3.
A5	Left	Rebar, 100 meters upstream from transect A4.
A5	Right	Rebar, 100 meters upstream from transect A4.
A6	Left	Rebar in rock cliff, 125 meters upstream from transect A5.
A6	Right	Rebar in rock cliff, 125 meters upstream from transect A5.

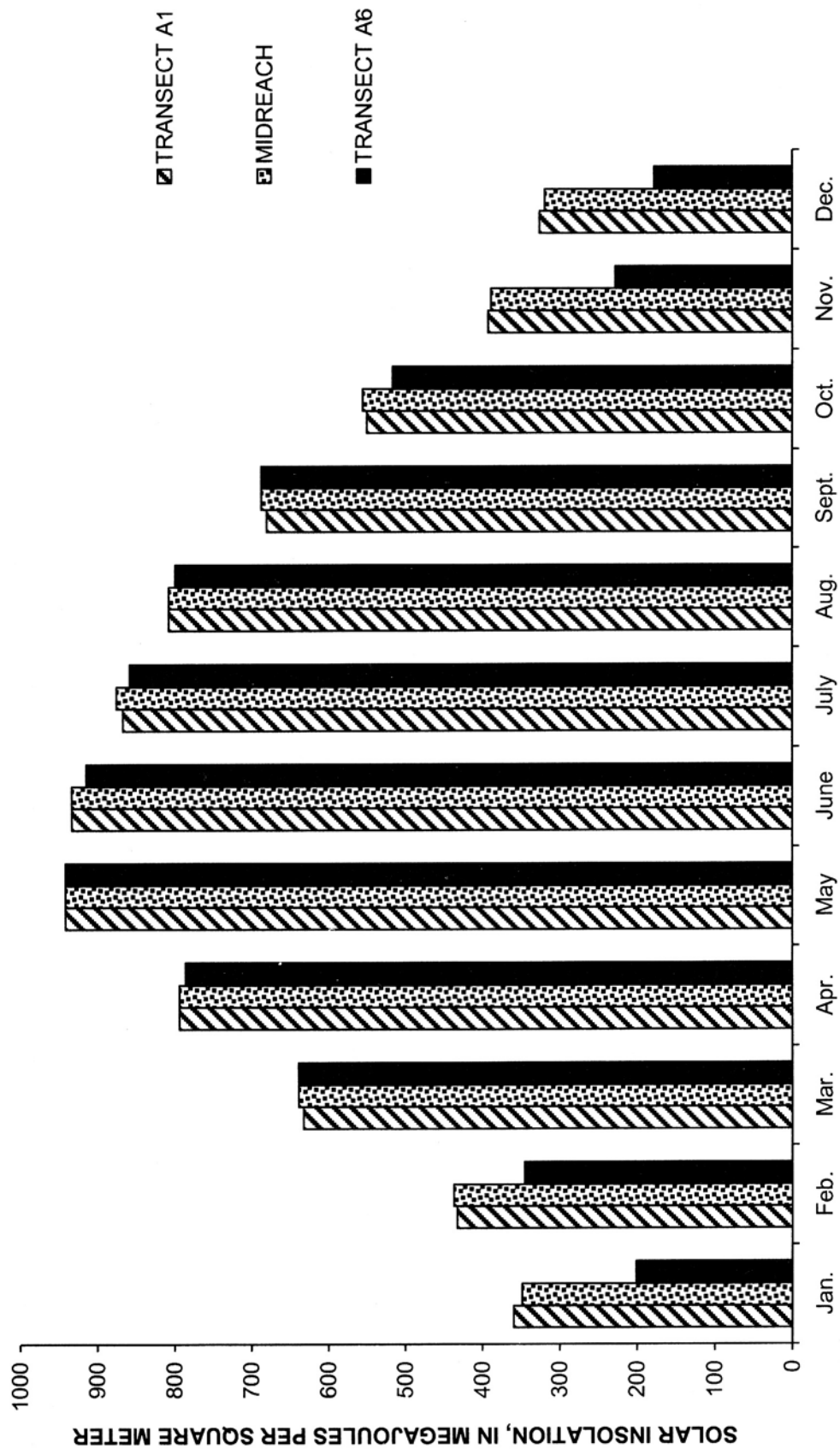
**Table 41.** Habitat characteristics of reach A, Salt River near Roosevelt, Arizona, December 13, 1995

[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment. Dashes indicate no data. NA, not applicable]

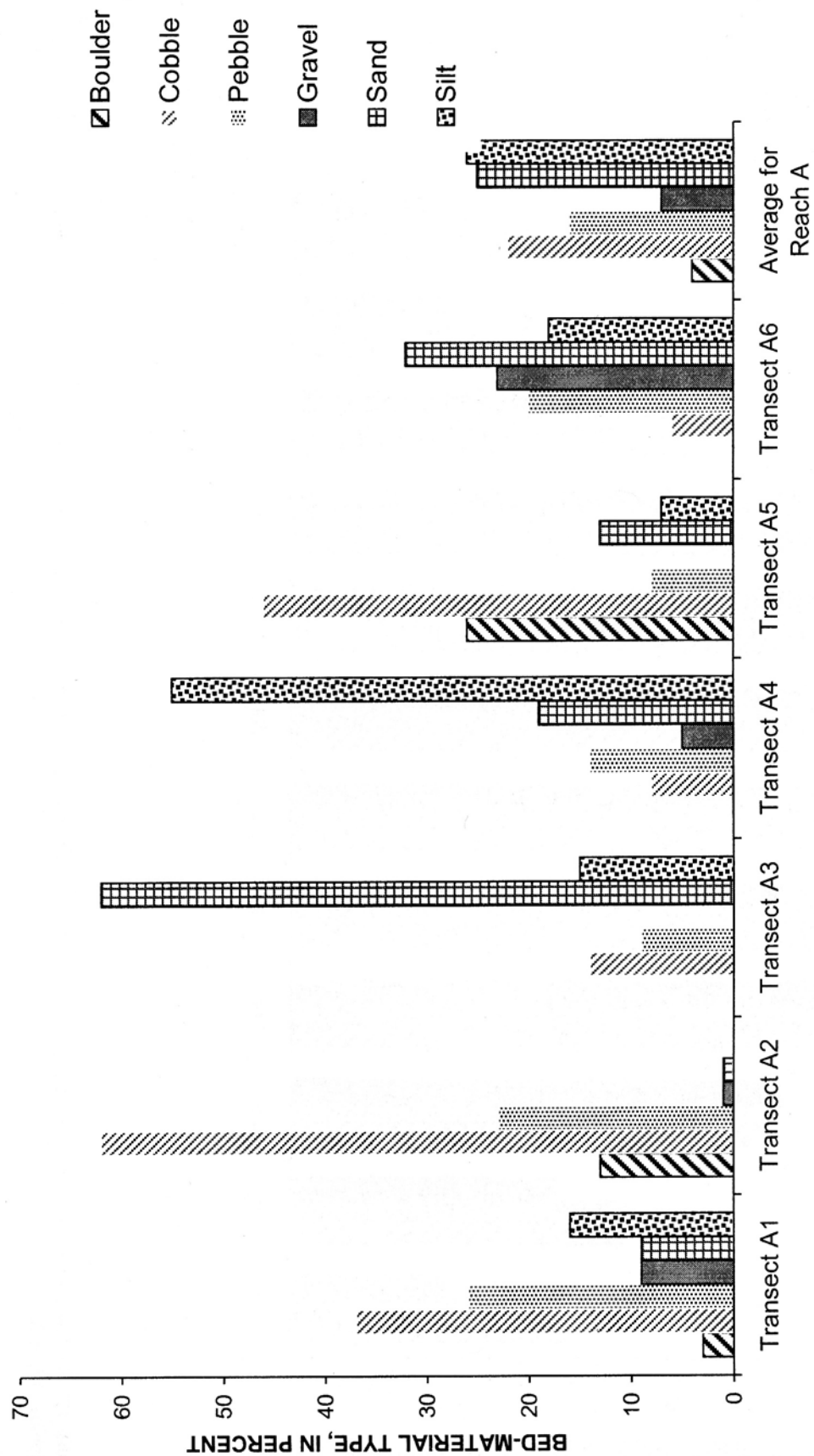
Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Run)									
61.6	320	144	26	28.0	0.43	1.55	Cobble	Gravel	3
				31.0	.40	.45	Cobble	Gravel	3
				46.0	.70	.41	Gravel	Cobble	4
				52.0	.61	.43	Cobble	Gravel	---
				61.5	<sup>1</sup> 1.04	<sup>2</sup> .01	Silt	Sand	0
Transect 2 (Riffle)									
23.0	358	158	0	1.5	.09	.12	Cobble	Gravel	3
				18.4	.30	.79	Cobble	NA	3
				22.6	<sup>1</sup> .43	1.69	Cobble	NA	---
Transect 3 (Pool)									
40.3	310	138	0	11.6	<sup>1</sup> 1.07	.22	Sand	Cobble	3
				20.0	.66	.28	Sand	NA	0
				30.0	.79	.19	Sand	NA	0
Transect 4 (Pool)									
62.0	254	155	0	12.8	<sup>1</sup> 1.00	.24	Silt	Sand	0
				30.0	.62	.25	Silt	Sand	0
				40.0	.33	.20	Silt	Sand	0
Transect 5 (Run)									
20.6	272	136	25	5.0	.52	.56	Boulder	Cobble	2
				9.5	<sup>1</sup> .98	.36	Boulder	Sand	2
				14.2	.97	.92	Boulder	Sand	2
Transect 6 (Riffle)									
55.8	302	102	12	30.6	.27	.26	Sand	Silt	0
				40.4	.27	.57	Sand	Cobble	2
				50.1	<sup>1</sup> .94	.58	Sand	Gravel	5

<sup>1</sup>Thalweg.

<sup>2</sup>Reverse flow.



**Figure 47.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, Salt River near Roosevelt, Arizona, based on measurements made December 13, 1995.



**Figure 48.** Bed-material types at transects 1–6 and average by reach A, Salt River near Roosevelt, Arizona, December 13, 1995.

**Table 42.** Density and dominance of woody vegetation for reach A, Salt River near Roosevelt, Arizona, December 13, 1995

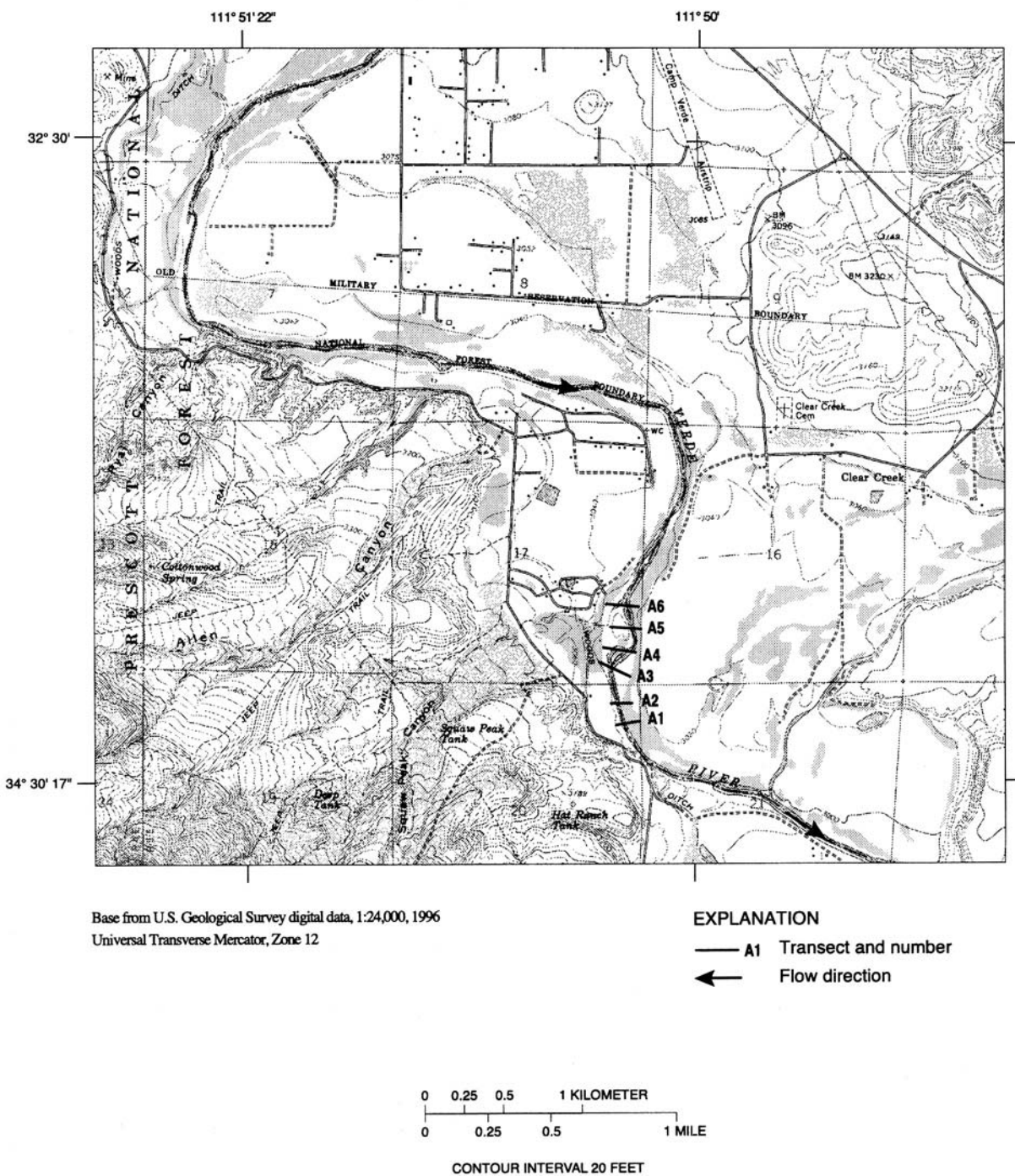
[Length of reach, 610 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Mesquite ( <i>Prosopis sp.</i> )	452	9	8	6
Tamarisk ( <i>Tamarix sp.</i> )	37	8	58	81
Willow ( <i>Salix sp.</i> )	54	2	17	12

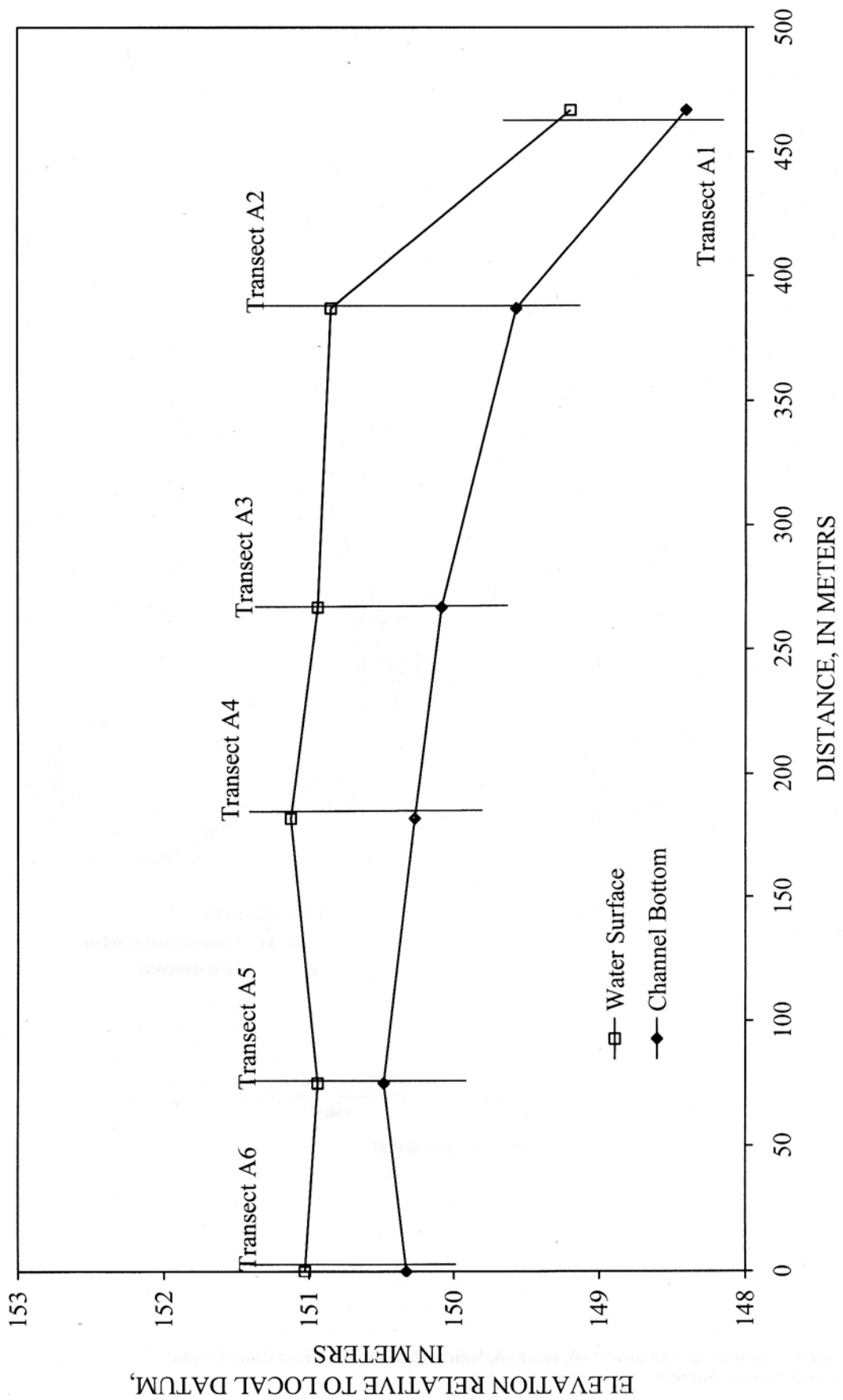
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**Verde River above West Clear Creek, near Camp Verde, Arizona**  
**(USGS station number: 09505570)**

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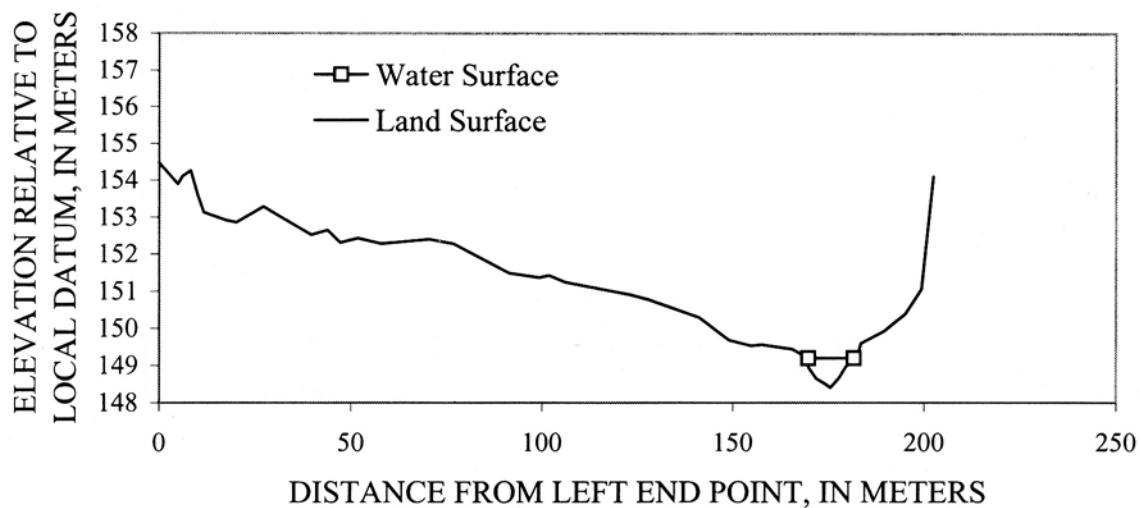


**Figure 49.** Location of transects 1–6, reach A, Verde River above West Clear Creek, near Camp Verde, Arizona.

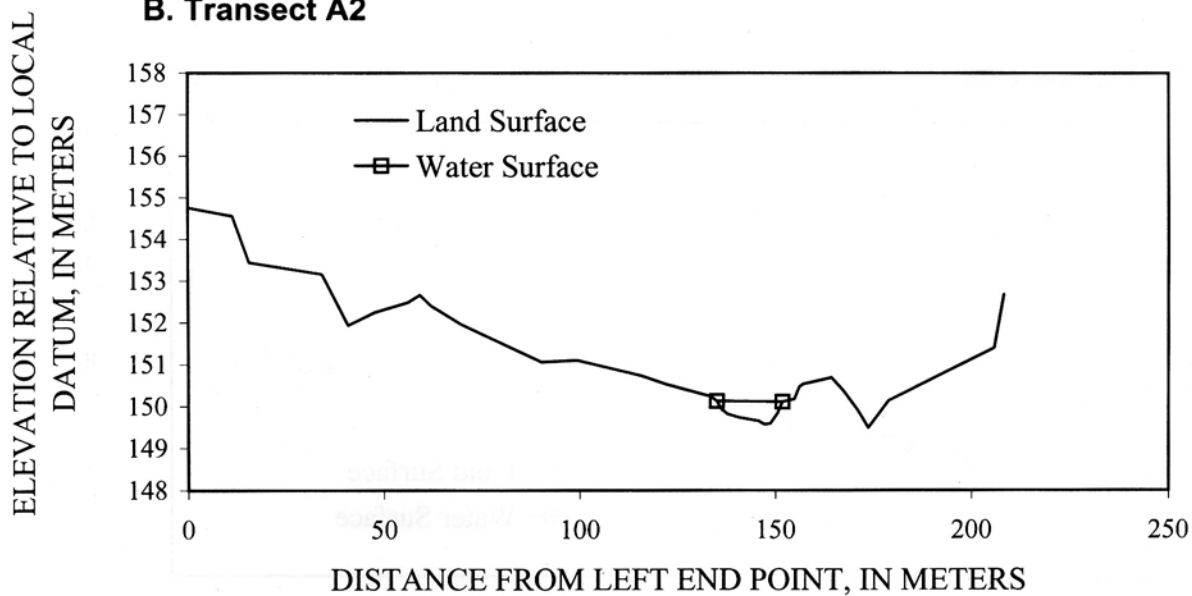


**Figure 50.** Longitudinal profile, reach A, Verde River above West Clear Creek, near Camp Verde, Arizona, December 1 and 5, 1997. Local datum established using arbitrary elevation.

### A. Transect A1



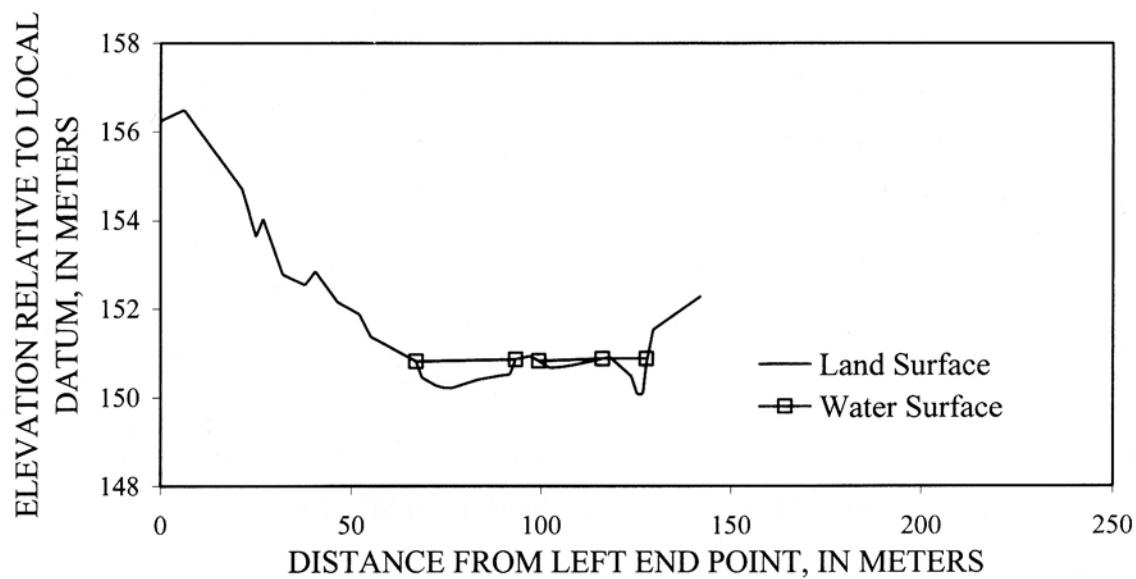
### B. Transect A2



**Figure 51A–F.** Cross sections of channel, reach A, Verde River above West Clear Creek, near Camp Verde, Arizona, December 1 and 5, 1997. *A*, Transect A1. *B*, Transect A2. *C*, Transect A3. *D*, Transect A4. *E*, Transect A5. *F*, Transect A6. Local datum established using arbitrary elevation.



### C. Transect A3



### D. Transect A4

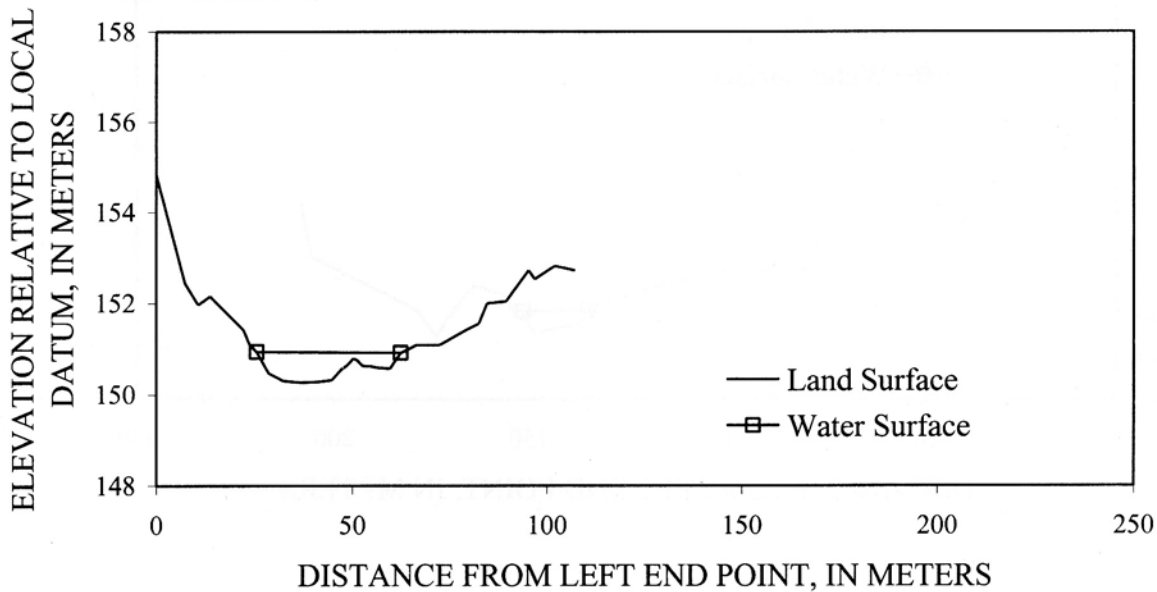
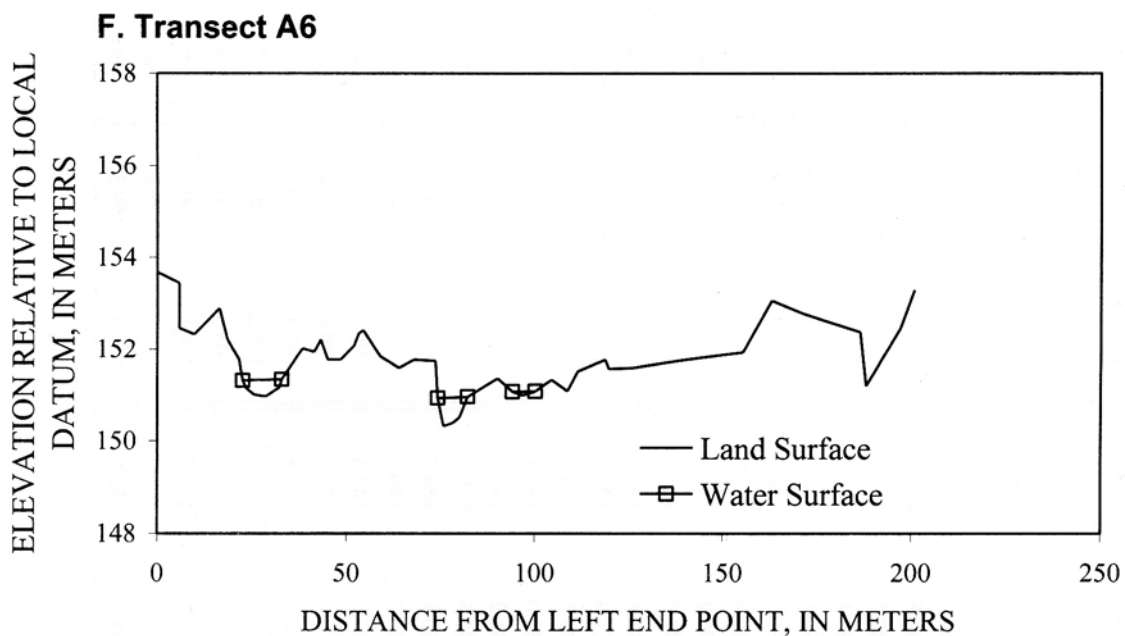
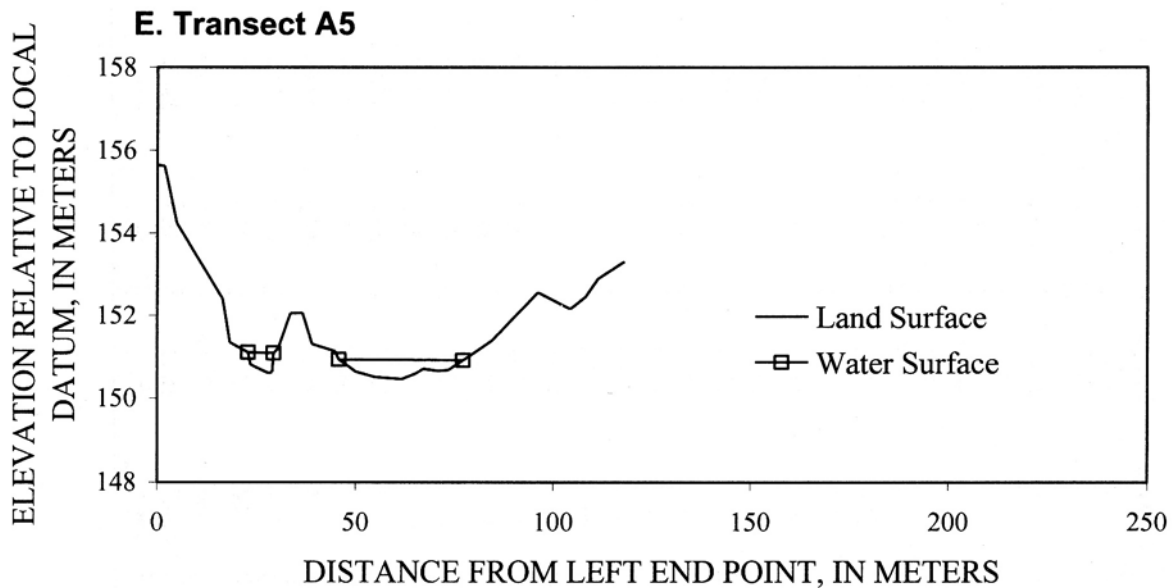


Figure 51A-F. Continued.



**Figure 51A–F.** Continued.

**Table 43.** Cross-sectional survey data for reach A, Verde River above West Clear Creek, near Camp Verde, Arizona, December 1 and 5, 1997

[All values are in meters. Distance is from left end point]

Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
0.0	154.5	0.0	155.1	0.0	156.2	0.0	154.8	0.0	155.6	0.0	153.7
4.9	153.9	0.0	154.8	6.1	156.5	7.3	152.4	1.8	155.6	5.8	153.4
6.1	154.1	11.3	154.6	21.3	154.7	10.7	152.0	4.9	154.3	5.8	152.5
8.2	154.3	15.5	153.4	25.0	153.6	13.7	152.2	16.5	152.4	9.8	152.3
10.1	153.6	34.1	153.2	26.8	154.0	22.3	151.4	18.3	151.3	16.5	152.9
11.6	153.1	40.8	151.9	32.0	152.8	23.8	151.1	22.9	151.1	18.6	152.2
17.4	152.9	47.5	152.2	37.8	152.5	25.6	150.9	23.5	150.8	21.6	151.8
20.1	152.9	56.1	152.5	40.5	152.8	28.7	150.5	25.6	150.7	22.6	151.3
27.1	153.3	59.1	152.7	46.3	152.2	32.3	150.3	28.0	150.6	23.5	151.2
39.6	152.5	61.9	152.4	52.1	151.9	36.3	150.3	29.0	150.6	25.6	151.0
43.9	152.6	69.8	152.0	55.2	151.4	41.1	150.3	29.3	151.1	28.7	151.0
47.2	152.3	90.2	151.1	58.8	151.2	44.8	150.3	30.5	151.2	31.1	151.1
51.8	152.4	99.4	151.1	67.1	150.8	47.2	150.6	33.5	152.1	32.3	151.2
57.9	152.3	115.8	150.7	68.6	150.5	48.8	150.6	36.6	152.1	32.9	151.3
70.4	152.4	121.9	150.5	72.2	150.3	50.3	150.8	39.0	151.3	38.4	152.0
76.8	152.3	133.5	150.2	74.1	150.2	51.2	150.8	44.8	151.1	41.5	151.9
91.4	151.5	135.0	150.1	76.2	150.2	52.7	150.6	45.7	150.9	43.3	152.2
99.4	151.4	136.2	149.9	83.5	150.4	54.9	150.6	50.0	150.6	45.1	151.8
101.8	151.4	137.8	149.8	89.0	150.5	56.4	150.6	54.9	150.5	48.5	151.8
106.1	151.2	140.8	149.7	91.7	150.5	59.7	150.6	61.6	150.5	52.1	152.1
123.1	150.9	145.7	149.7	93.3	150.9	62.5	150.9	65.2	150.6	53.3	152.3
127.7	150.8	147.2	149.6	96.9	150.9	66.4	151.1	67.1	150.7	54.6	152.4
141.1	150.3	148.7	149.6	99.4	150.8	72.5	151.1	70.7	150.7	59.1	151.8
149.0	149.7	150.6	149.8	102.1	150.7	79.9	151.4	73.5	150.7	64.0	151.6
154.8	149.5	151.8	150.1	105.2	150.7	82.6	151.5	77.1	150.9	68.0	151.8
157.6	149.6	154.8	150.2	108.8	150.7	84.7	152.0	84.4	151.4	73.8	151.7
165.5	149.4	156.1	150.5	116.1	150.9	89.6	152.0	96.0	152.6	74.4	150.9
169.8	149.2	157.0	150.5	118.3	150.9	95.4	152.7	104.2	152.2	75.9	150.3
169.8	149.0	164.3	150.7	123.7	150.5	96.9	152.5	108.2	152.5	78.3	150.4
171.9	148.7	167.3	150.4	125.3	150.1	102.1	152.8	111.3	152.9	80.2	150.5
174.3	148.5	171.0	149.9	126.8	150.1	107.3	152.7	118.0	153.3	82.3	151.0
175.6	148.4	173.7	149.5	127.7	150.8					90.2	151.4
177.7	148.7	178.9	150.1	129.5	151.5					94.2	151.1
179.5	149.0	205.7	151.4	142.0	152.3					96.9	151.0
181.7	149.2	208.2	152.7							100.3	151.1
182.6	149.2									104.5	151.3
183.5	149.6									108.8	151.1
189.6	149.9									111.6	151.5
195.1	150.4									118.9	151.8
199.3	151.1									119.8	151.6
202.4	154.1									126.2	151.6
										139.6	151.8
										155.4	151.9
										163.1	153.1
										171.3	152.8
										186.5	152.4
										188.1	151.2
										197.2	152.5
										200.9	153.3

**Table 44.** Description and location of semipermanent monuments for reach A, Verde River above West Clear Creek near Camp Verde, Arizona, December 1 and 5, 1997

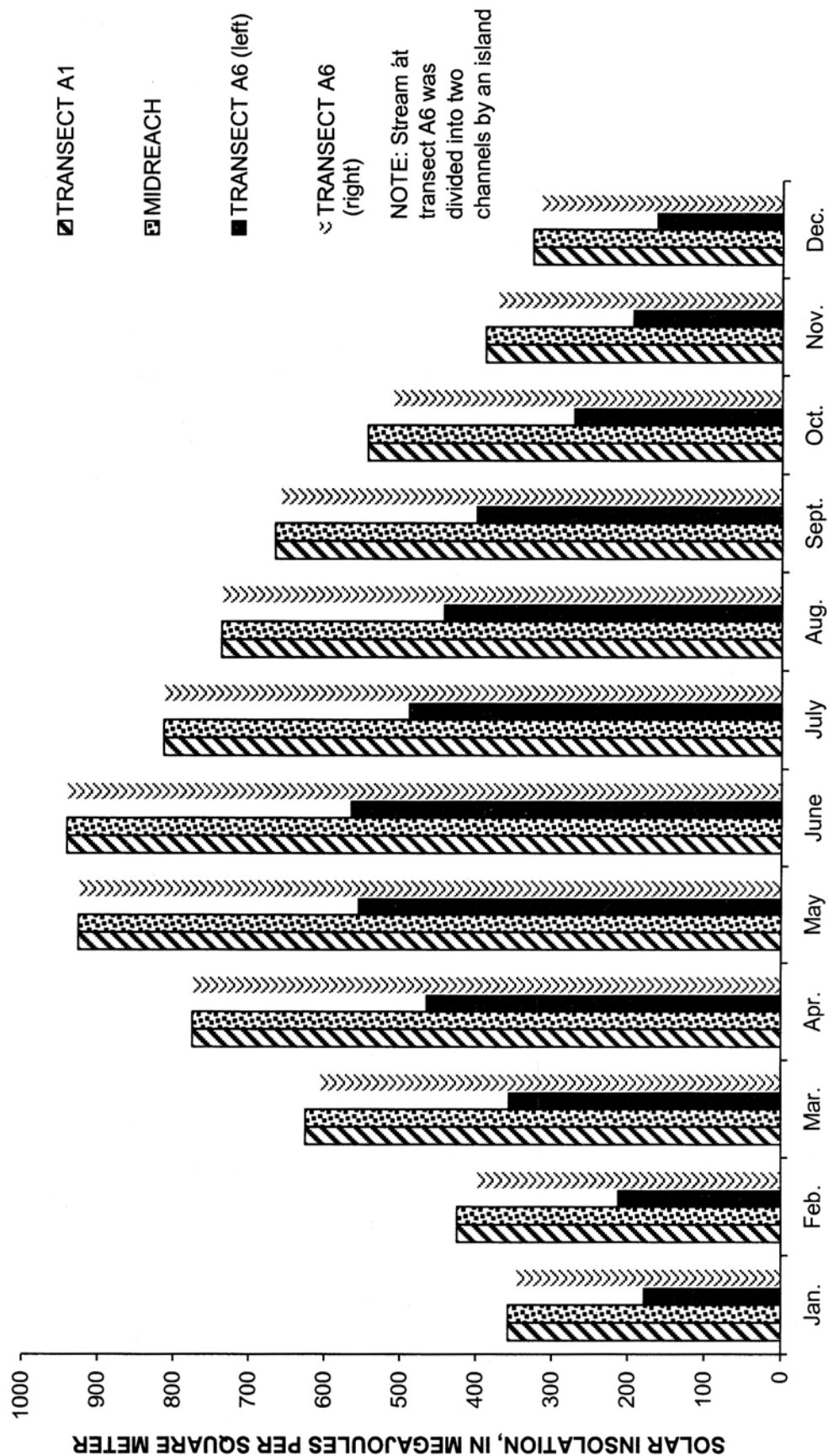
Transect	Type	Description of location and reference marks
A1	Left	Rebar. Reference-mark 1 is nail in streamward side of cottonwood tree at transect A2. Elevation is 153.21 meters local datum.
A1	Right	Rebar at foot bridge over canal at rest stop.
A2	Left	Rebar, 80 meters upstream from canal bridge in bedrock slope.
A2	Right	Rebar, 80 meters upstream from transect A1.
A3	Left	Rebar about 25 meters upstream from two railroad ties in fence line.
A3	Right	Rebar, 120 meters upstream from transect A2.
A4	Left	Rebar, 85 meters upstream from transect A3.
A4	Right	Rebar, 85 meters upstream from transect A3.
A5	Left	Rebar, 107 meters upstream from transect A4.
A5	Right	Rebar, 107 meters upstream from transect A4.
A6	Left	Rebar, 75 meters upstream from transect A5.
A6	Right	Rebar, 75 meters upstream from transect A5.

**Table 45.** Habitat characteristics of reach A, Verde River above West Clear Creek, near Camp Verde, Arizona, October 24, 1995

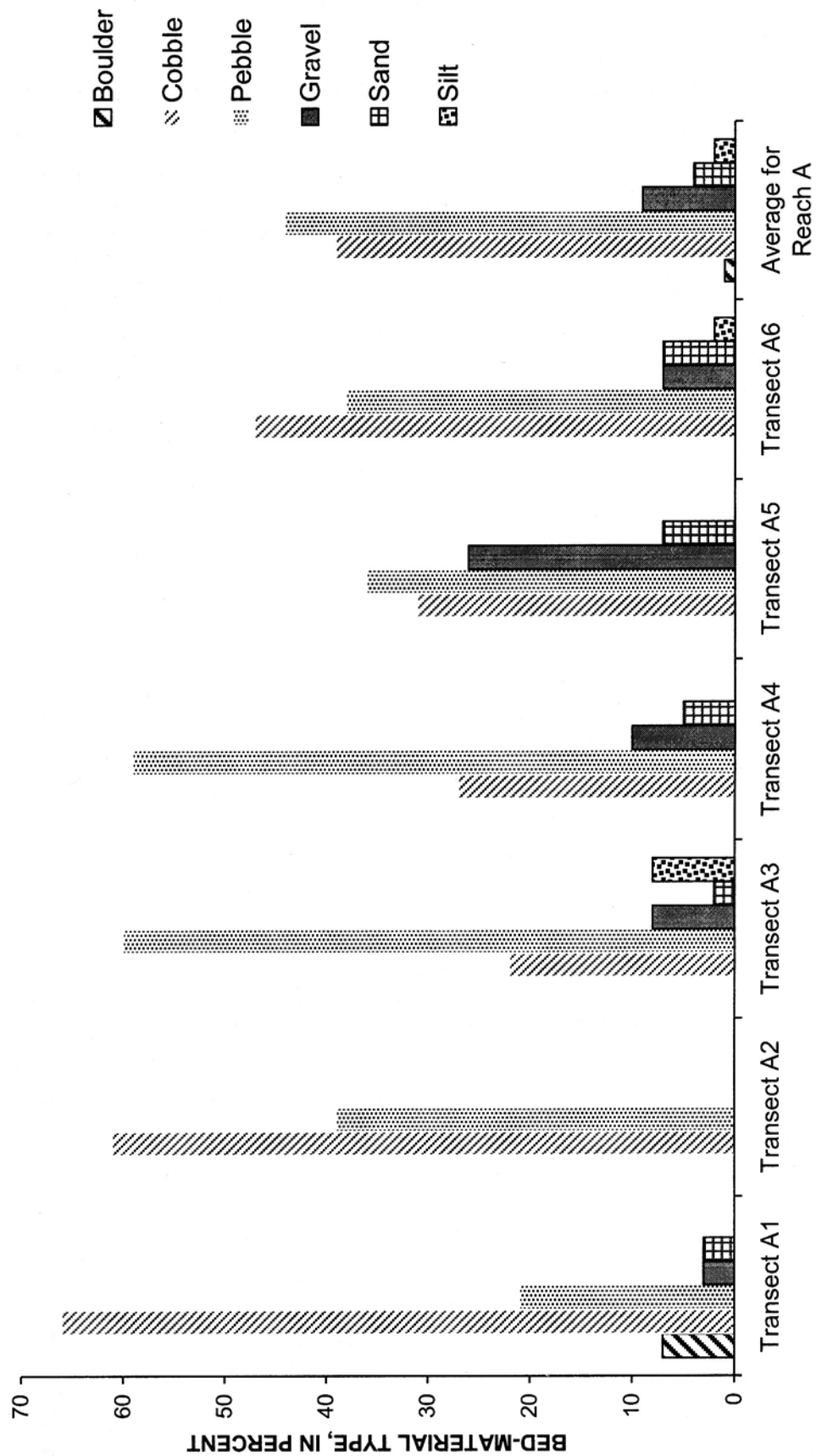
[Embeddedness categories: 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment]

Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Run)									
14.0	124	149	0	3.2	0.39	0.41	Cobble	Sand	3
				7.5	<sup>1</sup> .77	.97	Boulder	Cobble	4
				10.7	.24	.08	Cobble	Boulder	3
Transect 2 (Riffle)									
18.3	173	165	0	4.0	.35	.63	Cobble	Gravel	4
				8.2	.26	.87	Cobble	Boulder	3
				12.4	<sup>1</sup> .50	.70	Cobble	Gravel	2
Transect 3 (Pool)									
58.4	166	158	15	7.8	<sup>1</sup> .63	.45	Gravel	Sand	3
				14.0	.47	.25	Gravel	Cobble	2
				20.0	.28	.06	Gravel	Cobble	3
				43.2	.23	.11	Gravel	Cobble	2
Transect 4 (Run)									
45.6	168	153	0	4.0	<sup>1</sup> .58	.21	Gravel	Cobble	5
				17.0	.30	.22	Gravel	Cobble	4
				30.0	.32	.19	Gravel	Cobble	4
Transect 5 (Run)									
57.4	167	162	24	8.8	.32	1.00	Cobble	Gravel	4
				37.1	<sup>1</sup> .48	.33	Gravel	Cobble	2
				43.0	.41	.19	Gravel	Cobble	3
				49.0	.11	.30	Gravel	Cobble	3
Transect 6 (Riffle)									
124.0	151	146	0	3.0	<sup>1</sup> .73	.44	Cobble	Gravel	4
				69.8	.42	.54	Cobble	Gravel	4
				87.3	.24	.53	Cobble	Boulder	4
				105.7	.16	.17	Cobble	Sand	4

<sup>1</sup>Thalweg.



**Figure 52.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, Verde River above West Clear Creek, near Camp Verde, Arizona, based on measurements made October 24, 1995.



**Figure 53.** Bed-material types at transects 1–6 and average for reach A, Verde River above West Clear Creek, near Camp Verde, Arizona, October 24, 1995.

**Table 46.** Density and dominance of woody vegetation for reach A, Verde River above West Clear Creek, near Camp Verde, Arizona, October 24, 1995

[Length of reach, 467 meters]

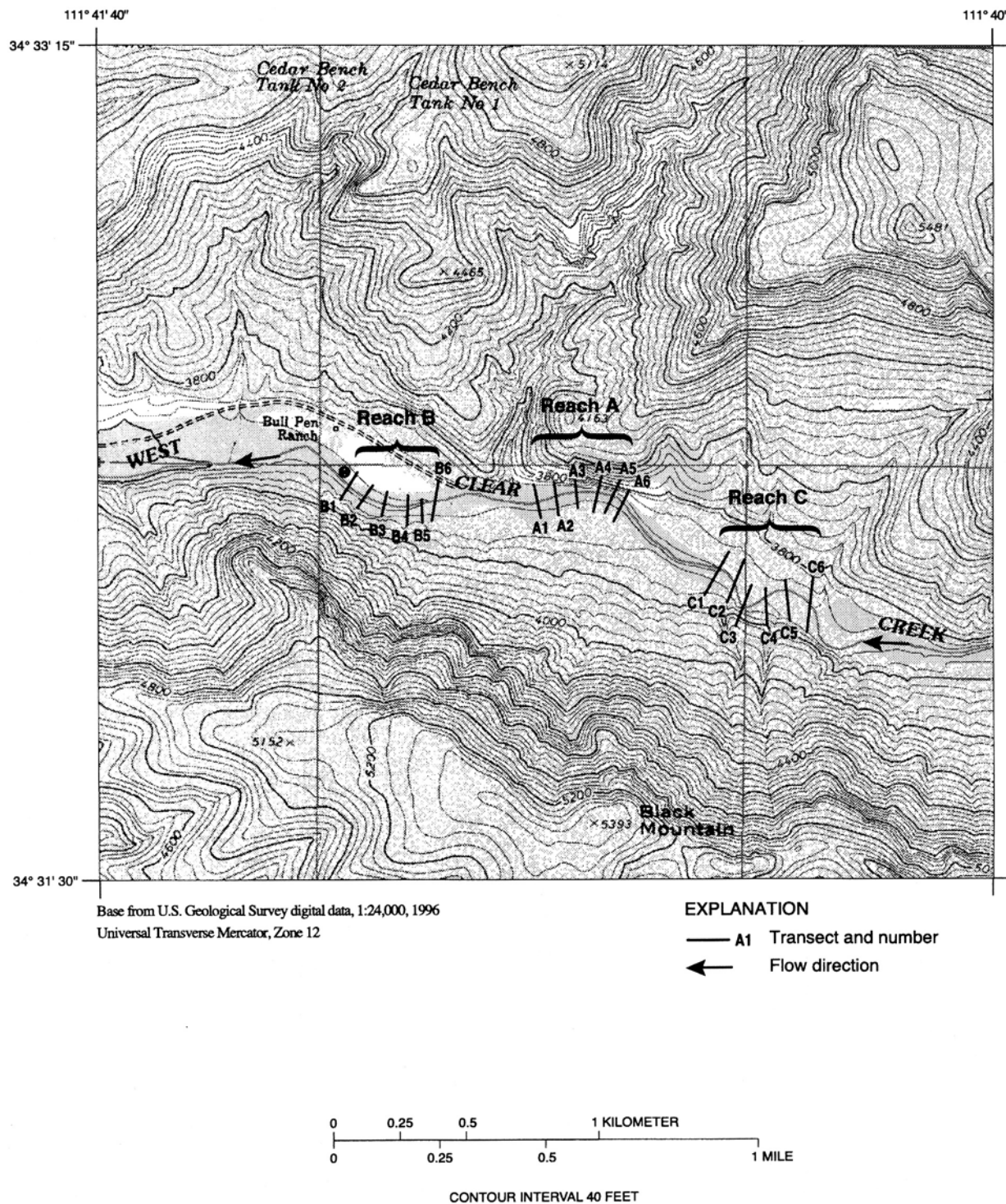
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Arizona alder ( <i>Alnus oblongifolia</i> )	133	3	8	3
Arizona sycamore ( <i>Plantanus wrightii</i> )	440	35	25	14
Fremont cottonwood ( <i>Populus fremontii</i> )	2,107	379	50	31
Mesquite ( <i>Prosopis sp.</i> )	113	5	8	7
Tamarisk ( <i>Tamarix sp.</i> )	16	2	42	24
Willow ( <i>Salix sp.</i> )	15	2	25	21

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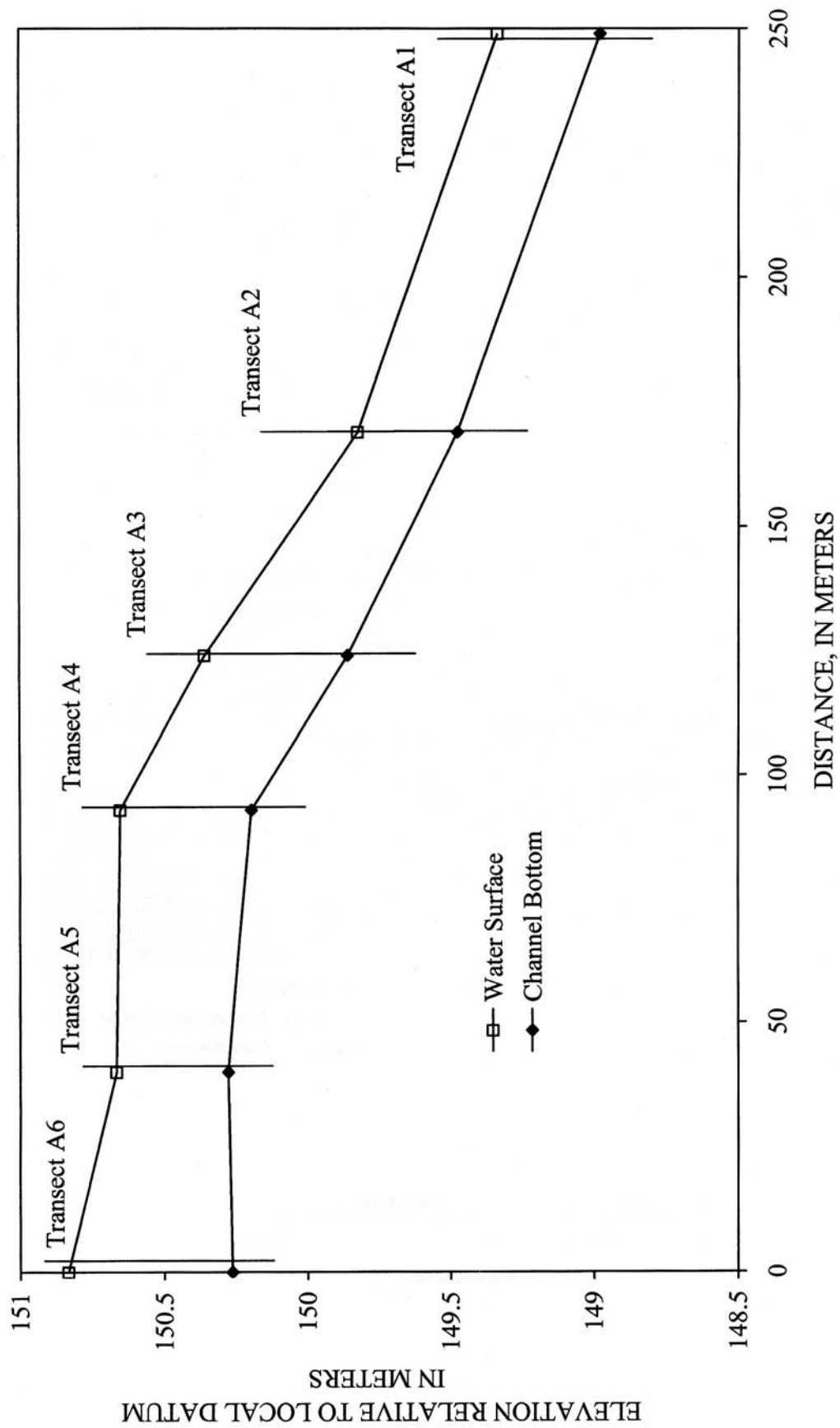
**West Clear Creek near Camp Verde, Arizona**  
**(USGS station number: 09505800)**

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**Figure 54.** Location of transects 1–6, reaches A–C, West Clear Creek near Camp Verde, Arizona.

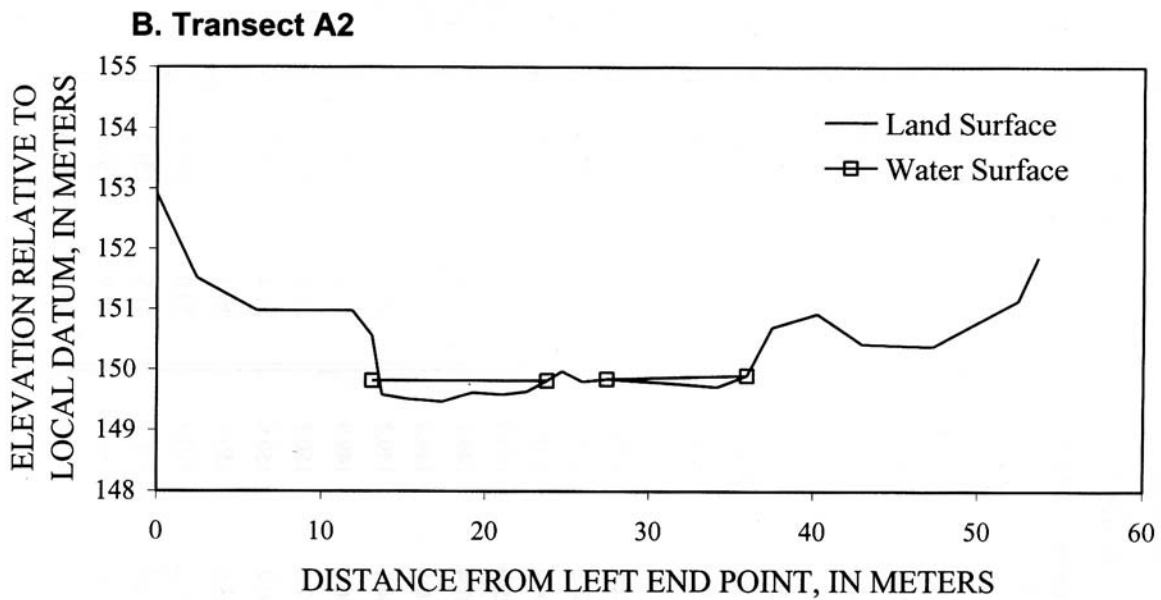
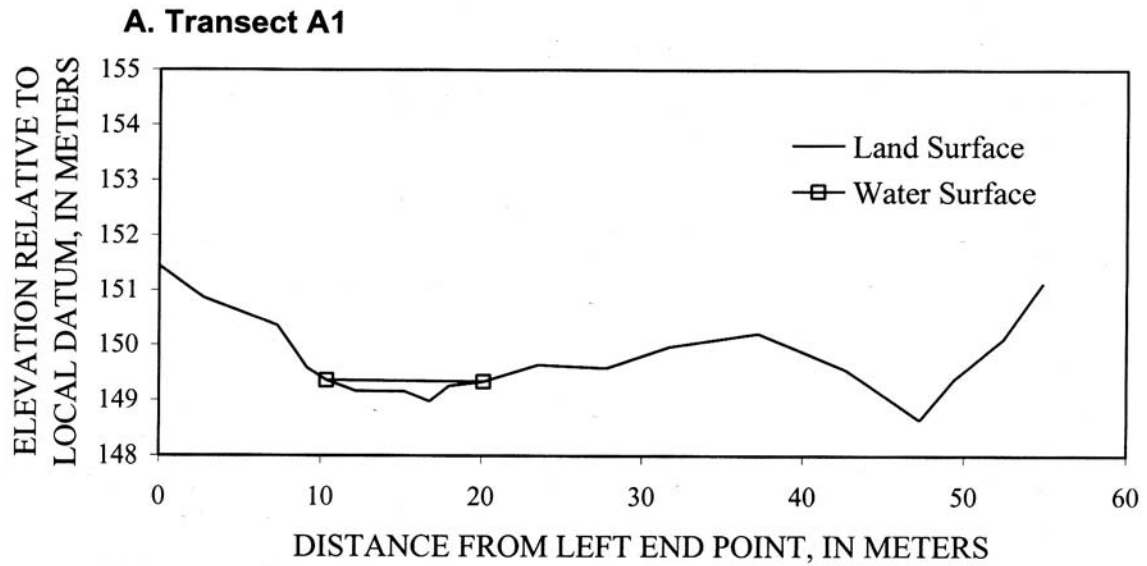


**Figure 55.** Longitudinal profile, reach A, West Clear Creek near Camp Verde, Arizona, December 3 and 4, 1997. Local datum established using arbitrary elevation.

**Table 47.** Cross-sectional survey data for reach A, West Clear Creek near Camp Verde, Arizona, December 3 and 4, 1997

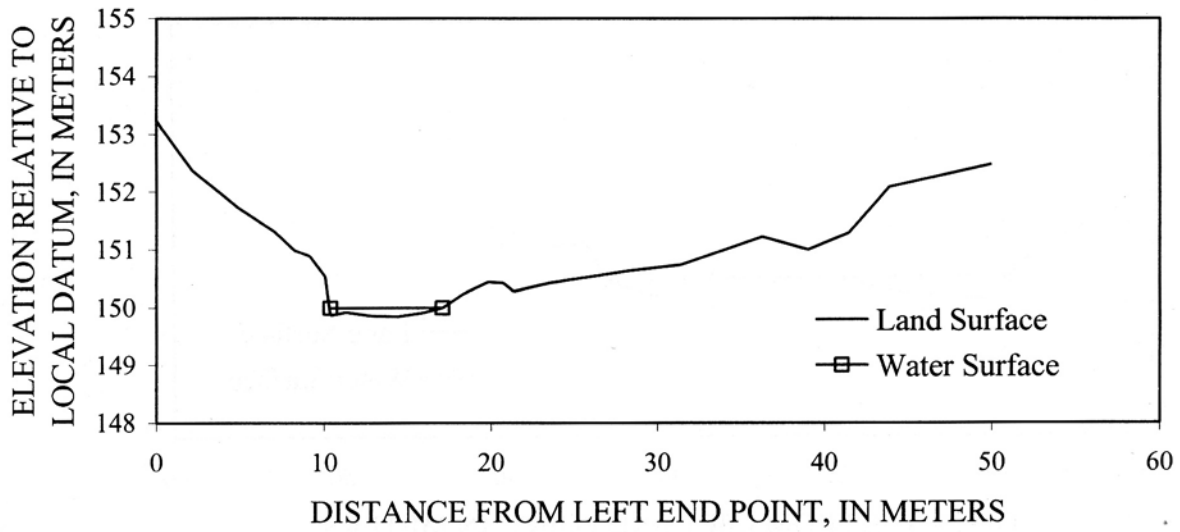
[All values are in meters. Distance is from left end point]

Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
0.0	151.4	0.0	152.9	0.0	153.2	0.0	153.4	0.0	152.2	0.0	154.1
2.7	150.9	2.4	151.5	2.1	152.4	1.2	152.9	3.7	151.7	4.9	152.8
7.3	150.4	6.1	151.0	4.9	151.7	3.4	152.3	7.6	151.1	5.8	152.6
9.1	149.6	11.9	151.0	7.0	151.3	5.5	151.7	9.1	150.7	6.7	152.7
10.4	149.4	13.1	150.6	8.2	151.0	7.6	151.2	10.7	150.3	16.2	152.7
12.2	149.2	13.7	149.6	9.1	150.9	8.8	151.0	13.4	150.4	19.2	151.5
15.2	149.2	15.2	149.5	10.1	150.5	10.1	150.7	15.2	150.4	20.4	151.4
16.8	149.0	17.4	149.5	10.4	149.9	12.2	150.5	17.1	150.5	22.6	150.8
18.0	149.3	19.2	149.6	11.3	149.9	15.2	150.2	19.8	150.6	24.1	150.6
20.1	149.3	21.0	149.6	12.8	149.9	16.5	150.3	21.9	150.6	25.6	150.4
23.5	149.6	22.6	149.6	14.3	149.8	18.6	150.5	25.0	150.5	27.7	150.4
27.7	149.6	23.8	149.8	15.8	149.9	21.3	150.3	27.4	150.7	28.7	150.4
31.7	150.0	24.7	150.0	17.1	150.0	23.5	150.4	30.8	150.3	29.9	150.3
37.2	150.2	25.9	149.8	18.3	150.2	26.5	150.7	33.5	150.6	31.4	150.3
42.7	149.6	27.4	149.8	19.8	150.4	32.0	150.8	35.1	151.3	33.2	150.3
47.2	148.7	30.8	149.8	20.7	150.4	35.1	151.3	36.9	151.2	34.7	150.6
49.4	149.4	34.1	149.7	21.3	150.3	36.9	151.8	41.5	151.6	35.8	150.8
52.4	150.1	36.0	149.9	23.5	150.4	38.1	151.7			36.9	151.3
54.9	151.1	37.5	150.7	28.3	150.6	45.4	151.5			37.5	152.2
		40.2	150.9	31.4	150.7	47.4	152.5			39.3	152.4
		43.0	150.4	36.3	151.2					41.1	152.9
		47.2	150.4	39.0	151.0					43.0	153.3
		52.4	151.1	41.5	151.3						
		53.6	151.9	43.9	152.1						
				50.0	152.5						



**Figure 56A–F.** Cross sections of channel, reach A, West Clear Creek, near Camp Verde, Arizona, December 3 and 5, 1997. A, Transect A1. B, Transect A2. C, Transect A3. D, Transect A4. E, Transect A5. F, Transect A6. Local datum established using arbitrary elevation.

### C. Transect A3



### D. Transect A4

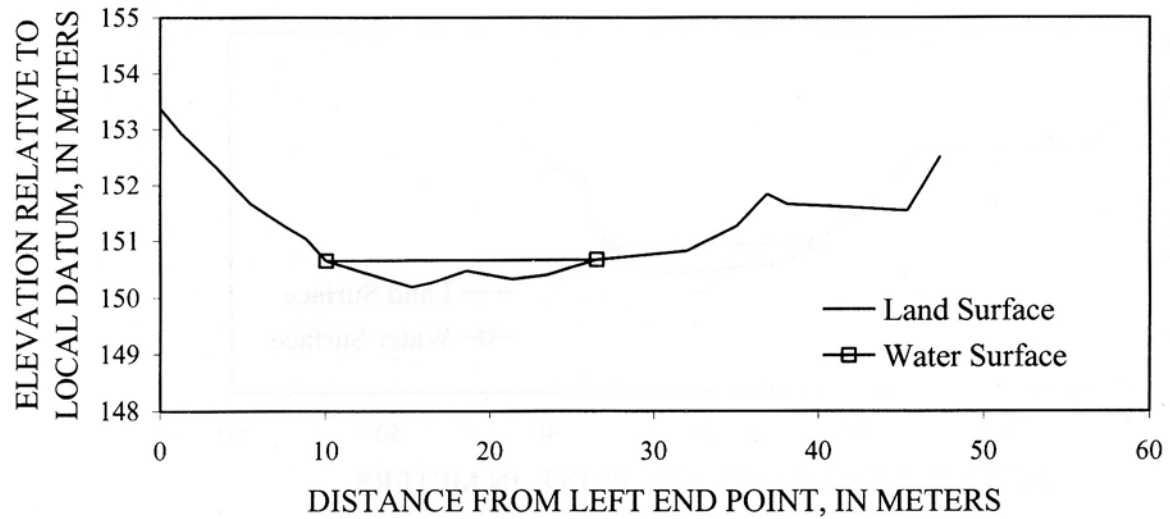
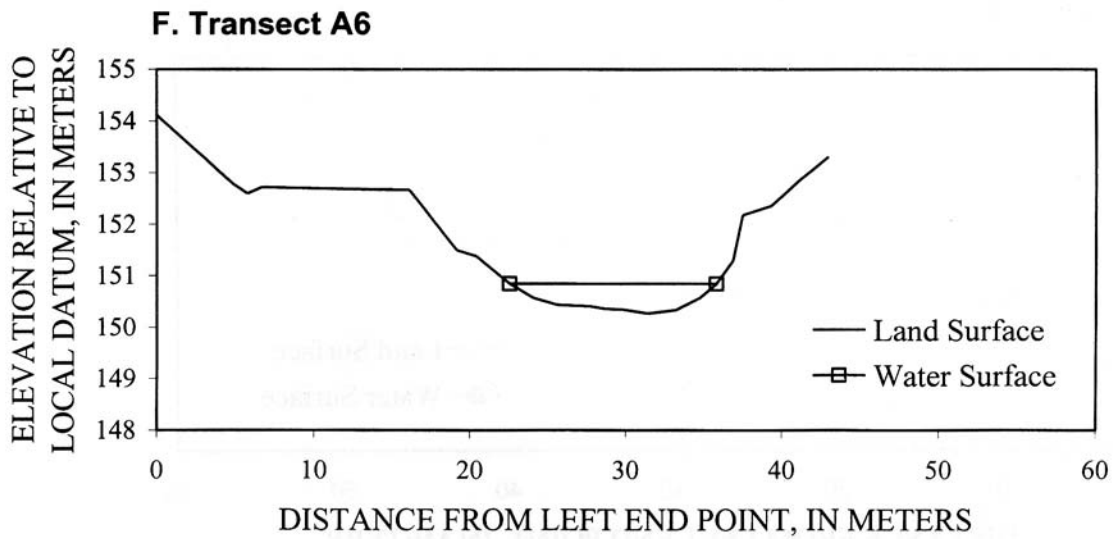
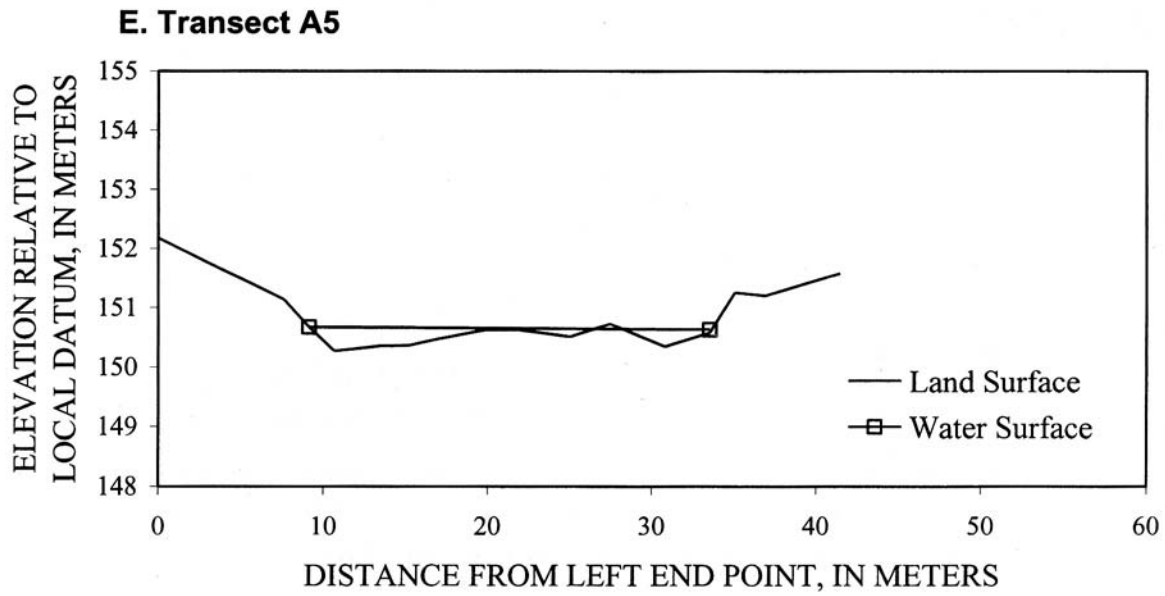


Figure 56A–F. Continued.



**Figure 56A–F.** Continued.

**Table 48.** Description and location of semipermanent monuments for reach A, West Clear Creek near Camp Verde, Arizona, December 3 and 4, 1997

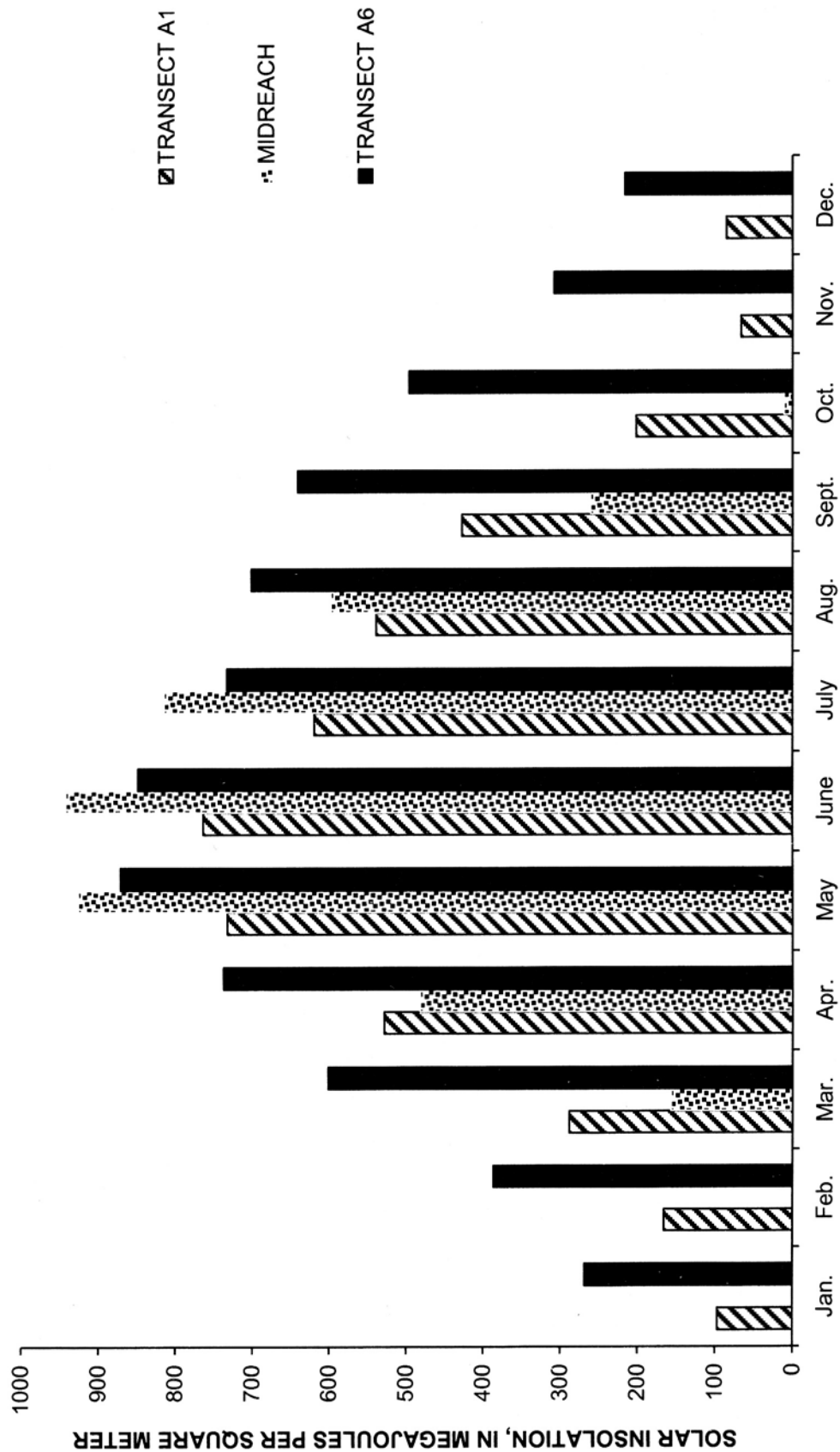
Transect	Type	Description of location and reference marks
A1	Left	Rebar, about 75 meters upstream from gaging station. Reference-mark 1 is rebar painted white at base of cliff about 75 meters upstream from gaging station. Established in 1995. Elevation is 154.37 meters.
A1	Right	Rebar, about 75 meters upstream from gaging station.
A2	Left	Rebar, 55 meters upstream from transect A1.
A2	Right	Rebar, 55 meters upstream from transect A1.
A3	Left	Rebar, about 40 meters upstream from transect A2.
A3	Right	Rebar, 40 meters upstream from transect A2.
A4	Left	Rebar, 29 meters upstream from transect A3.
A4	Right	Rebar, 29 meters upstream from transect A3.
A5	Left	Rebar, 45 meters upstream from transect A4.
A5	Right	Rebar, 45 meters upstream from transect A4.
A6	Left	Rebar, 38 meters upstream from transect A5.
A6	Right	Rebar, 38 meters upstream from transect A5.

**Table 49.** Habitat characteristics of reach A, West Clear Creek near Camp Verde, Arizona, October 11, 1995

[Embeddedness categories: 1, more than 75 percent covered by fine sediment; 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment]

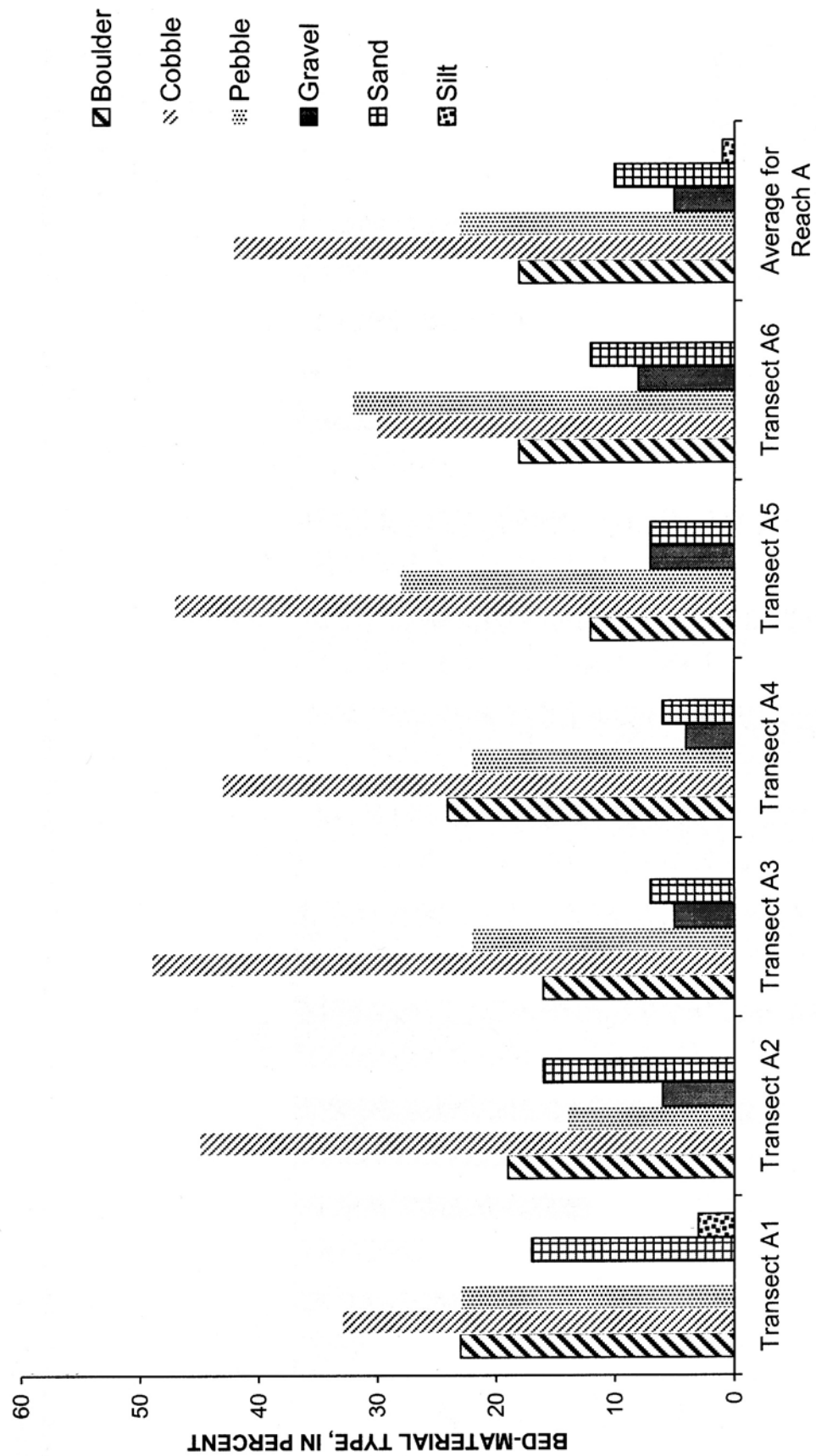
Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
10.1	283	110	21	3.8	<sup>1</sup> 0.31	0.50	Cobble	Gravel	1
				5.8	.22	.72	Cobble	Gravel	3
				8.1	.15	.22	Cobble	Gravel	3
Transect 2 (Riffle)									
23.0	278	63	65	2.4	<sup>1</sup> .36	.30	Boulder	Cobble	3
				5.2	.24	.20	Boulder	Gravel	3
				8.0	.26	.09	Cobble	Gravel	3
				19.4	.20	.16	Boulder	Cobble	2
Transect 3 (Riffle)									
19.3	284	56	41	2.5	.20	.19	Boulder	Cobble	2
				6.9	<sup>1</sup> .34	1.02	Boulder	Cobble	3
				8.5	.27	.33	Boulder	Cobble	3
				15.3	.16	.08	Cobble	Boulder	3
Transect 4 (Riffle)									
15.7	277	86	25	3.4	<sup>1</sup> .38	.38	Boulder	Cobble	2
				7.4	.11	.55	Boulder	Gravel	3
				11.4	.17	.12	Cobble	Boulder	3
Transect 5 (Run)									
18.7	275	103	13	2.6	.39	.06	Cobble	Boulder	4
				6.3	<sup>1</sup> .48	.19	Cobble	Boulder	3
				13.3	.16	.08	Cobble	Gravel	4
Transect 6 (Run)									
12.8	267	94	19	3.4	.37	.25	Boulder	Cobble	3
				6.7	<sup>1</sup> .52	.17	Cobble	Gravel	2
				9.0	.49	.16	Boulder	Cobble	4

<sup>1</sup>Thalweg.



**Figure 57.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, West Clear Creek near Camp Verde, Arizona, based on measurements made October 11, 1995.





**Figure 58.** Bed-material types at transects 1–6 and average for reach A, West Clear Creek near Camp Verde, Arizona, October 11, 1995.

**Table 50.** Density and dominance of woody vegetation for reach A, West Clear Creek near Camp Verde, Arizona, October 11, 1995

[Length of reach, 207 meters]

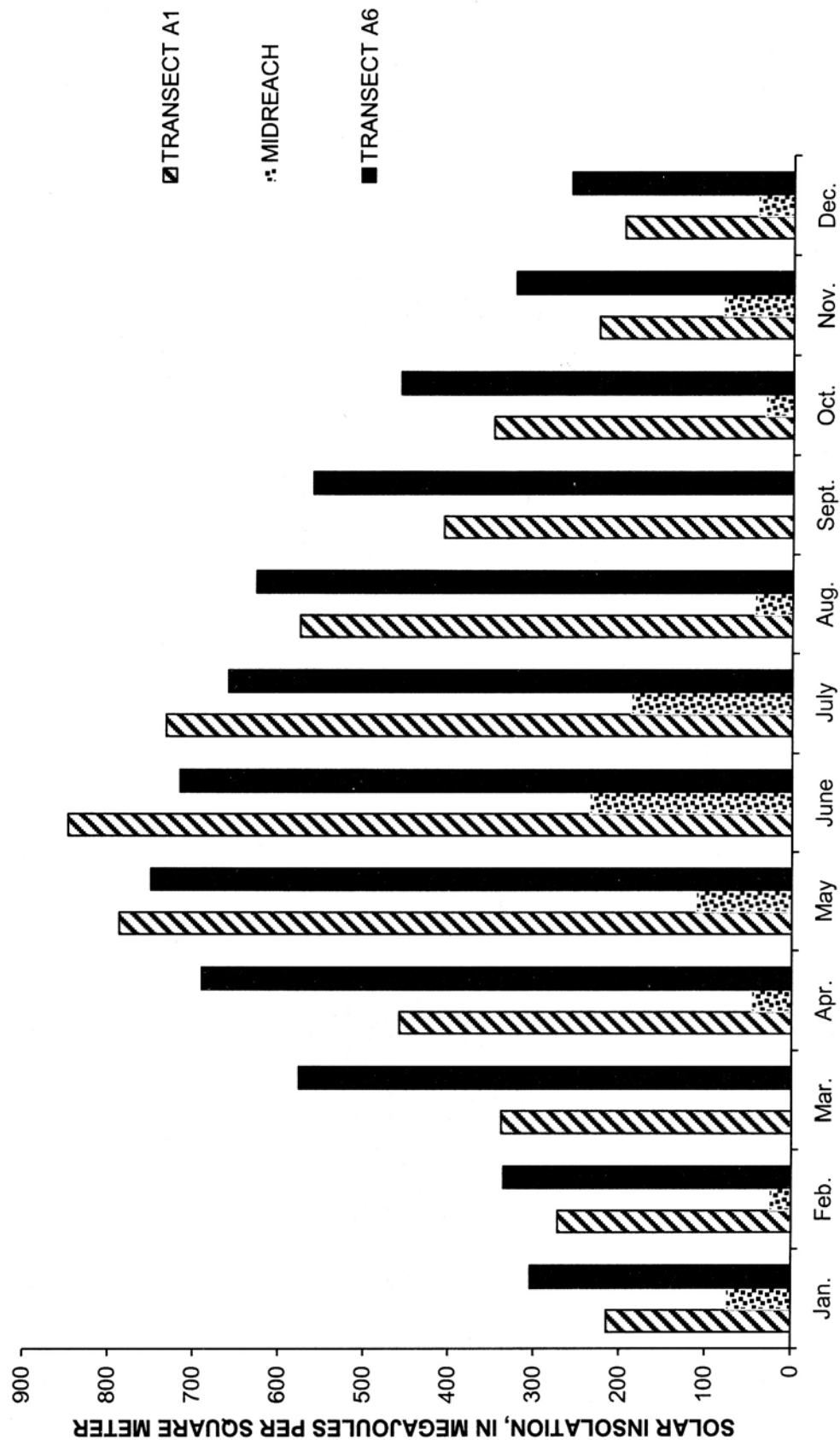
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Arizona alder ( <i>Alnus oblongifolia</i> )	602	602	50	21
Arizona sycamore ( <i>Plantanus wrightii</i> )	612	704	58	24
Box elder ( <i>Acer negundo</i> )	548	132	17	5
Fremont cottonwood ( <i>Populus fremontii</i> )	1,980	475	17	5
Juniper ( <i>Juniperus sp.</i> )	350	200	33	12
Silverleaf oak ( <i>Quercus hypoleucoides</i> )	855	86	8	2
Velvet ash ( <i>Fraxinus velutina</i> )	334	494	75	31

**Table 51.** Habitat characteristics of reach A, West Clear Creek near Camp Verde, Arizona, October 24, 1996

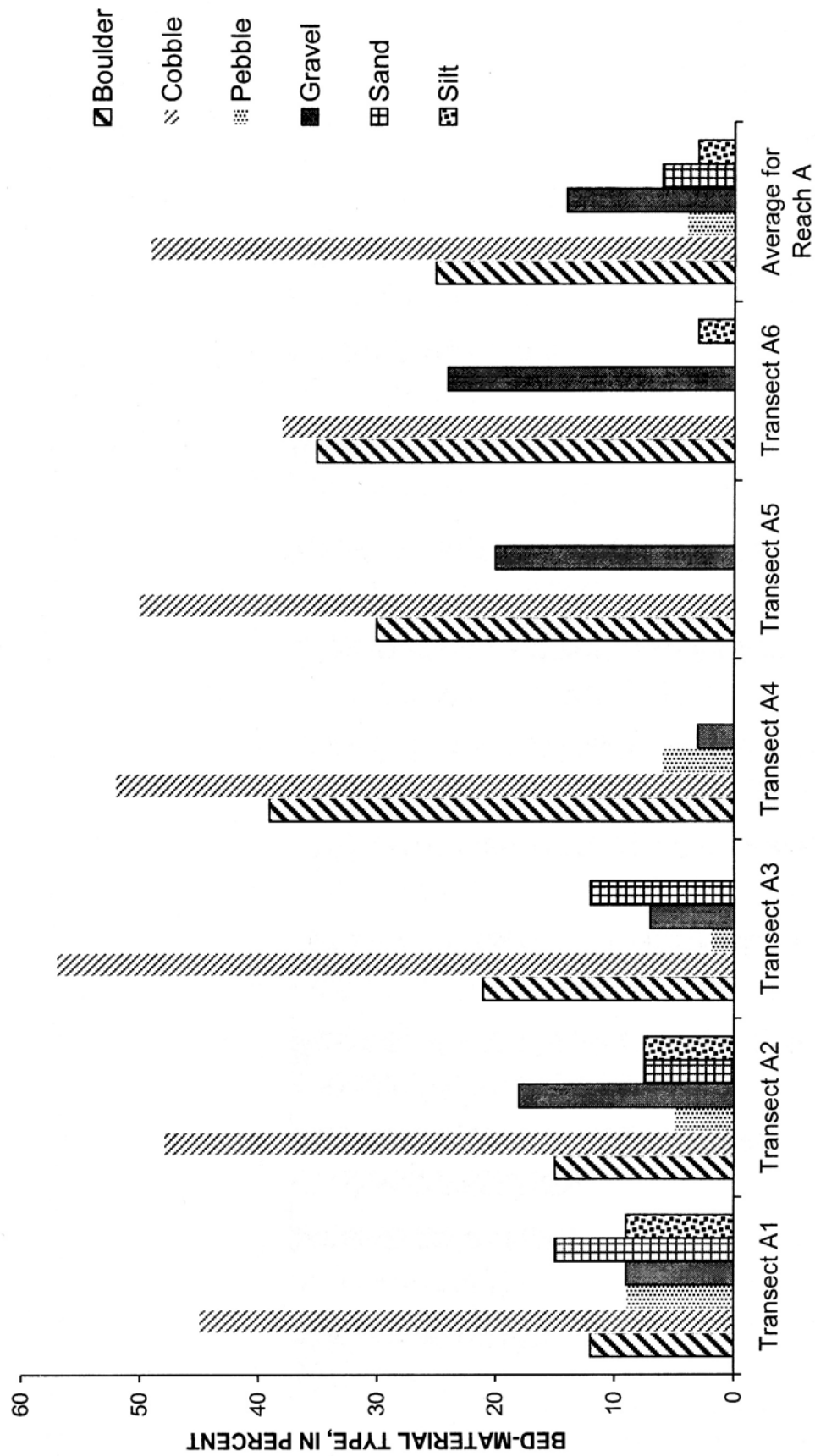
[Embeddedness categories: 1, more than 75 percent covered by fine sediment; 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment. &lt;, less than]

Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
10.9	279	114	40	2.0	0.18	0.12	Cobble	Gravel	3
				4.2	.24	.23	Cobble	Gravel	1
				7.0	<sup>1</sup> .36	.53	Boulder	Cobble	3
Transect 2 (Riffle)									
22.3	274	34	69	4.2	<sup>1</sup> .40	.24	Boulder	Cobble	2
				5.7	.21	.05	Gravel	Boulder	5
				8.7	.24	.27	Boulder	Cobble	2
				18.9	.18	.16	Cobble	Silt	3
Transect 3 (Riffle)									
18.2	264	49	78	1.1	.21	.10	Gravel	Cobble	5
				2.7	.21	.05	Cobble	Silt	3
				4.2	.18	.46	Boulder	Cobble	3
				6.0	<sup>1</sup> .40	.41	Boulder	Gravel	2
Transect 4 (Riffle)									
14.1	269	70	26	2.3	<sup>1</sup> .36	.47	Boulder	Cobble	4
				5.1	.27	.69	Boulder	Cobble	4
				9.3	.21	.29	Cobble	Boulder	3
Transect 5 (Run)									
18.5	259	82	25	5.1	<sup>1</sup> .52	.20	Cobble	Gravel	3
				9.4	.30	.06	Cobble	Boulder	2
				13.7	.15	<.01	Cobble	Boulder	3
Transect 6 (Run)									
13.1	275	119	10	2.4	.40	.22	Boulder	Cobble	4
				6.1	<sup>1</sup> .61	.13	Cobble	Gravel	3
				9.0	.58	.06	Gravel	Boulder	2

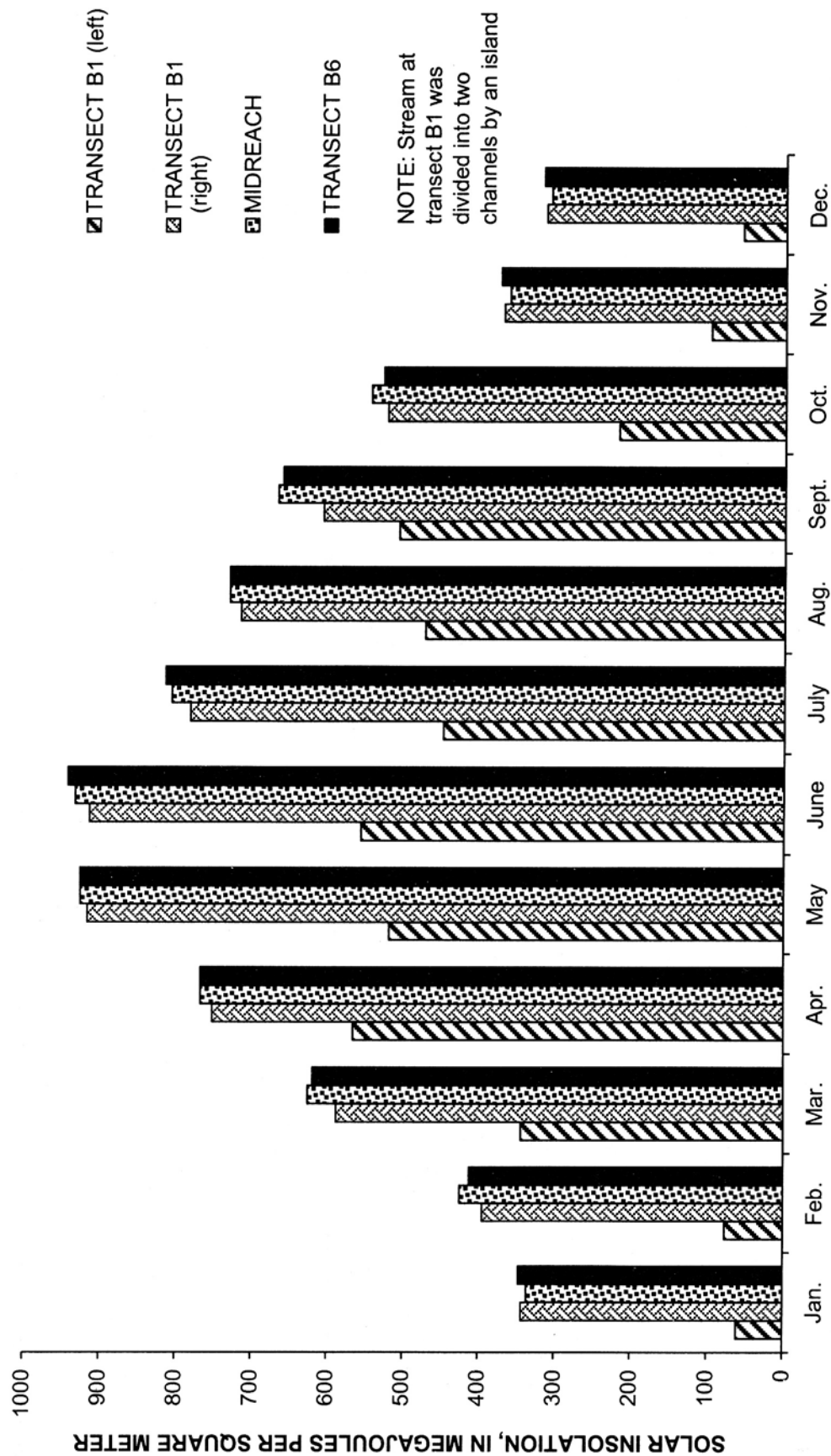
<sup>1</sup>Thalweg.



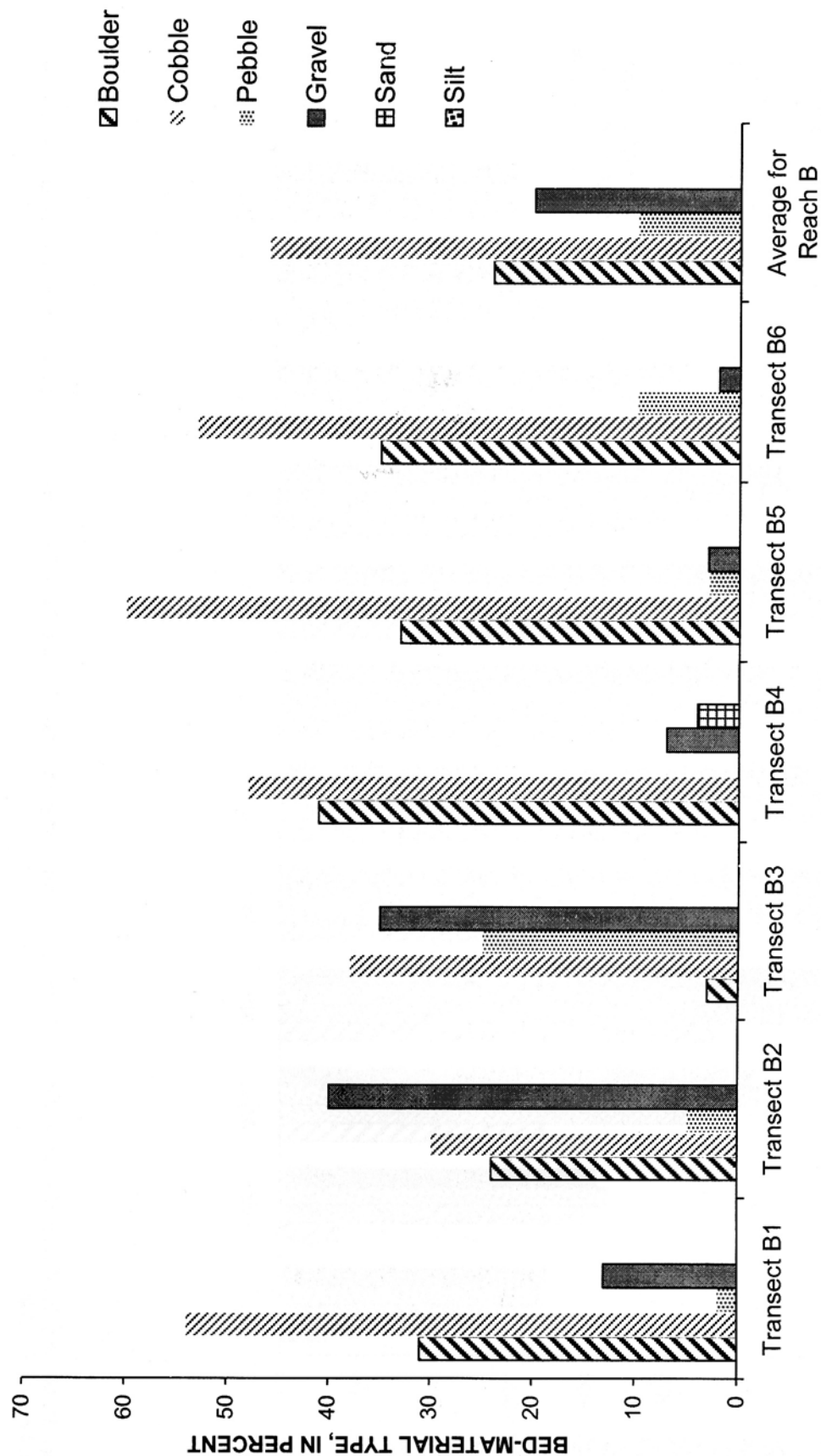
**Figure 59.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, West Clear Creek near Camp Verde, Arizona, based on measurements made October 24, 1996.



**Figure 60.** Bed-material types at transects 1–6 and average for reach A, West Clear Creek near Camp Verde, Arizona, October 24, 1996.



**Figure 61.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach B, West Clear Creek near Camp Verde, Arizona, based on measurements made October 31, 1996.



**Figure 62.** Bed-material types at transects 1–6 and average for reach B, West Clear Creek near Camp Verde, Arizona, October 31, 1996.

**Table 52.** Density and dominance of woody vegetation for reach B, West Clear Creek near Camp Verde, Arizona, October 24, 1996  
[Length of reach, 210 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Arizona alder ( <i>Alnus oblongifolia</i> )	477	334	42	15
Arizona sycamore ( <i>Plantanus wrightii</i> )	1,023	951	58	20
Boxelder ( <i>Acer negundo</i> )	28	3	8	2
Fremont cottonwood ( <i>Populus fremontii</i> )	3,632	436	8	2
Juniper ( <i>Juniperus sp.</i> )	350	176	33	12
Nettleaf hackberry ( <i>Celtis reticulata</i> )	88	20	17	5
Oak ( <i>Quercus sp.</i> )	13	2	8	2
Single leaf piñon ( <i>Pinus monophylla</i> )	177	21	8	2
Velvet ash ( <i>Fraxinus velutina</i> )	242	424	92	38

**Table 53.** Habitat characteristics of reach B, West Clear Creek near Camp Verde, Arizona, October 31, 1996

[Embeddedness categories 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment]

Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
34.2	239	96	43	1.0	0.20	1.03	Boulder	Cobble	4
				2.0	.30	1.11	Boulder	Cobble	4
				26.0	.24	.08	Boulder	Cobble	3
				31.0	<sup>1</sup> .34	.08	Boulder	Cobble	5
Transect 2 (Run)									
13.1	225	97	29	4.1	<sup>1</sup> .46	.15	Boulder	Gravel	4
				7.4	.24	.12	Boulder	Cobble	4
				10.3	.30	.30	Gravel	Boulder	4
Transect 3 (Pool)									
21.1	255	103	24	4.2	.15	.25	Gravel	Cobble	5
				9.8	.55	.09	Cobble	Gravel	3
				15.6	<sup>1</sup> .98	.02	Gravel	Cobble	3
Transect 4 (Riffle)									
9.8	314	92	26	2.0	.24	.26	Boulder	Cobble	4
				4.6	<sup>1</sup> .46	.45	Boulder	Cobble	3
				7.1	.27	.39	Boulder	Cobble	5
Transect 5 (Riffle)									
11.4	326	136	22	3.1	.21	.43	Boulder	Cobble	4
				6.0	<sup>1</sup> .40	.57	Cobble	Boulder	5
				9.0	.30	.21	Boulder	Cobble	4
Transect 6 (Riffle)									
16.9	332	140	3	6.1	<sup>1</sup> .34	.12	Boulder	Cobble	4
				11.5	.34	.10	Boulder	Cobble	4
				13.9	.24	.71	Boulder	Cobble	5

<sup>1</sup>Thalweg.

**Table 54.** Density and dominance of woody vegetation for reach C, West Clear Creek near Camp Verde, Arizona, October 31, 1996

[Length of reach, 319 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Arizona alder ( <i>Alnus oblongifolia</i> )	140	97	75	40
Arizona sycamore ( <i>Plantanus wrightii</i> )	432	173	58	23
Juniper ( <i>Juniperus sp.</i> )	234	28	25	7
Mesquite ( <i>Prosopis sp.</i> )	133	4	8	2
Netleaf hackberry ( <i>Celtis reticulata</i> )	18	1	17	5
Single leaf piñon ( <i>Pinus monophylla</i> )	538	43	8	5
Velvet ash ( <i>Fraxinus velutina</i> )	266	64	33	14
Willow ( <i>Salix sp.</i> )	10	1	17	5

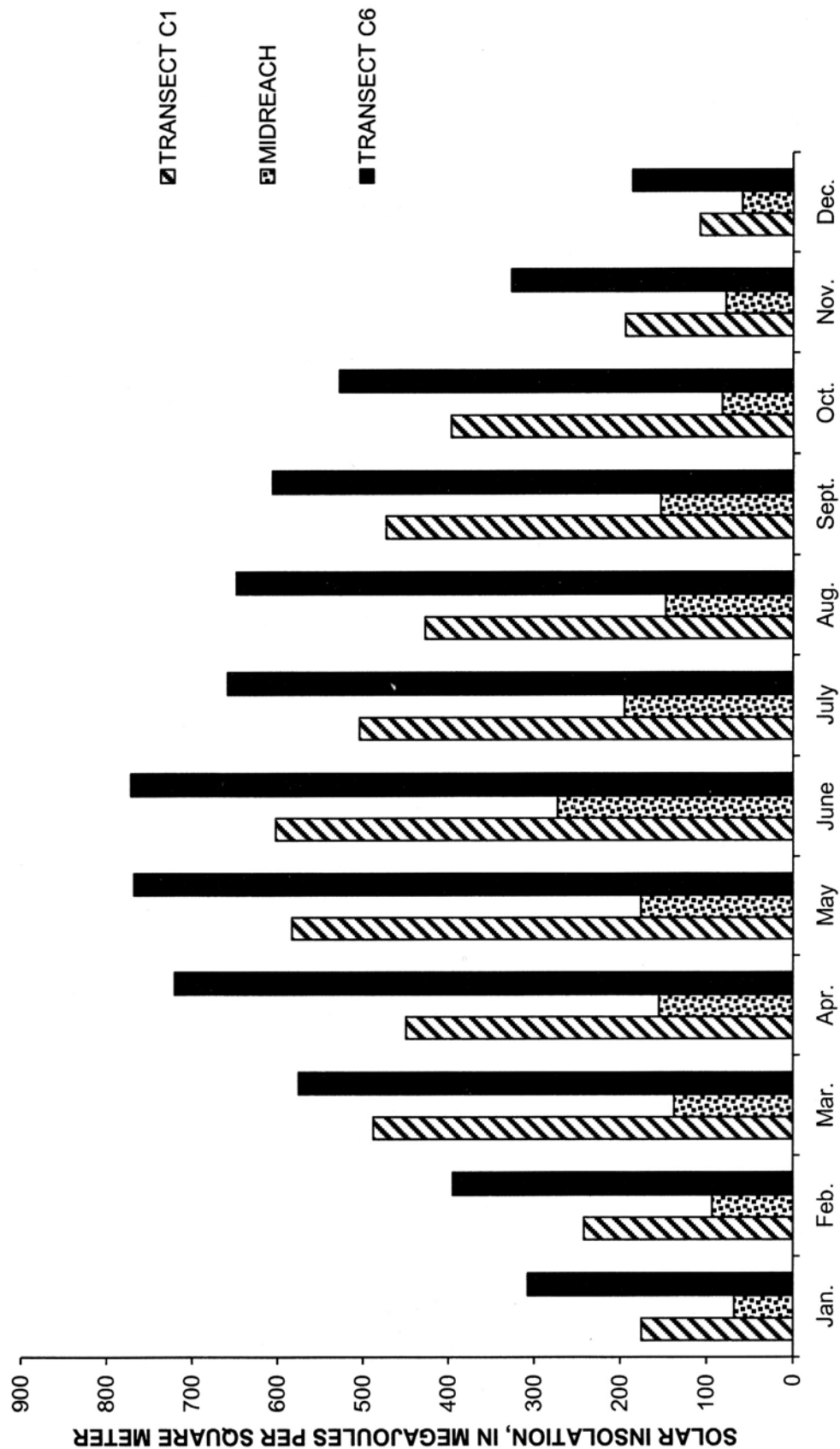
**Table 55.** Habitat characteristics of reach C, West Clear Creek near Camp Verde, Arizona, November 6, 1996

[Embeddedness categories: 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment]

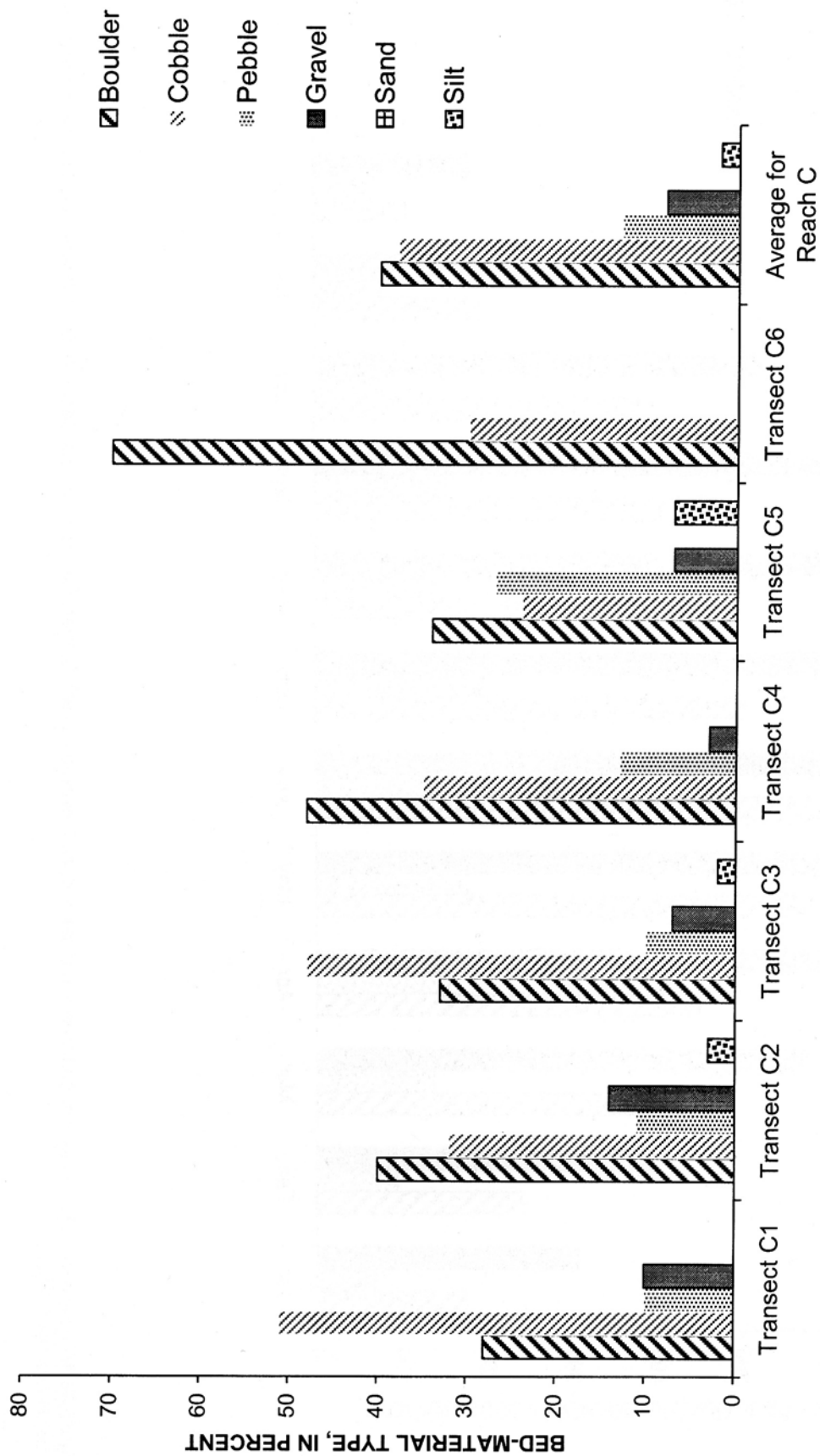
Width of wetted channel, in meters	Canopy			Velocity			Substrate		
	Aspect, in degrees	Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
13.8	256	81	37	3.8	0.09	0.29	Cobble	Boulder	3
				8.4	<sup>1</sup> .32	.41	Boulder	Cobble	3
				12.5	.27	.76	Boulder	Cobble	3
Transect 2 (Run)									
14.7	260	98	44	4.2	.08	0	Boulder	Cobble	3
				8.2	.42	.26	Boulder	Gravel	3
				12.8	<sup>1</sup> .59	.08	Boulder	Gravel	4
Transect 3 (Run)									
15.0	257	78	29	3.4	.15	.12	Cobble	Boulder	4
				6.8	<sup>1</sup> .46	.20	Boulder	Cobble	4
				11.1	.27	.01	Cobble	Boulder	4
Transect 4 (Riffle)									
14.1	254	108	16	2.4	.12	.40	Boulder	Cobble	4
				4.7	<sup>1</sup> .36	.44	Boulder	Cobble	5
				8.8	.15	.14	Cobble	Boulder	4
Transect 5 (Riffle)									
15.7	256	85	28	4.0	<sup>1</sup> .34	.50	Cobble	Gravel	4
				8.5	.12	.39	Cobble	Gravel	4
				12.2	.12	.02	Cobble	Boulder	4
Transect 6 (Riffle)									
9.3	259	106	3	2.3	.37	.17	Boulder	Cobble	4
				4.4	.26	.72	Boulder	Cobble	5
				6.5	<sup>1</sup> .49	.10	Boulder	Cobble	5

<sup>1</sup>Thalweg.





**Figure 63.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach C, West Clear Creek near Camp Verde, Arizona, based on measurements made November 6, 1996.



**Figure 64.** Bed-material types at transects 1–6 and average for reach C, West Clear Creek near Camp Verde, Arizona, November 6, 1996.

**Table 56.** Density and dominance of woody vegetation for reach C, West Clear Creek near Camp Verde, Arizona, November 6, 1996

[Length of reach, 121 meters]

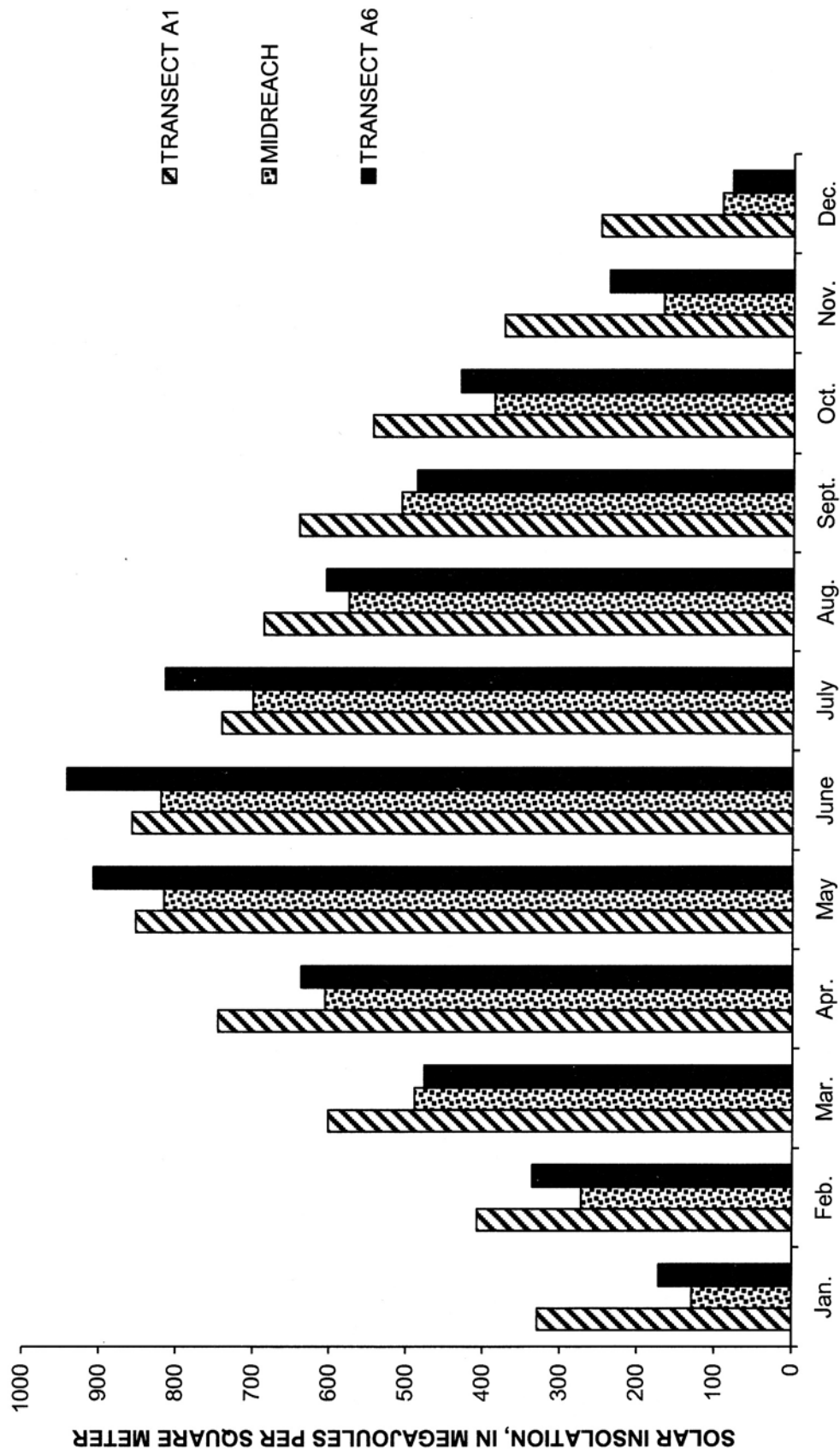
Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Arizona alder ( <i>Alnus oblongifolia</i> )	762	632	50	22
Arizona sycamore ( <i>Plantanus wrightii</i> )	760	372	33	13
Boxelder ( <i>Acer negundo</i> )	305	46	17	4
Mesquite ( <i>Prosopis</i> sp.)	50	4	8	2
Mulberry ( <i>Morus</i> sp.)	38	3	8	2
Netleaf hackberry ( <i>Celtis reticulata</i> )	38	3	8	2
Juniper ( <i>Juniperus</i> sp.)	137	93	50	18
Velvet ash ( <i>Fraxinus velutina</i> )	187	252	67	36

**Table 57.** Habitat characteristics of reach A, West Clear Creek near Camp Verde, Arizona, November 6, 1997

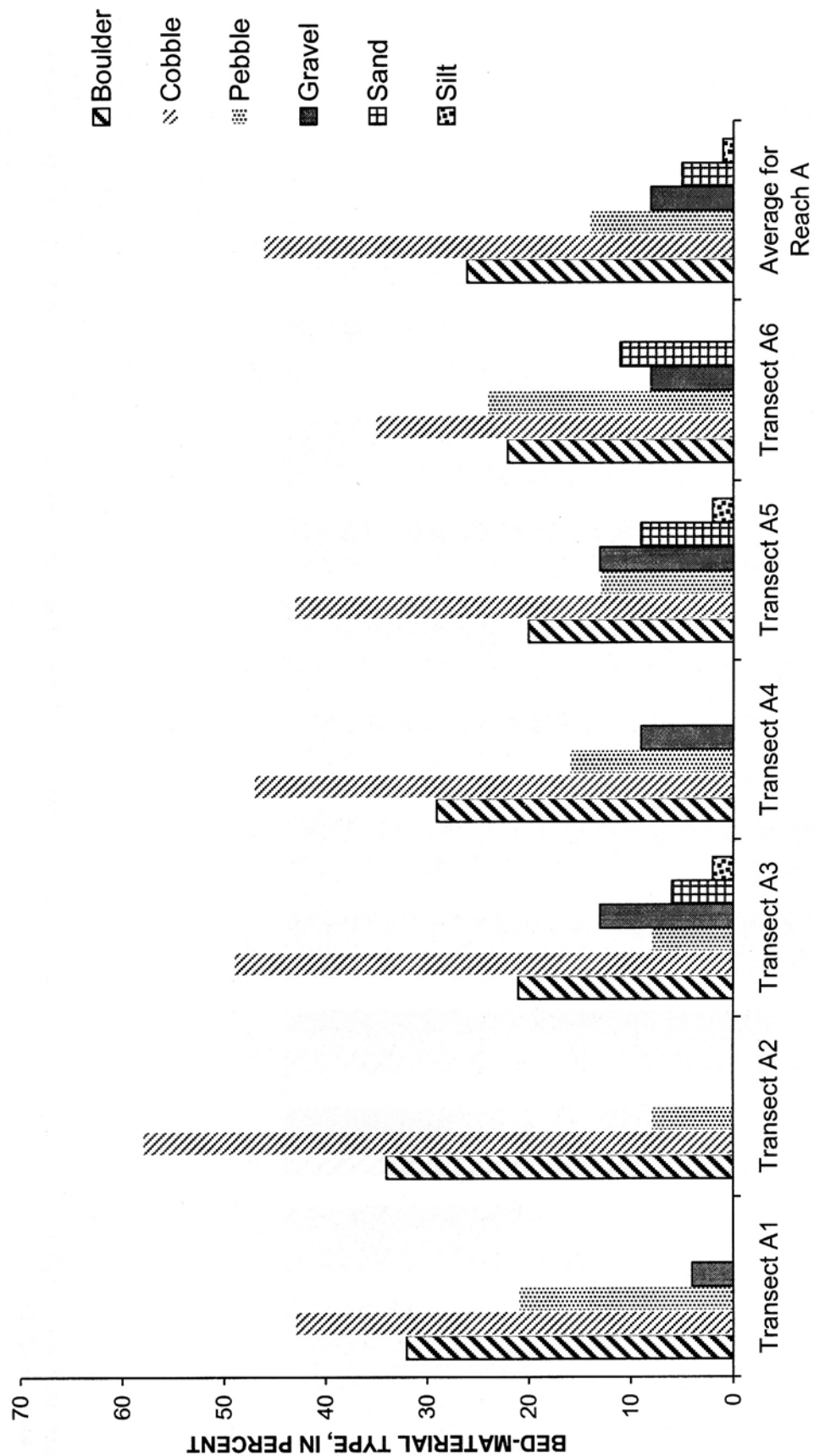
[Embeddedness categories: 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment]

Width of wetted channel, in meters	Aspect, in degrees	Canopy		Velocity			Substrate		
		Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
10.0	284	125	56	2.4	0.15	0.64	Cobble	Boulder	4
				5.7	<sup>1</sup> .34	.60	Cobble	Boulder	4
				8.0	.12	.29	Boulder	Cobble	4
Transect 2 (Riffle)									
21.0	278	52	81	2.8	<sup>1</sup> .30	.07	Cobble	Boulder	4
				6.2	.24	.46	Cobble	Boulder	4
				9.2	.23	.32	Cobble	Boulder	4
				19.5	.15	.19	Cobble	Gravel	3
Transect 3 (Riffle)									
18.6	266	50	98	2.0	.27	.08	Gravel	Boulder	5
				6.5	<sup>1</sup> .36	.43	Cobble	Gravel	4
				8.4	.34	.39	Boulder	Cobble	4
				15.2	.15	.05	Gravel	Cobble	4
Transect 4 (Riffle)									
15.0	263	84	37	5.5	<sup>1</sup> .36	.58	Cobble	Gravel	4
				9.0	.09	.09	Boulder	Cobble	4
				12.5	.24	.15	Boulder	Cobble	4
Transect 5 (Run)									
19.1	255	67	50	4.1	<sup>1</sup> .43	.24	Boulder	Gravel	4
				9.5	.27	.34	Cobble	Boulder	4
				15.0	.12	.13	Cobble	Gravel	4
Transect 6 (Run)									
11.7	258	115	48	3.0	.35	.18	Cobble	Gravel	4
				5.0	.46	.19	Cobble	Gravel	3
				8.5	<sup>1</sup> .49	.12	Gravel	Cobble	5

<sup>1</sup>Thalweg.



**Figure 65.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, West Clear Creek near Camp Verde, Arizona, based on measurements made November 6, 1997.



**Figure 66.** Bed-material types at transects 1–6 and average for reach A, West Clear Creek near Camp Verde, Arizona, November 6, 1997.

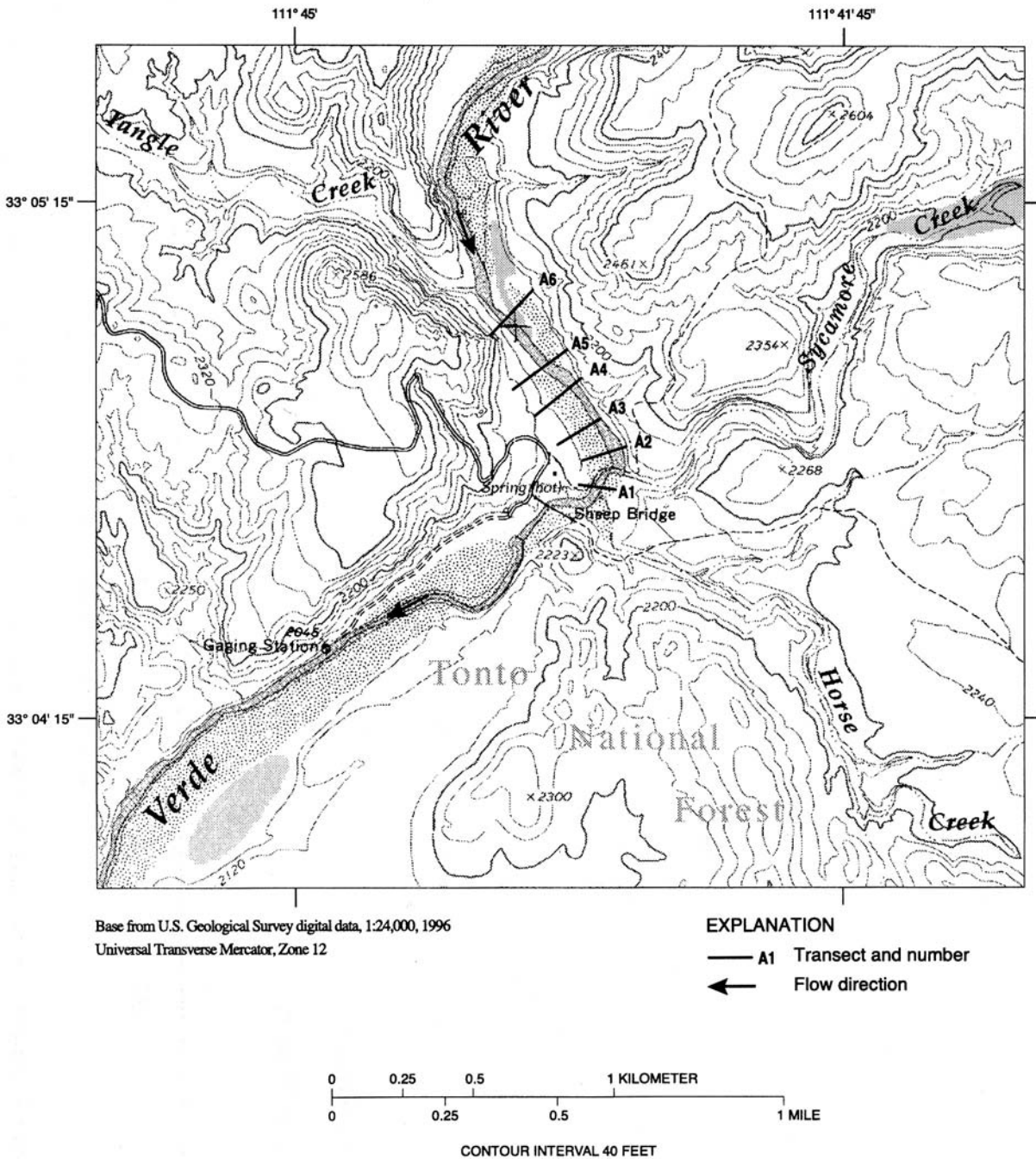
**Table 58.** Density and dominance of woody vegetation for reach A, West Clear Creek near Camp Verde, Arizona, November 6, 1997  
[Length of reach, 249 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Arizona alder ( <i>Alnus oblongifolia</i> )	225	720	75	48
Arizona sycamore ( <i>Plantanus wrightii</i> )	120	80	17	10
Fremont cottonwood ( <i>Populus fremontii</i> )	20	4	8	3
Netleaf hackberry ( <i>Celtis reticulata</i> )	95	19	8	3
Velvet ash ( <i>Fraxinus velutina</i> )	318	741	58	35

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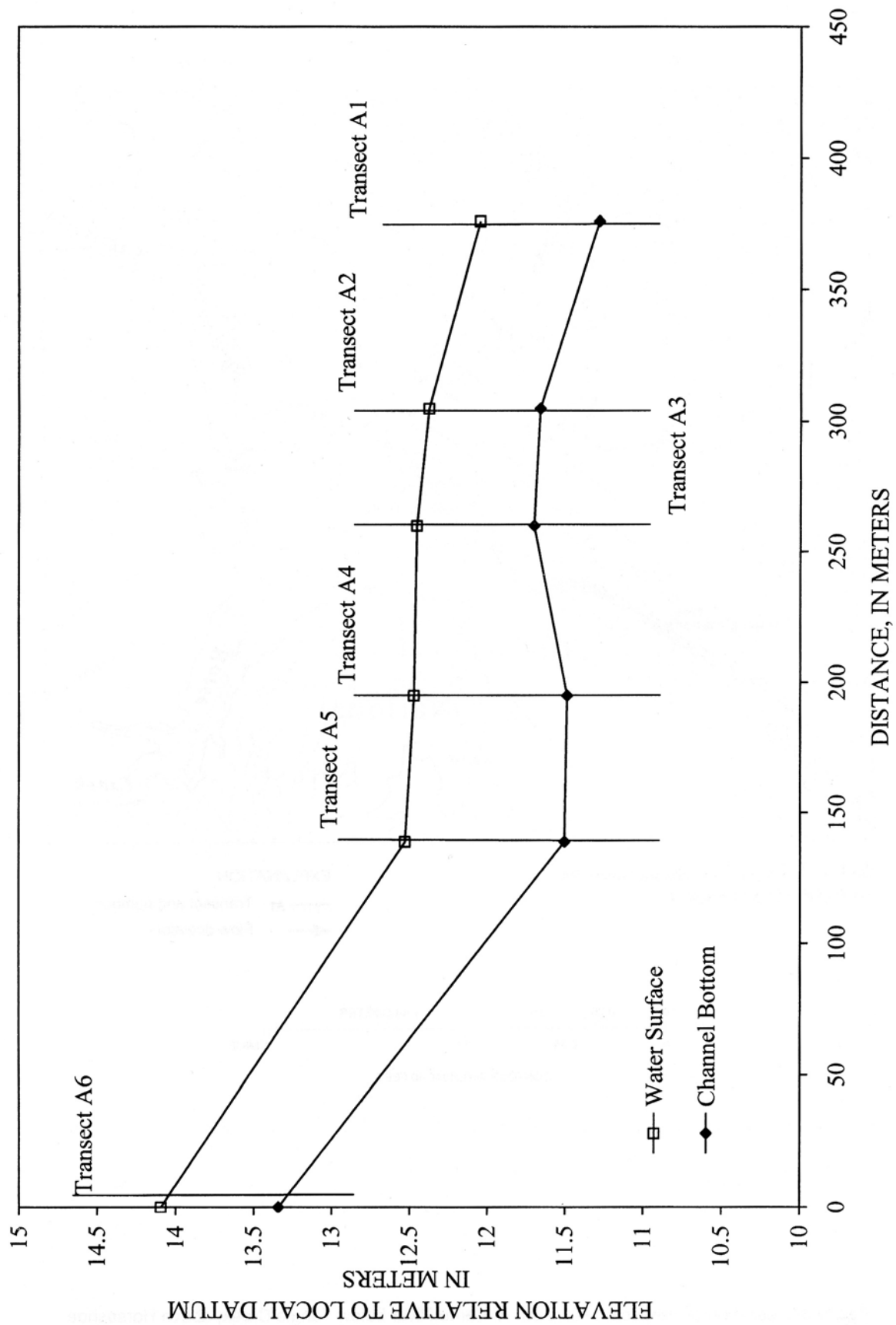
**Verde River below Tangle Creek, above Horseshoe Dam, Arizona**  
**(USGS station number: 09508500)**

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**Figure 67.** Location of transects 1–6, reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona.



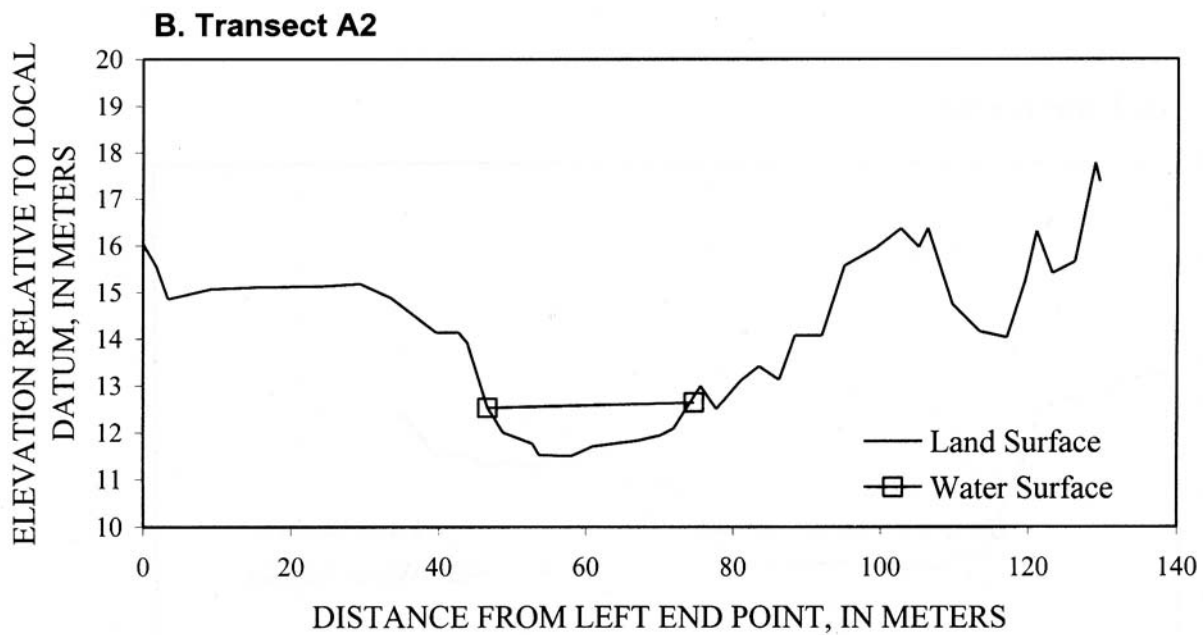
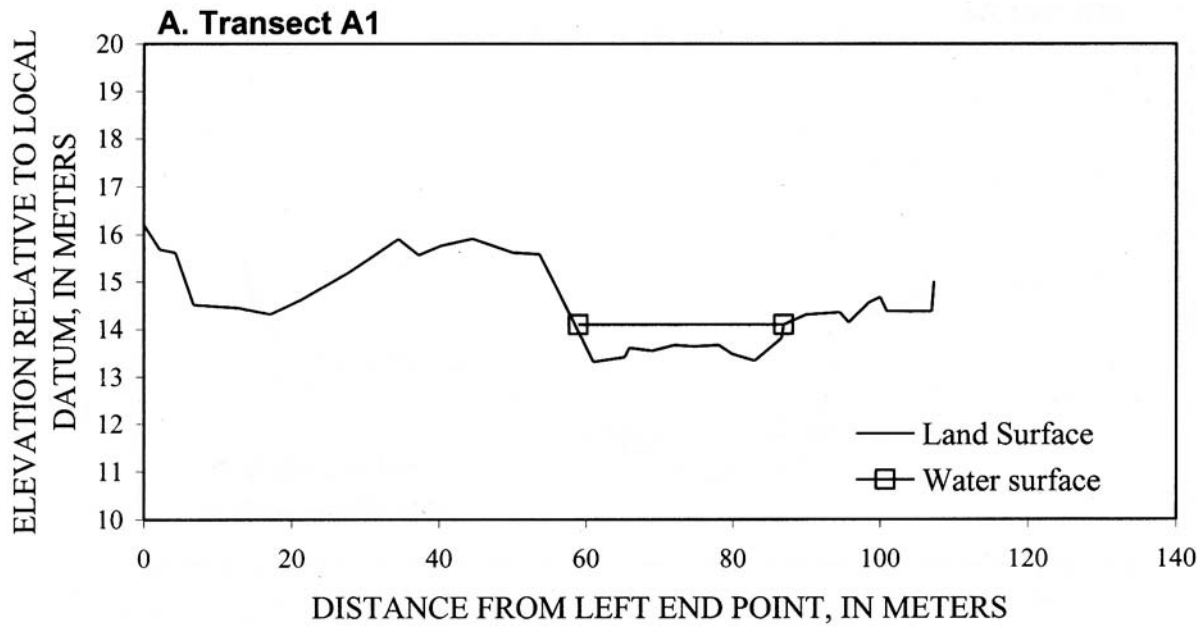


**Figure 68.** Longitudinal profile, reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, July 29, 1998. Local datum established using arbitrary elevation.

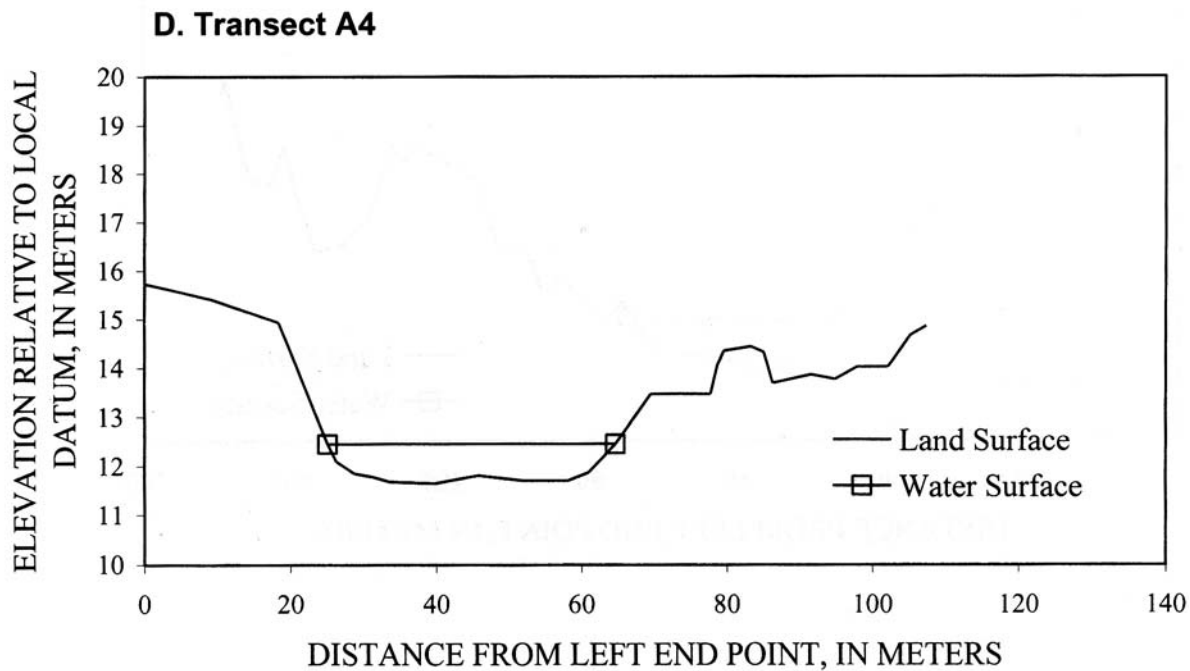
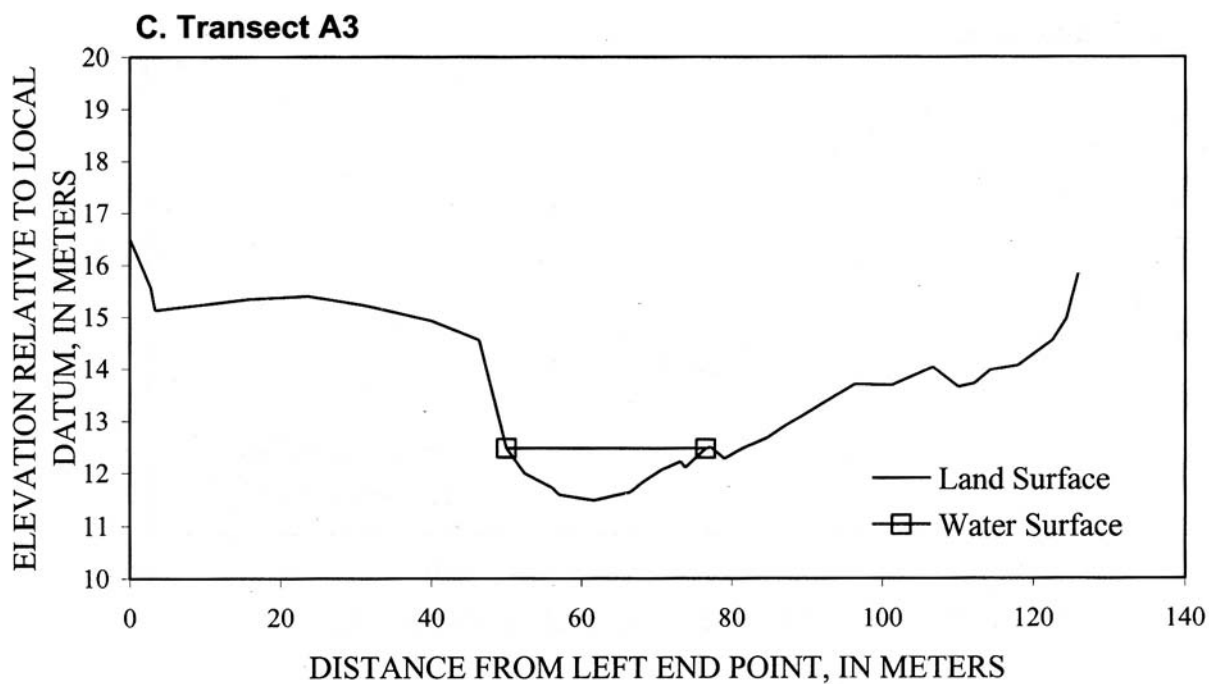
**Table 59.** Cross-sectional survey data for reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, July 29, 1998

[All values are in meters. Distance is from left end point]

Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
0.0	16.2	0.0	16.0	0.0	16.5	0.0	15.7	0.0	15.8	0.0	14.3
2.1	15.7	1.8	15.5	2.7	15.6	9.1	15.4	4.3	15.7	8.5	13.0
4.3	15.6	3.4	14.9	3.4	15.1	18.3	14.9	9.1	12.4	13.1	12.0
6.7	14.5	9.1	15.1	15.8	15.3	25.0	12.5	12.2	11.7	14.0	11.8
12.8	14.4	15.2	15.1	23.5	15.4	26.2	12.1	15.2	11.7	14.3	11.4
17.1	14.3	24.4	15.1	31.1	15.2	28.7	11.9	18.3	11.7	15.8	11.3
21.3	14.6	29.3	15.2	39.9	14.9	31.1	11.8	21.3	11.8	18.3	11.4
27.4	15.2	33.5	14.9	46.3	14.5	33.5	11.7	24.4	11.9	21.3	11.5
34.4	15.9	39.6	14.1	50.0	12.5	39.6	11.6	30.5	11.9	24.4	11.4
37.2	15.6	42.7	14.1	52.4	12.0	45.7	11.8	39.6	12.2	27.4	11.5
40.2	15.8	43.9	13.9	56.1	11.7	51.8	11.7	43.3	12.2	29.6	11.6
44.5	15.9	46.6	12.5	57.0	11.6	57.9	11.7	47.2	12.1	31.7	11.7
50.0	15.6	48.8	12.0	61.6	11.5	61.0	11.9	51.8	12.4	34.4	11.7
53.6	15.6	52.7	11.8	66.4	11.6	64.6	12.5	54.9	12.8	37.8	11.7
61.0	13.3	53.6	11.5	68.3	11.8	69.5	13.5	57.9	12.6	41.5	11.7
65.2	13.4	57.9	11.5	70.7	12.1	77.7	13.5	65.5	13.0	45.1	11.9
65.8	13.6	61.0	11.7	73.2	12.2	78.6	14.1	70.7	13.6	48.8	12.0
68.9	13.5	67.1	11.8	73.8	12.1	79.6	14.4	84.4	14.0	53.3	12.2
71.9	13.7	70.1	11.9	76.5	12.5	83.2	14.4	86.6	13.8	56.1	12.1
74.4	13.6	71.9	12.1	77.1	12.5	85.0	14.3	91.4	14.1	60.0	12.2
78.0	13.7	75.6	13.0	77.4	12.5	86.3	13.7	98.1	14.4	62.2	12.3
79.9	13.5	77.7	12.5	78.9	12.3	91.4	13.9	101.2	14.6	65.2	12.5
82.9	13.3	81.1	13.1	81.4	12.5	94.8	13.8	105.5	15.1	73.2	12.8
86.6	13.8	83.5	13.4	84.7	12.7	97.8	14.0	108.2	14.9	77.7	13.1
86.9	14.1	86.3	13.1	87.2	12.9	102.1	14.0	110.6	14.9	82.9	13.2
89.9	14.3	88.4	14.1	96.3	13.7	105.2	14.7	112.5	15.1	86.3	13.0
94.5	14.4	92.0	14.1	101.2	13.7	107.3	14.9	117.0	15.7	91.4	13.0
95.7	14.1	95.1	15.6	106.7	14.0					103.3	13.1
98.5	14.6	99.4	16.0	110.0	13.7						
100.9	14.4	105.2	16.0	114.3	14.0						
107.0	14.4	106.4	16.4	118.0	14.1						
107.3	15.0	109.7	14.7	122.5	14.5						
		113.4	14.2	124.4	15.0						
		117.0	14.0	125.9	15.8						
		119.5	15.3								
		121.0	16.3								
		123.1	15.4								
		126.2	15.7								
		128.9	17.8								
		129.5	17.4								

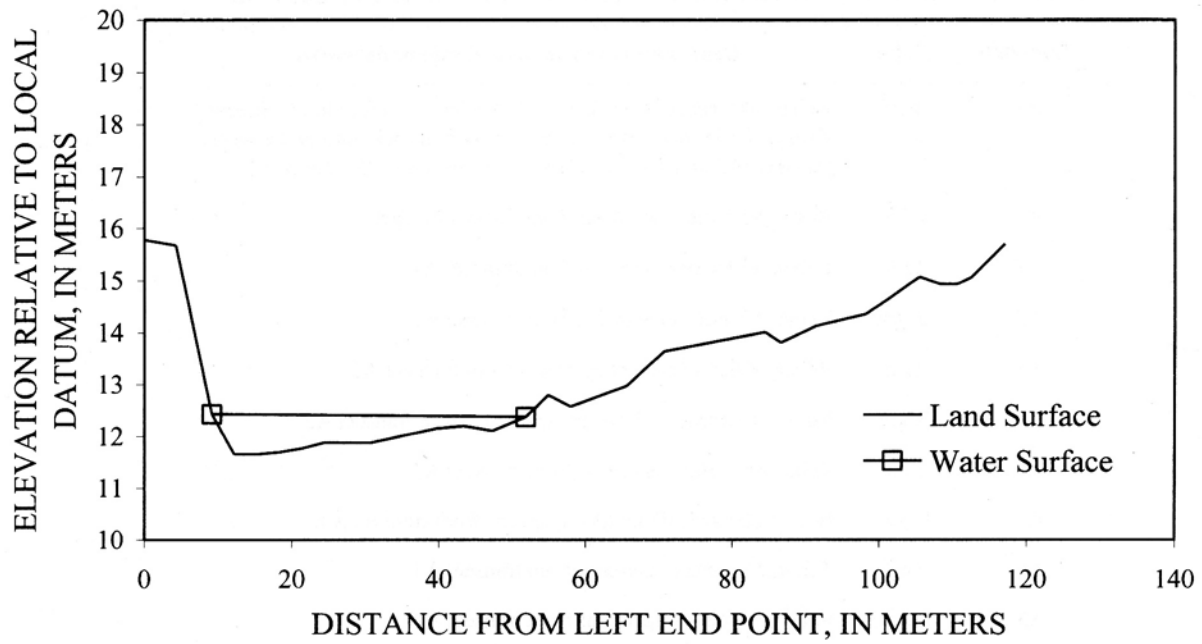


**Figure 69A–F.** Cross sections of channel, reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, July 29, 1998. *A*, Transect A1. *B*, Transect A2. *C*, Transect A3. *D*, Transect A4. *E*, Transect A5. *F*, Transect A6. Local datum established using arbitrary elevation.



**Figure 69A–F.** Continued.

### E. Transect A5



### F. Transect A6

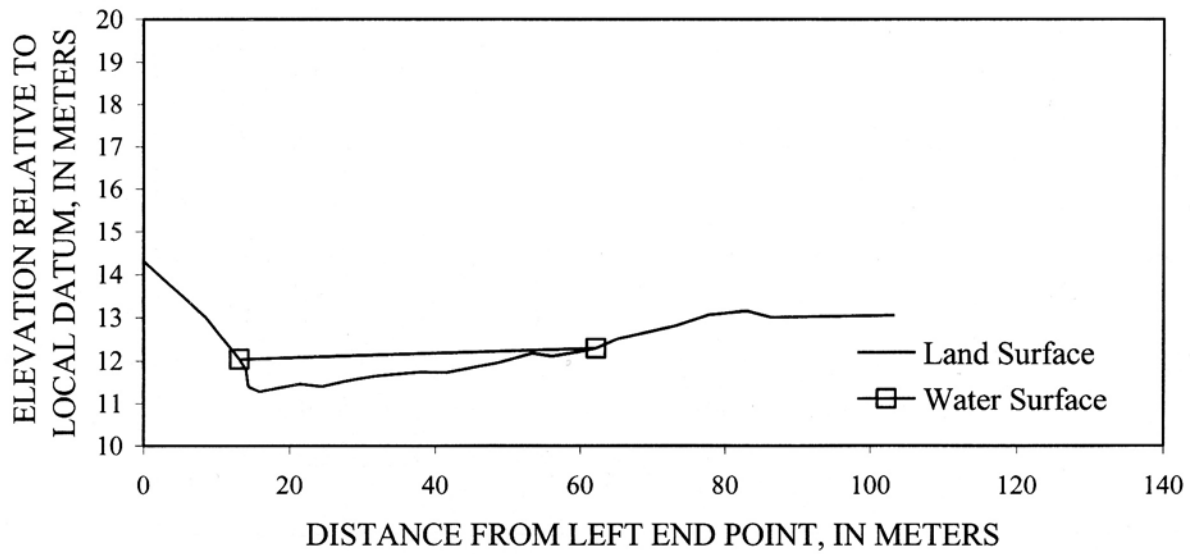


Figure 69A–F. Continued.

**Table 60.** Description and location of semipermanent monuments for reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, July 29, 1998

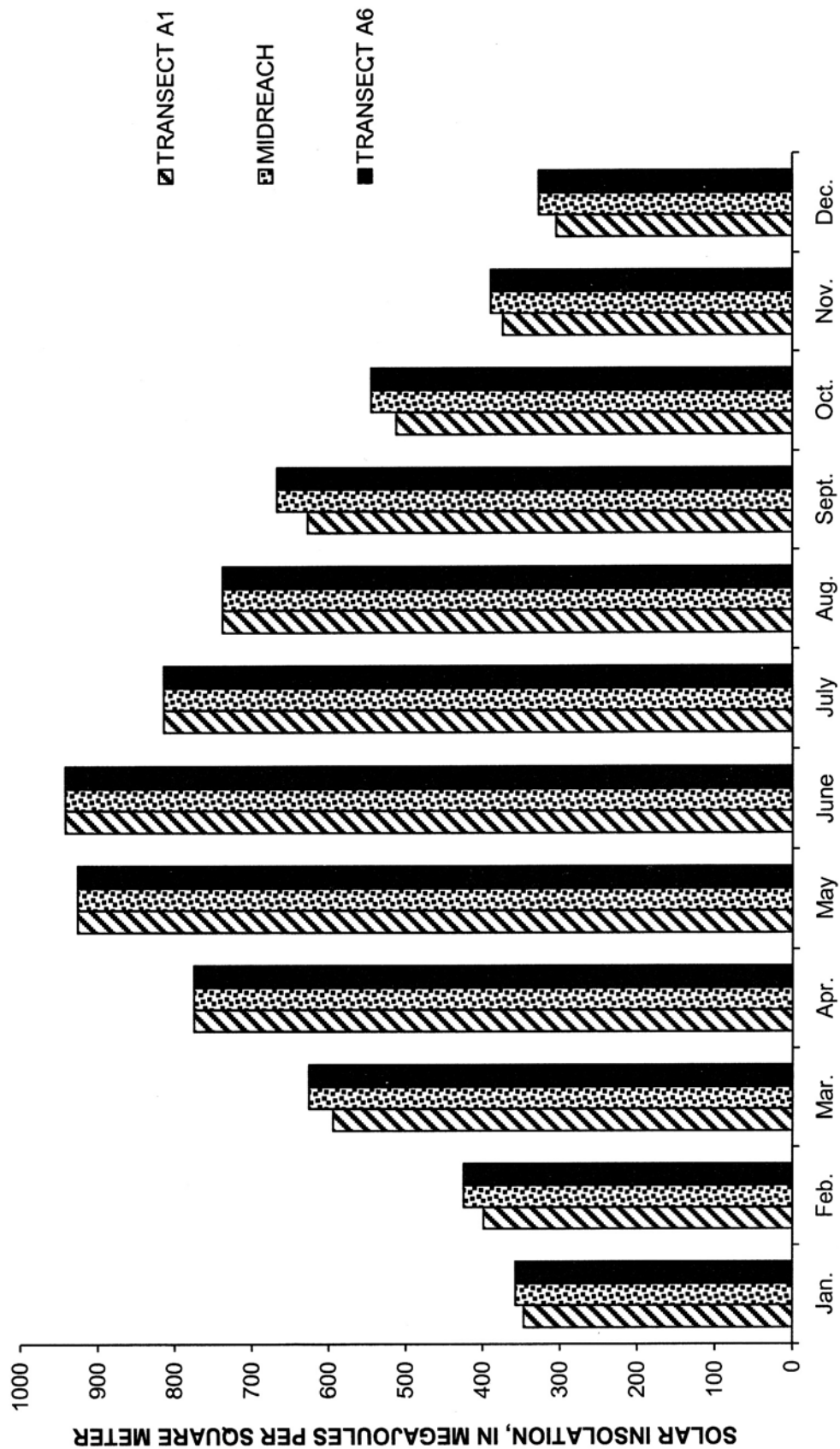
Transect	Type	Description of location and reference marks
A1	Left	Rebar. Reference-mark 1 is cable anchor on left side of Sheeps Bridge. Reference-mark 2 is bolt in rock in rock outcrop between transects A3 and A4 on high bank. Elevation is 25.87 meters.
A1	Right	Rebar, 47 meters upstream from Sheeps Bridge.
A2	Left	Rebar, 47 meters upstream from transect A1.
A2	Right	Rebar, 47 meters upstream from transect A1.
A3	Left	Rebar about 45 meters upstream from transect A2.
A3	Right	Rebar, in bedrock 45 meters upstream from transect A2.
A4	Left	Rebar, 65 meters upstream from transect A3.
A4	Right	Bolt in bedrock, 65 meters upstream from transect A3.
A5	Left	Rebar, 56 meters upstream from transect A4.
A5	Right	Rebar, 56 meters upstream from transect A4.
A6	Left	Rebar, 139 meters upstream from transect A5.
A6	Right	Rebar, 139 meters upstream from transect A5.

**Table 61.** Habitat characteristics of reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, January 31, 1996

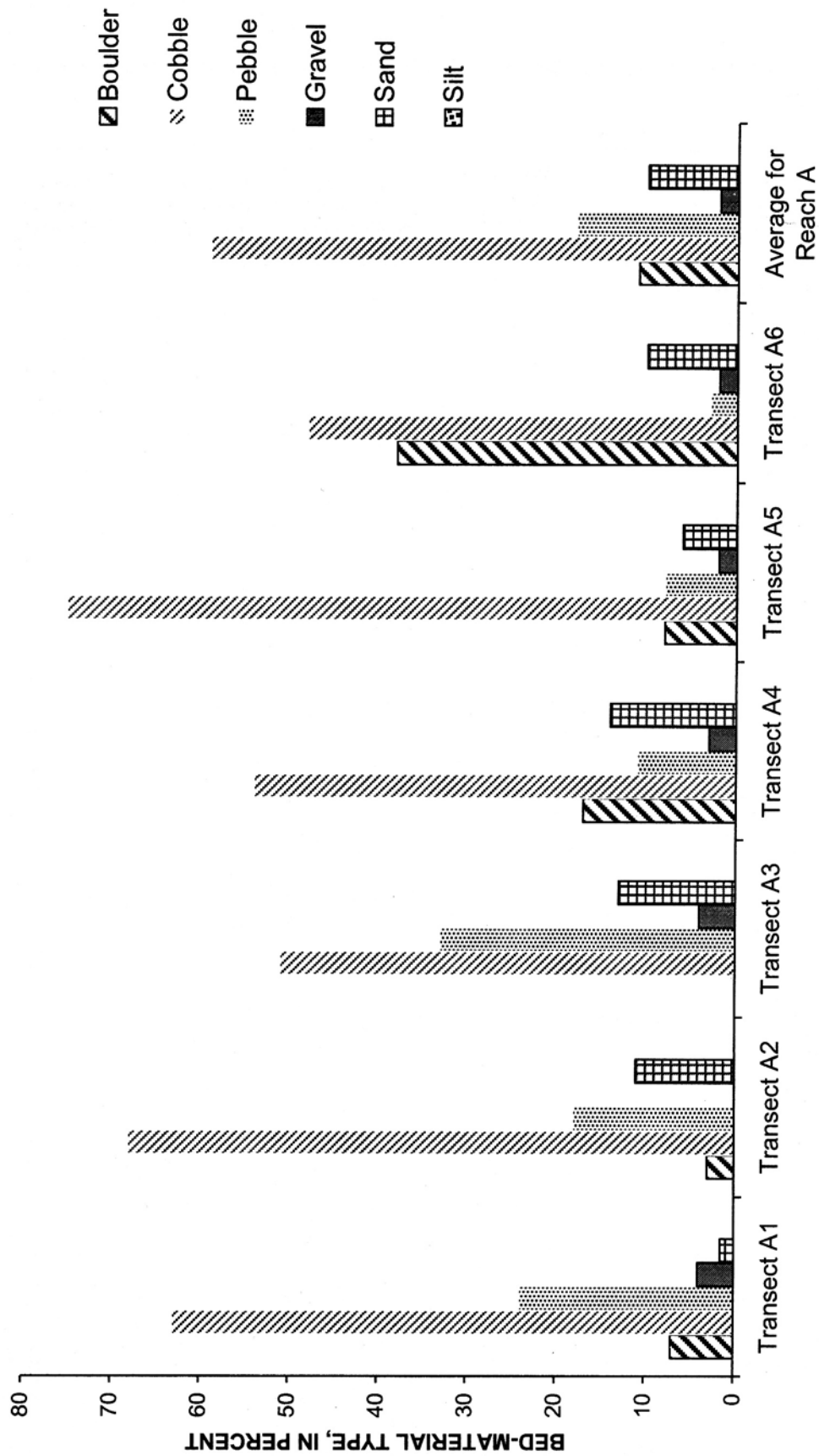
[Embeddedness categories: 2, 51 to 75 percent covered by fine sediment; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment; 5, less than 5 percent covered by fine sediment]

Width of wetted channel, in meters	Aspect, in degrees	Canopy		Velocity			Substrate		
		Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Riffle)									
46.9	133	156	18	3.5	<sup>1</sup> 0.67	0.82	Cobble	Boulder	5
				14.0	.46	1.20	Cobble	Gravel	5
				26.0	.18	.45	Cobble	Boulder	5
Transect 2 (Run)									
45.3	175	149	25	5.0	<sup>1</sup> .88	.90	Cobble	Sand	4
				18.0	.29	.34	Cobble	Sand	4
				31.0	.27	.42	Cobble	Sand	4
Transect 3 (Run)									
42.8	166	160	3	4.9	<sup>1</sup> .72	.40	Cobble	Sand	4
				22.0	.41	.32	Cobble	Sand	4
				34.0	.61	.46	Cobble	Sand	4
Transect 4 (Run)									
32.3	167	156	15	9.2	<sup>1</sup> .85	.60	Cobble	Sand	3
				15.0	.83	.56	Cobble	Boulder	3
				21.0	.42	.28	Boulder	Cobble	2
Transect 5 (Run)									
24.4	155	156	10	4.4	.79	.65	Boulder	Cobble	3
				8.8	<sup>1</sup> .98	.70	Cobble	Sand	3
				13.3	.78	.78	Cobble	Boulder	3
Transect 6 (Riffle)									
31.6	109	157	13	5.8	<sup>1</sup> .65	1.01	Boulder	Cobble	2
				17.1	.47	.90	Boulder	Cobble	3
				25.3	.59	.47	Boulder	Cobble	3

<sup>1</sup>Thalweg.



**Figure 70.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, based on measurements made January 31, 1996.



**Figure 71.** Bed-material types at transects 1–6 and average for reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, January 31, 1996.



**Table 62.** Density and dominance of woody vegetation for reach A, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, January 31, 1996

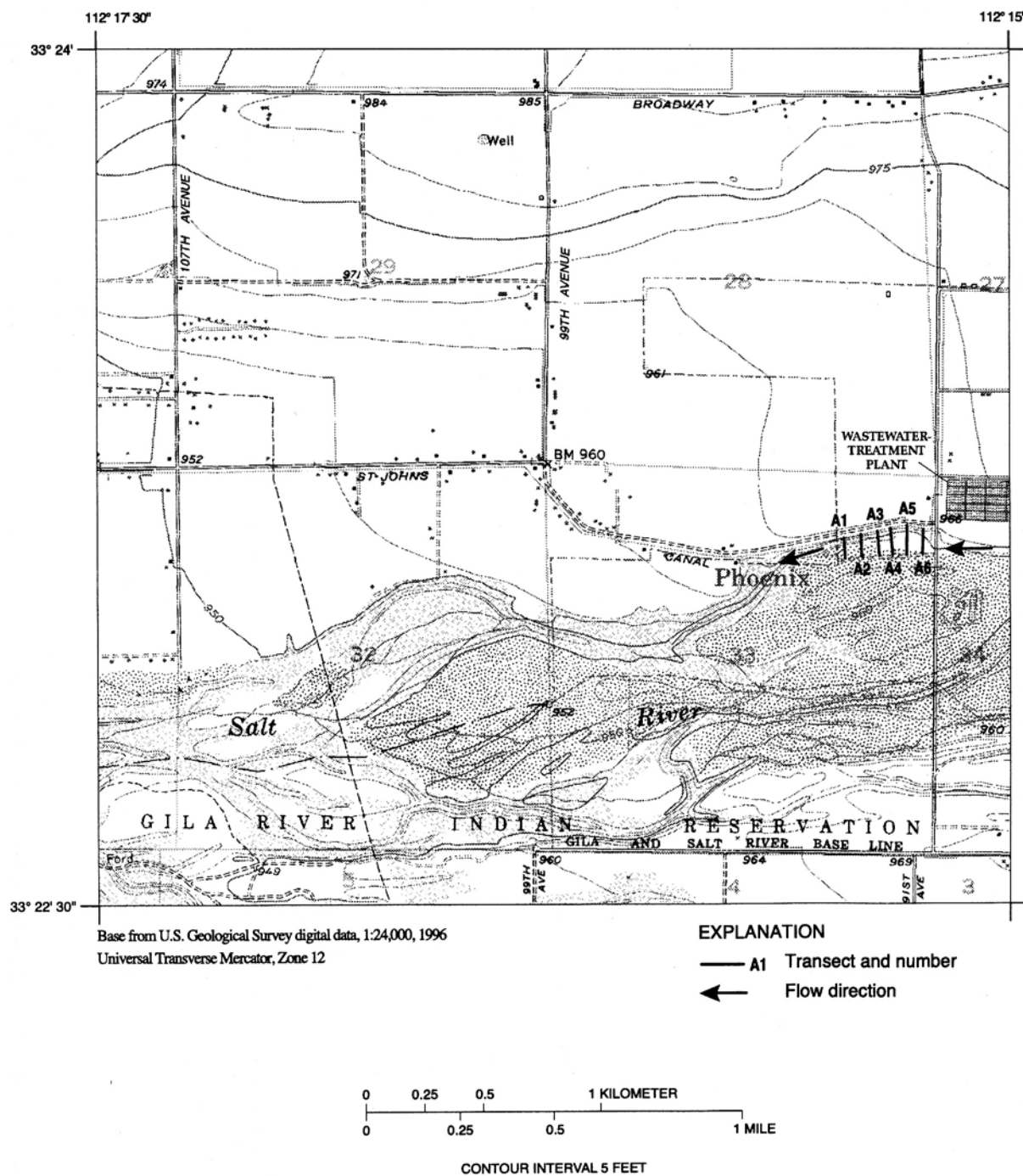
[Length of reach, 355 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Fremont cottonwood ( <i>Populus fremontii</i> )	13	0	8	3
Mesquite ( <i>Prosopis sp.</i> )	380	8	8	3
Tamarisk ( <i>Tamarix sp.</i> )	33	2	8	7
Willow ( <i>Salix sp.</i> )	238	159	83	86

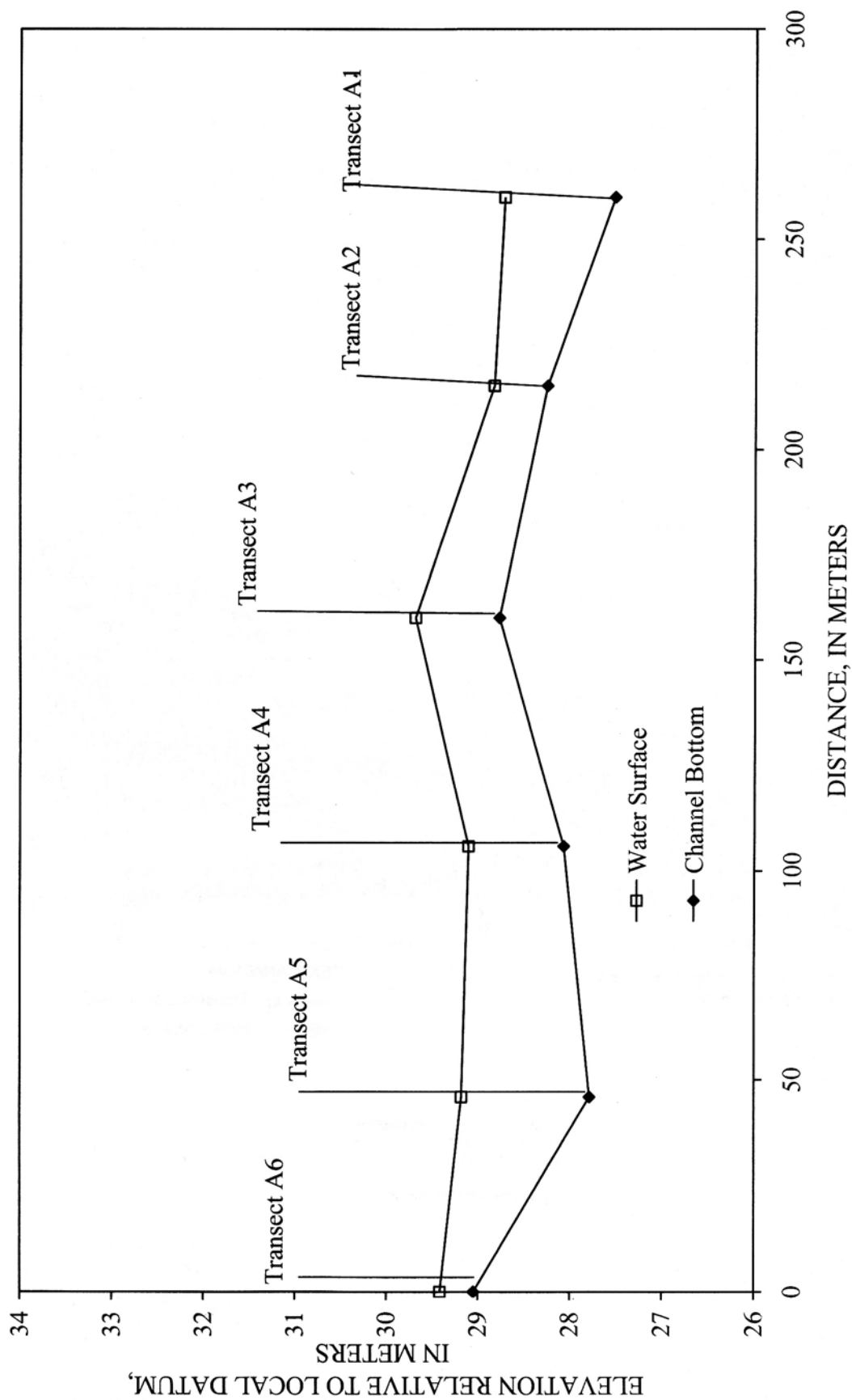
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**91st Avenue Wastewater-Treatment Plant Outfall near Phoenix, Arizona**  
**(USGS station number: 09512407)**

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**Figure 72.** Location of transects 1–6, reach A, 91st Avenue wastewater-treatment plant outfall near Phoenix, Arizona.

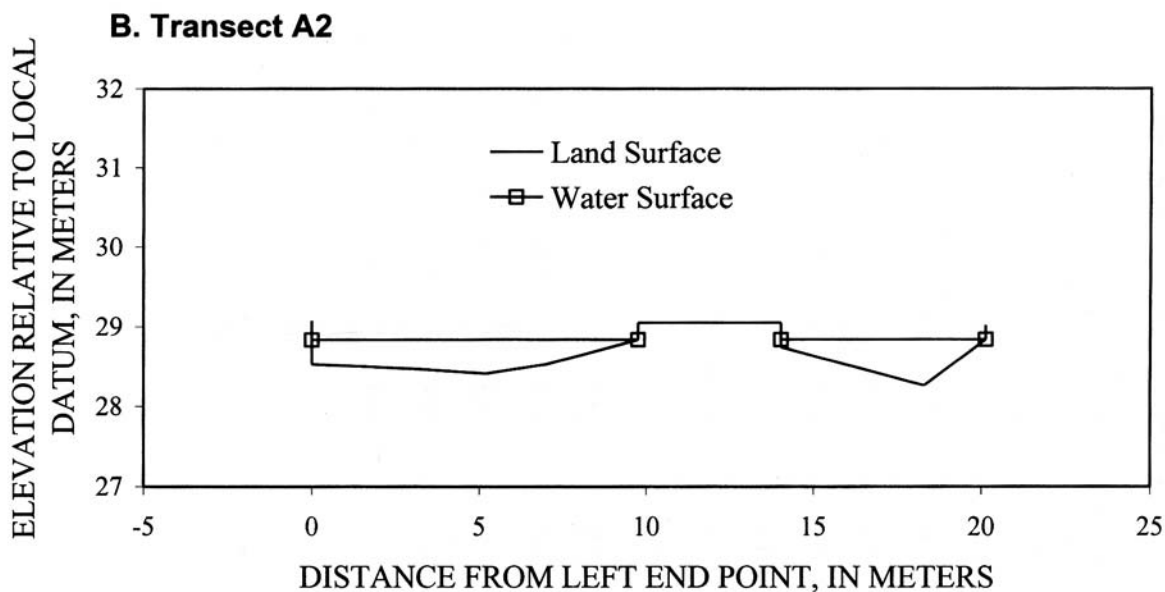
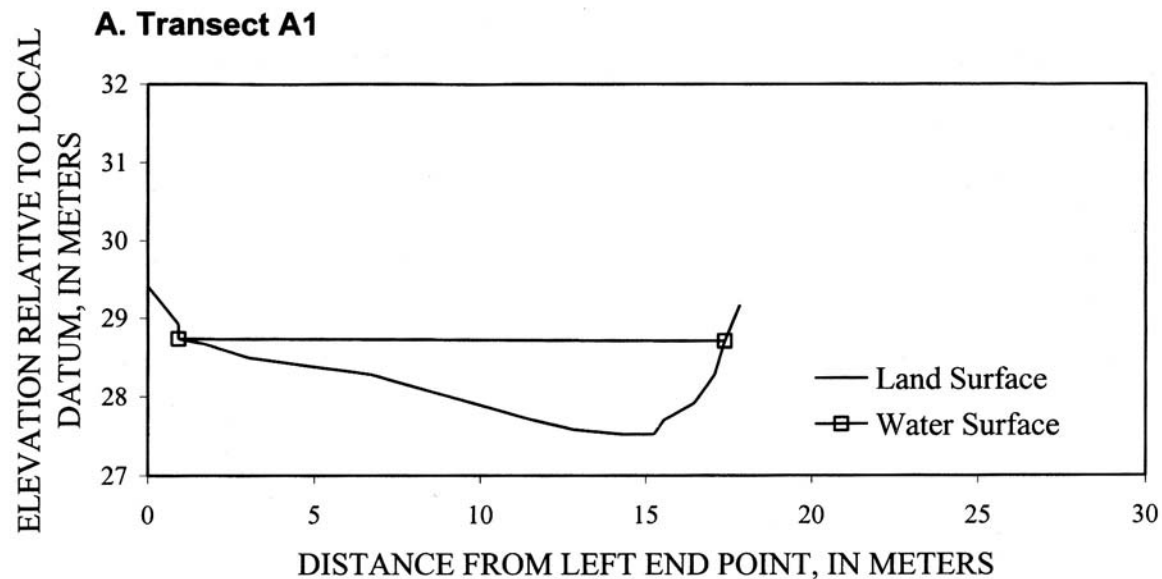


**Figure 73.** Longitudinal profile, reach A, 91st Avenue wastewater-treatment plant outfall near Phoenix, Arizona, October 21 and 22, 1997. Local datum established using arbitrary elevation.

**Table 63.** Cross-sectional survey data for reach A, 91st Avenue wastewater-treatment plant outfall near Phoenix, Arizona, October 21 and 22, 1997

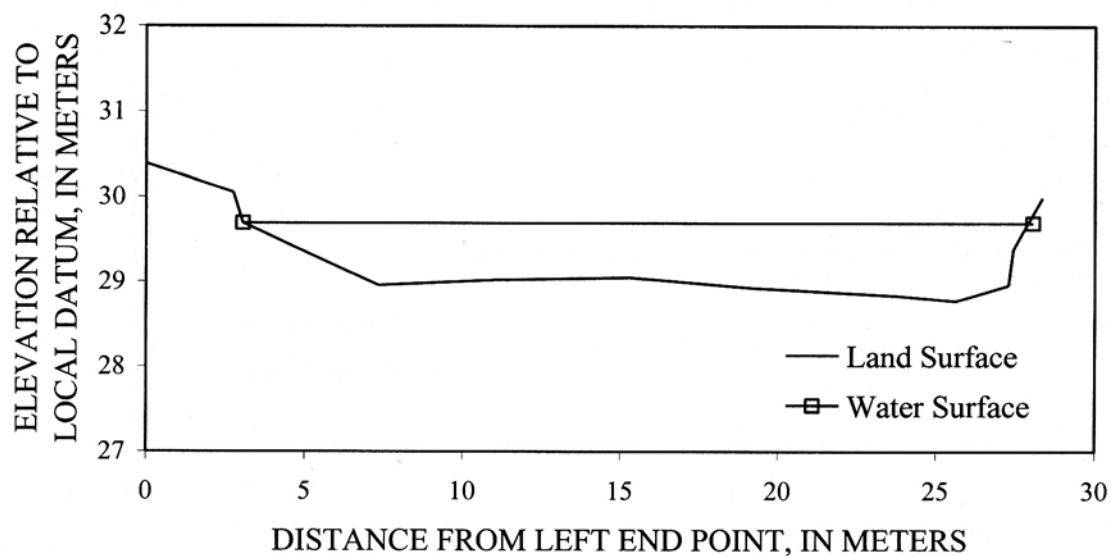
[All values are in meters. Distance is from left end point]

Transect A1		Transect A2		Transect A3		Transect A4		Transect A5		Transect A6	
Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation	Distance	Elevation
0.0	29.4	0.0	29.1	0.0	30.4	0.0	30.4	0.0	30.1	0.0	30.8
.9	28.9	.0	28.5	2.7	30.1	1.8	30.2	2.4	29.1	1.7	30.0
.9	28.7	3.0	28.5	3.0	29.7	1.8	30.0	3.4	28.9	2.1	29.7
1.7	28.7	5.2	28.4	4.3	29.5	3.0	29.8	4.3	28.8	4.6	29.5
3.0	28.5	7.0	28.5	7.3	29.0	3.7	29.7	9.6	28.5	5.2	29.4
6.7	28.3	9.8	28.8	11.0	29.0	5.5	29.6	10.7	28.3	6.9	29.2
9.8	27.9	9.8	29.0	15.2	29.0	8.1	29.8	11.3	28.3	8.2	29.0
11.6	27.7	14.0	29.0	19.2	28.9	11.6	30.0	13.4	28.2	10.1	29.2
12.8	27.6	14.0	28.7	23.8	28.8	14.0	30.0	15.4	28.2	11.3	29.4
14.3	27.5	16.2	28.5	25.6	28.8	15.2	30.0	16.3	28.3	11.7	29.6
15.2	27.5	18.3	28.3	27.3	29.0	16.9	29.9	17.4	28.5	12.2	29.7
15.5	27.7	20.1	28.8	27.4	29.4	19.2	30.0	18.6	28.8	15.2	30.4
16.5	27.9	20.1	29.0	28.3	30.0	19.2	30.3	19.8	29.0	15.2	30.5
17.1	28.3					22.7	30.9	19.8	29.7	16.2	31.2
17.4	28.7							21.3	30.8		
17.8	29.2							22.7	31.0		



**Figure 74A–F.** Cross sections of channel, reach A, 91st Avenue wastewater-treatment plant outfall near Phoenix, Arizona, October 21 and 22, 1997. *A*, Transect A1. *B*, Transect A2. *C*, Transect A3. *D*, Transect A4. *E*, Transect A5. *F*, Transect A6. Local datum established using arbitrary elevation.

### C. Transect A3



### D. Transect A4

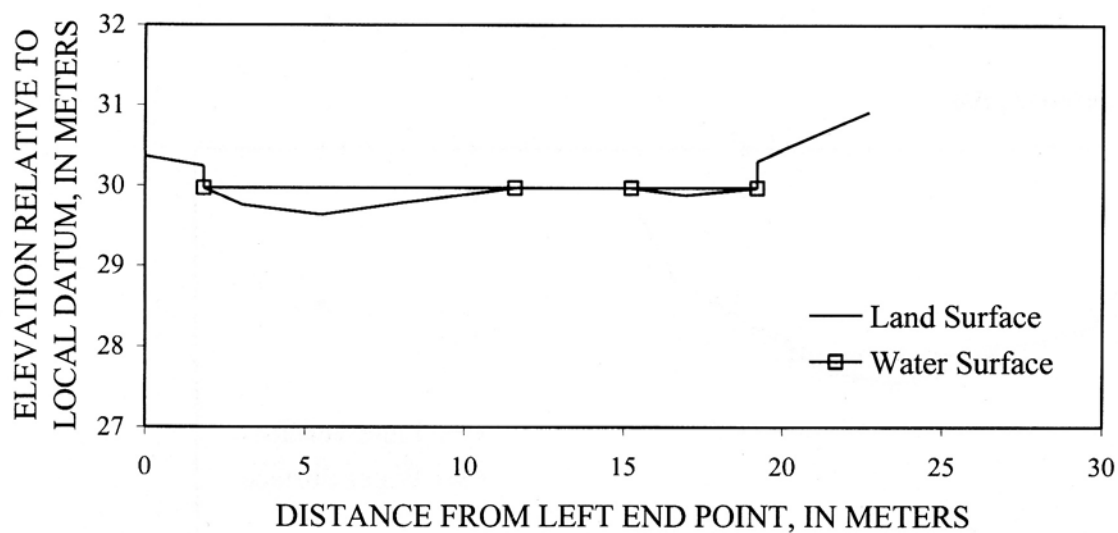
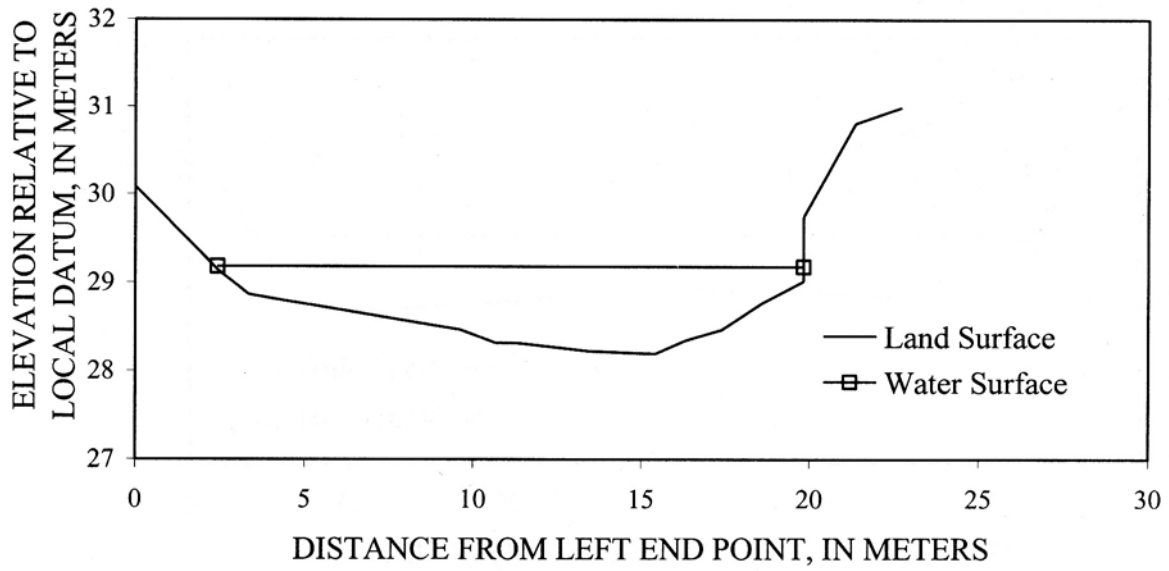
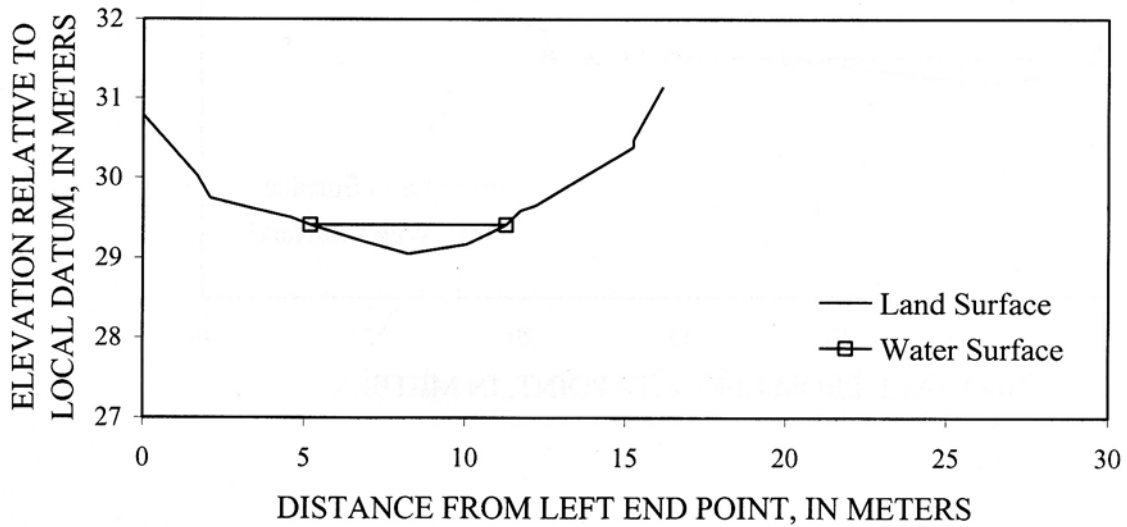


Figure 74A-F. Continued.

**E. Transect A5**



**F. Transect A6**



**Figure 74A–F.** Continued.



**Table 64.** Description and location of semipermanent monuments for reach A, 91st Avenue wastewater-treatment plant outfall, near Phoenix, Arizona, October 21 and 22, 1997

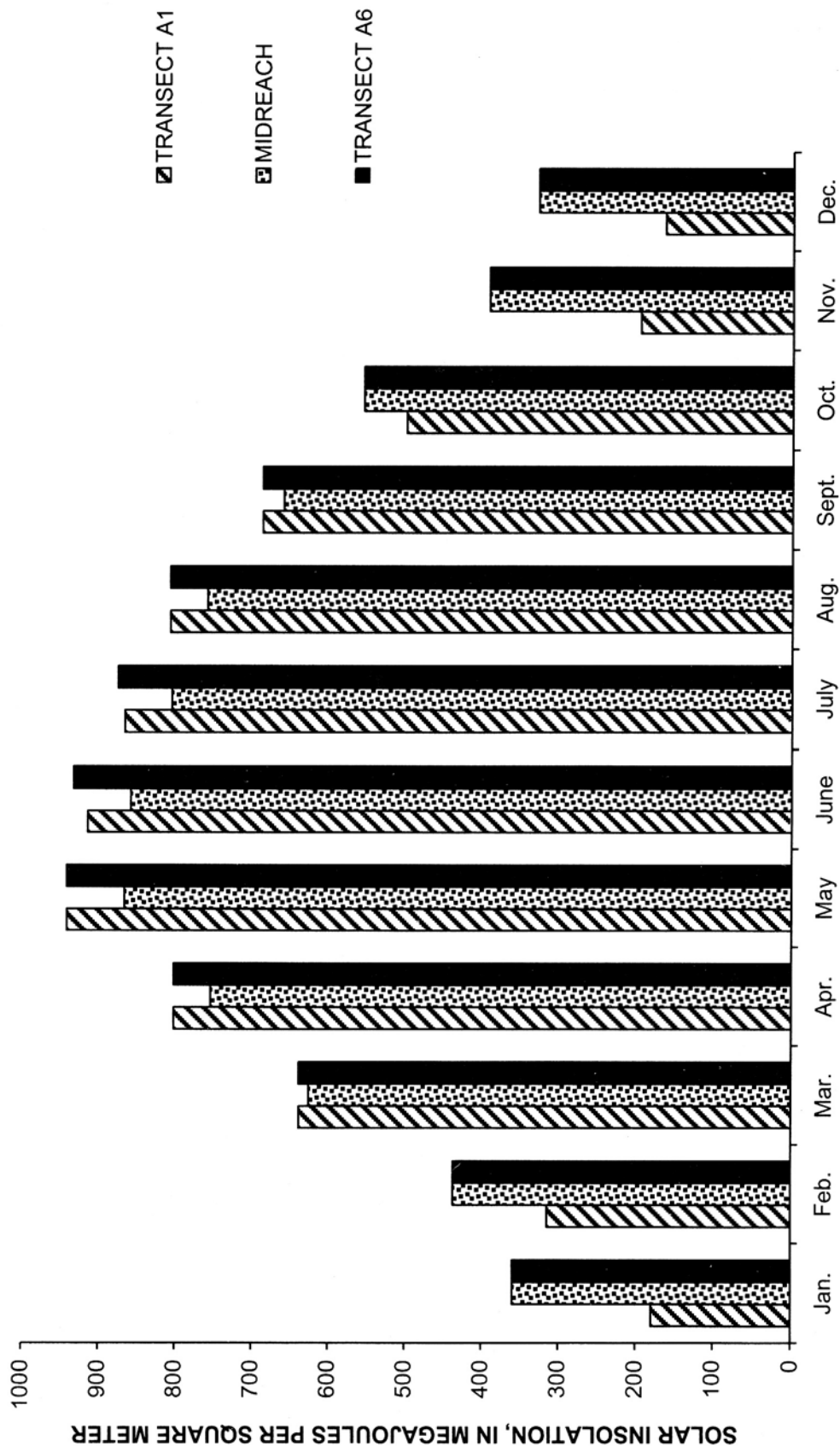
Transect	Type	Description of location and reference marks
RM-1	Brass tablet	Arizona Department of Transportation bench mark on downstream side of road crossing. Elevation, 30.48 meters.
A1	Left	Rebar, 45 meters downstream from transect A2.
A1	Right	Rebar, 45 meters downstream from transect A2.
A2	Left	Rebar, 55 meters downstream from transect A3.
A2	Right	Rebar, 55 meters downstream from transect A3.
A3	Left	Rebar, 54 meters downstream from transect A4.
A3	Right	Rebar, 54 meters downstream from transect A4.
A4	Left	Rebar, 114 meters downstream from transect A5.
A4	Right	Rebar, 114 meters downstream from transect A5.
A5	Left	Rebar, 46 meters downstream from transect A6.
A5	Right	Rebar, 46 meters downstream from transect A6.
A6	Left	Rebar, 38 meters downstream from 91st Avenue.
A6	Right	Rebar, 38 meters downstream from 91st Avenue.

**Table 65.** Habitat characteristics of reach A, 91st Avenue wastewater-treatment plant outfall near Phoenix, Arizona, November 29, 1995

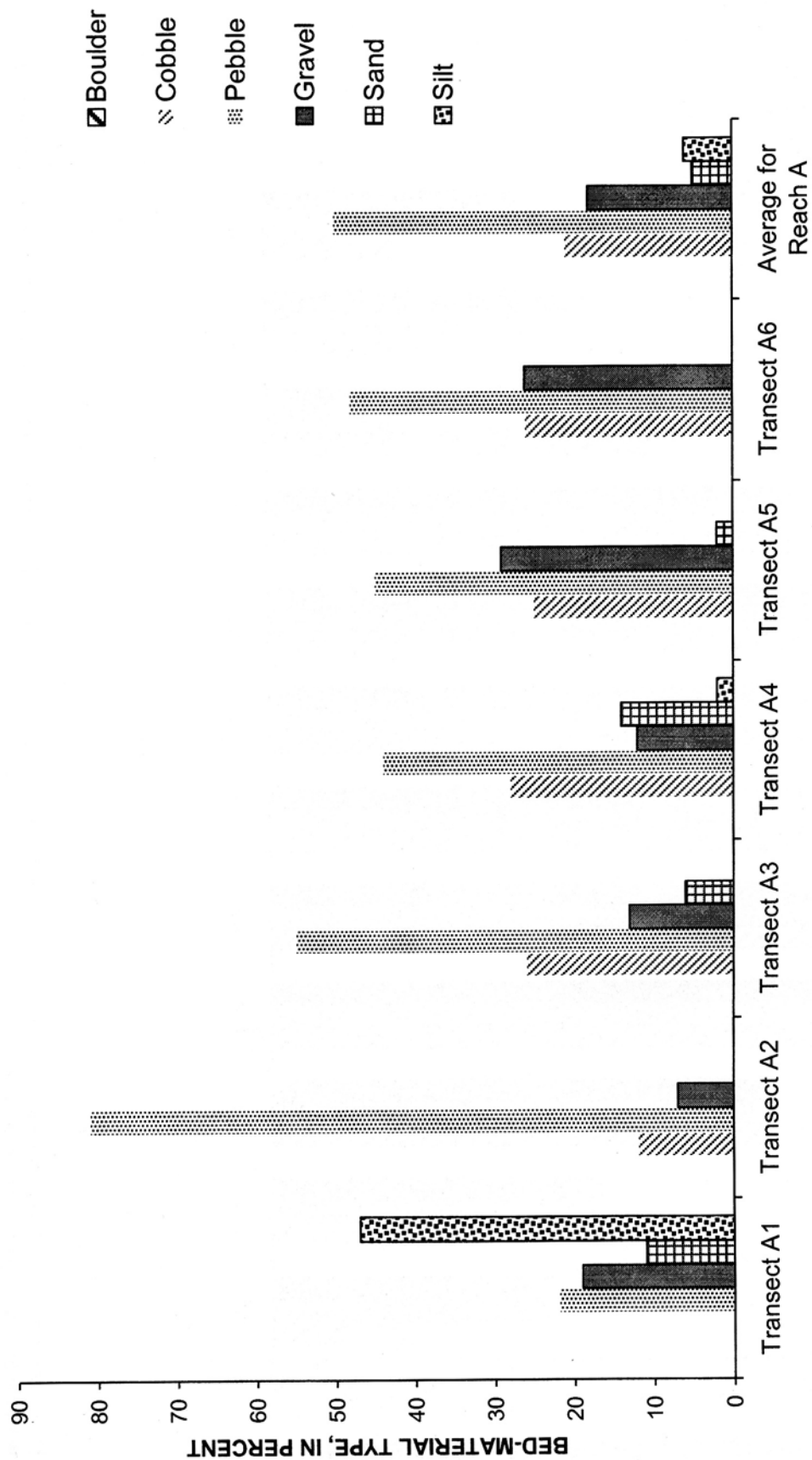
[Embeddedness categories: 0, no gravel, cobbles, or boulders present; 3, 26 to 50 percent covered by fine sediment; 4, 5 to 25 percent covered by fine sediment. Dashes indicate no data. <, less than]

Width of wetted channel, in meters	Aspect, in degrees	Canopy		Velocity			Substrate		
		Angle of opening, in degrees	Density, in percent	Distance from left edge of water, in meters	Depth, in meters	Velocity, in meters per second	Dominant	Subdominant	Embeddedness
Transect 1 (Run)									
15.2	245	66	51	3.2	0.61	0	Gravel	Sand	4
				6.4	.76	<.01	Silt	Sand	0
				9.8	<sup>1</sup> 1.20	.30	Gravel	---	---
Transect 2 (Run)									
18.6	254	149	18	2.1	.43	.94	Cobble	Gravel	4
				4.2	.53	1.02	Cobble	Gravel	4
				17.3	<sup>1</sup> 1.57	1.08	Gravel	Cobble	4
Transect 3 (Run)									
25.2	200	115	48	7.8	.19	1.09	Gravel	Cobble	3
				15.6	.36	.78	Cobble	Gravel	4
				23.4	<sup>1</sup> 1.65	.43	Gravel	Cobble	4
Transect 4 (Run)									
18.4	279	155	25	2.1	<sup>1</sup> 1.85	1.24	---	---	---
				7.5	.40	.99	---	---	4
Transect 5 (Run)									
15.8	296	119	28	4.0	.18	.72	Cobble	Gravel	4
				8.0	.56	1.13	Cobble	Gravel	4
				12.2	<sup>1</sup> 1.69	1.20	---	---	---
Transect 6 (Run)									
46.0	305	115	46	3.0	<sup>1</sup> 1.64	1.25	Cobble	Boulder	4

<sup>1</sup>Thalweg.



**Figure 75.** Monthly distribution of solar insolation at transects 1, 6, and midreach, reach A, 91st Avenue wastewater-treatment plant outfall near Phoenix, Arizona, based on measurements made November 29, 1995.



**Figure 76.** Bed-material types at transects 1–6 and average for reach A, 91st Avenue wastewater-treatment plant outfall near Phoenix, Arizona, November 29, 1995.

**Table 66.** Density and dominance of woody vegetation for reach A, 91st Avenue wastewater-treatment plant outfall near Phoenix, Arizona, November 29, 1995

[Length of reach, 260 meters]

Species name	Mean basal area, in square centimeters	Dominance, in square centimeters	Absolute frequency, in percent	Relative density, in percent
Willow ( <i>Salix sp.</i> )	804	531	50	32
Fremont cottonwood ( <i>Populus fremontii</i> )	661	397	42	29
Tamarisk ( <i>Tamarix sp.</i> )	28	12	42	21
Palo verde ( <i>Cercidium sp.</i> )	23	5	17	11
Tree tobacco ( <i>Nicotiana glauca</i> )	13	2	8	7