UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FLOOD ELEVATIONS FOR THE SOLEDUCK RIVER AT SOL DUC HOT SPRINGS, CLALLAM COUNTY, WASHINGTON

By Leonard M. Nelson

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS REPORT 83-4083

Prepared in cooperation with the
NATIONAL PARK SERVICE

Tacoma, Washington
1983

UNITED STATES DEPARTMENT OF THE INTERIOR
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METRIC CONVERSION FACTORS

Multiply	By	To obtain
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level." NGVD of 1929 is referred to as sea level in this report.

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ABSTRACT

Elevations and inundation areas of a 100-year flood of the Soleduck River, Washington, were determined by the U.S. Geological Survey for the area in the vicinity of the Sol Duc Hot Springs resort, a public facility in the Olympic National Park that under Federal law must be located beyond or protected from damage by a 100-year flood. Results show that most flooding could be eliminated by raising parts of an existing dike. In general, little flood damage is expected, except at the southern end of an undeveloped airstrip that could become inundated and hazardous due to flow from a tributary. The airstrip is above the 100-year flood of the Soleduck River.

INTRODUCTION

Public facilities constructed on Federal lands or with Federal funds are required by Executive Order 11988 to be located beyond or protected from damage by a 100-year flood. The National Park Service asked the U.S. Geological Survey to determine the elevations and inundation areas of a 100-year flood of the Soleduck River in the vicinity of the Sol Duc Hot Springs resort. The adequacy of dike protection for the developed areas was also investigated.

The resort is located in the Olympic National Park (fig. 1) in northwest Washington, 20 miles southwest (40 miles by road) of the city of Port Angeles and 8 miles southeast (14 miles by road) of Fairholm. During the summer a concessionaire operates a resort at the springs under contract with the National Park Service. The main resort building, with swimming pools, cabins, and a maintenance building, is located on the flood plain southwest of the Soleduck River, and is protected from the floodwaters by a manmade dike. A residence, a six-unit motel, the resort trailer campground, and National Park Service campground are located on the opposite side of the river and lie above the 100-year flood elevation. An airstrip, located 2,500 feet west of the main resort, also lies above the 100-year flood elevation.

The surrounding area is dense forest. Annual rainfall of the area is approximately 100 inches. Flooding generally occurs during the winter months, November through February, when storms originating over the Pacific Ocean produce intense precipitation.

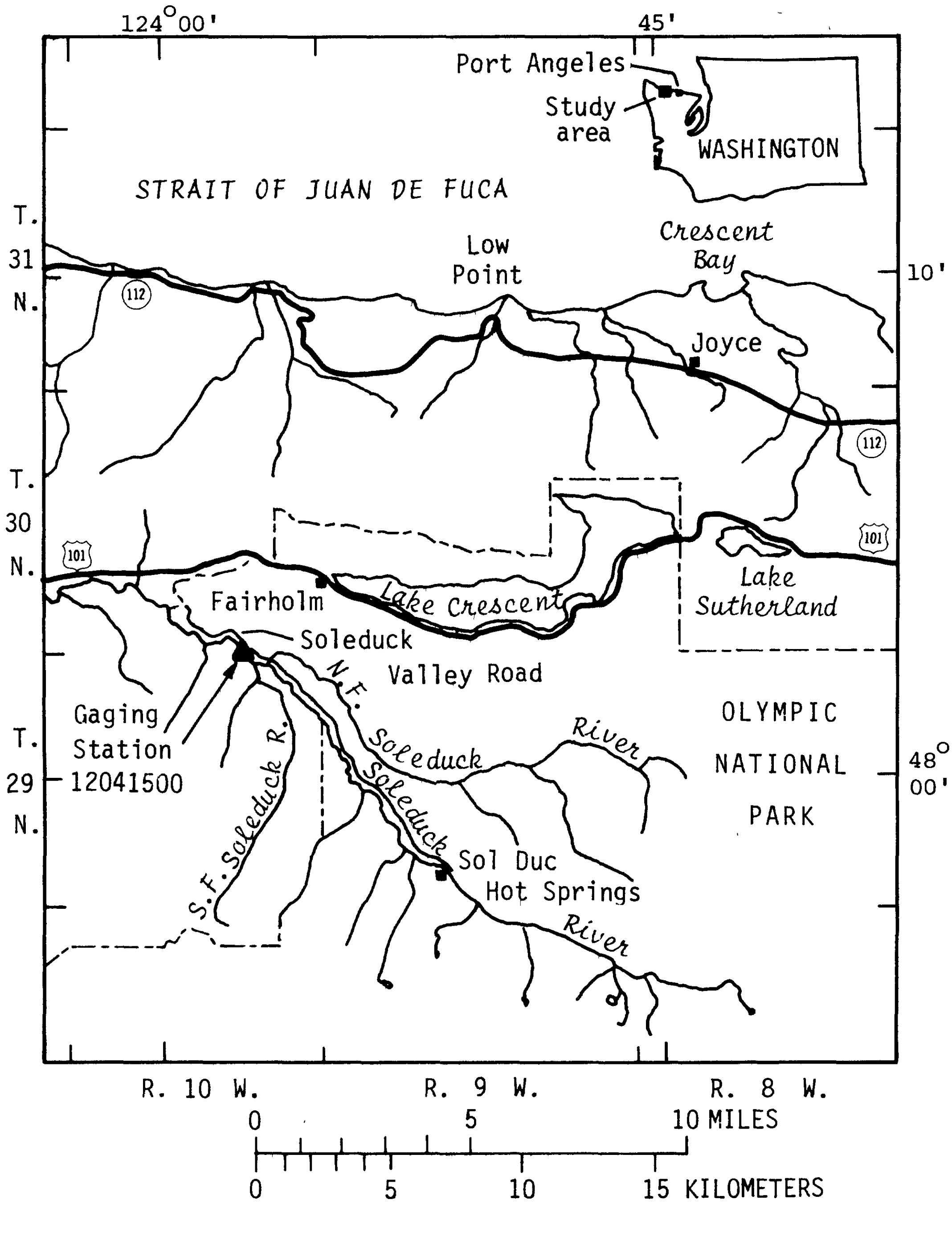

FIGURE 1.--Location of Sol Duc Hot Springs.

HYDROLOGY

Several methods of estimating the 100-year flood for the Soleduck River at the Sol Duc Hot Springs were investigated. The regression equation for the 100-year flood suggested by Moss and Haushild (1978) and the regression equation used in the Clallam County flood insurance study (U.S. Department of Housing and Urban Development, 1980) were studied; the latter was used.

A gaging station, Soleduck River near Fairholm, is located 7.6 miles downstream of Sol Duc Hot Springs and has 48 years of streamflow record. The Soleduck River drains an area of 83.8 mi^2 upstream of the gaging station. The highest discharge during the 48 years was 23,500 ft^3/s on November 26, 1949, and the 100-year flood using the station data is 25,900 ft^3/s.

The values of the 100-year flood using the Moss and Haushild regression and the Clallam County regression were compared with those obtained from the gaging station data. The values obtained from the regressions lie outside the confidence limits computed from the station data; therefore, frequency computations based on the station data were used. However, the Clallam County regression was used as an aid for transferring the 100-year discharge from the gaging station to Sol Duc Hot Springs: the regression values at the Hot Springs were increased by the ratio of the station values to the regression values at the station. The Soleduck River drainage upstream of the Sol Duc Hot Springs is 22.7 mi^2. The 100-year flood was estimated at 7,500 ft^3/s at Sol Duc Hot Springs. This flood has a 1-percent chance of occurring in any one year.

HYDRAULICS

Hydraulic analysis was performed to determine water-surface elevations resulting from passage of the 100-year flood at Sol Duc Hot Springs. The study reach, shown in figures 8 and 9, extends about 6,500 feet, from just upstream of the resort area to about a mile downstream of it, and has a total fall of about 30 feet. The main channel is about 70 feet wide and contains two islands in the lower half of the reach. A low dike is built along the left bank in the vicinity of the resort. The flood plain is 500 to 1,000 feet wide.

Seventeen cross sections of the Soleduck River were surveyed during February 1982 and used in the hydraulic analysis of riverine flooding. Typical cross sections (J, I, D) are shown in figure 2. The elevation and distance data for the cross sections were obtained using vertical and horizontal control from National Park Service drawing No. 149/80,018, a topographic map of the developed part of the resort. The vertical elevations on this drawing were obtained from the U.S. Army Corps of Engineers map-control station RM1 and are referenced to the National Geodetic Vertical Datum of 1929. The horizontal positions and distances are based upon the assumed coordinate system used for the drawing.

The U.S. Geological Survey step-backwater computer program (Shearman, 1976) was used to determine elevations at each of 13 cross sections (table 1) for a peak flood discharge of 7,500 ft^3/s. Cross-section locations are shown in figure 3 and the Thalweg and water-surface profiles are shown in figure 9. The most downstream point of interest in this study is at section A. In order to have a defined starting elevation at section A, water-surface profiles were computed through four cross sections downstream from section A. The hydraulic analysis was based on unobstructed flow. Backwater from debris pileup may cause the flood elevations to be higher in some areas. Channel roughness factors (Manning's n) used in the hydraulic computations were chosen on the basis of field observations. The main channel bed and banks are composed of sand, gravel, and cobbles. The overbank areas are covered with heavy brush, trees, and many fallen trees. Roughness value of 0.035 was used for the main channel, and 0.050 to 0.100 was used for the flood plains. Average water velocities were found to range from 4.3 ft/s at section M to 12.8 ft/s at section H (table 1).

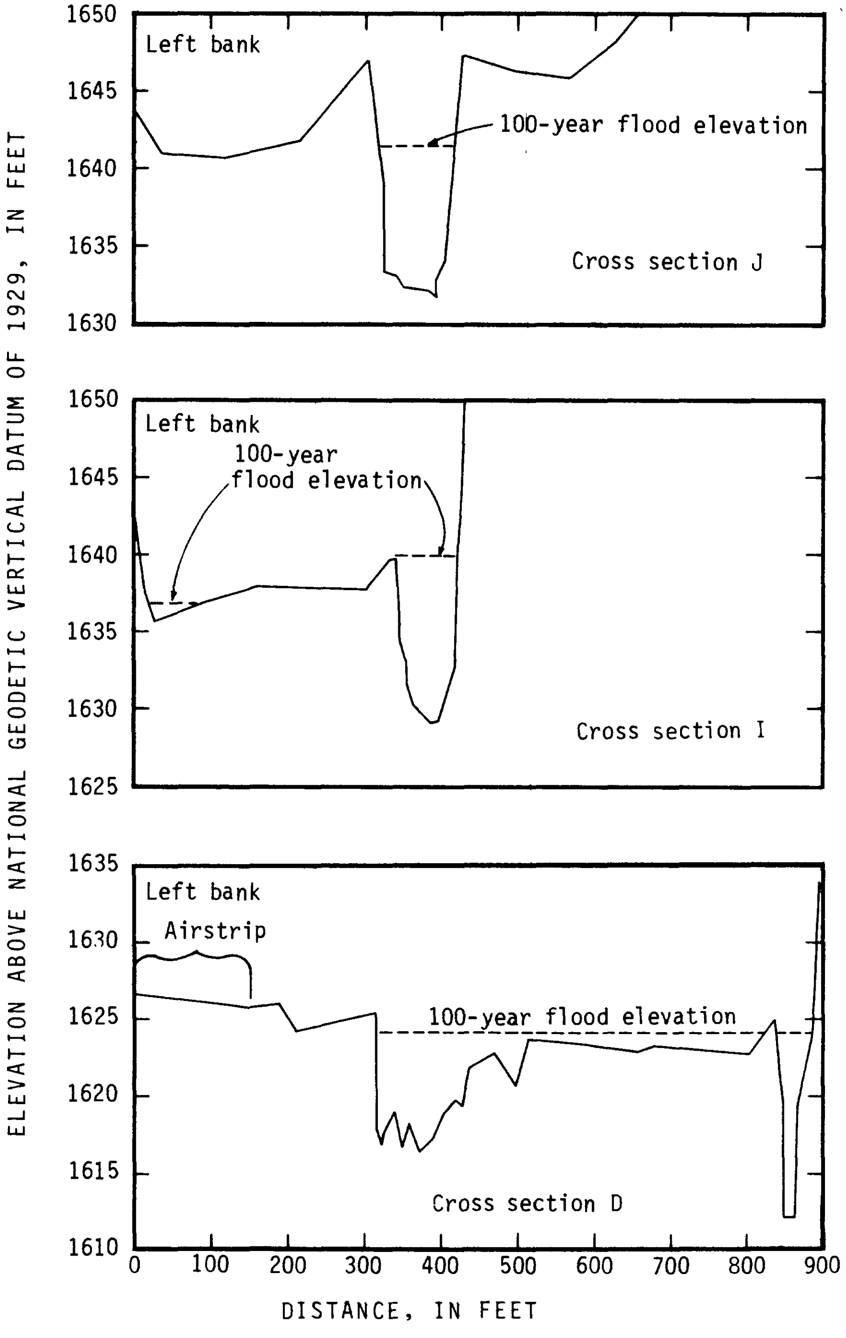

FIGURE 2.--Typical cross sections.

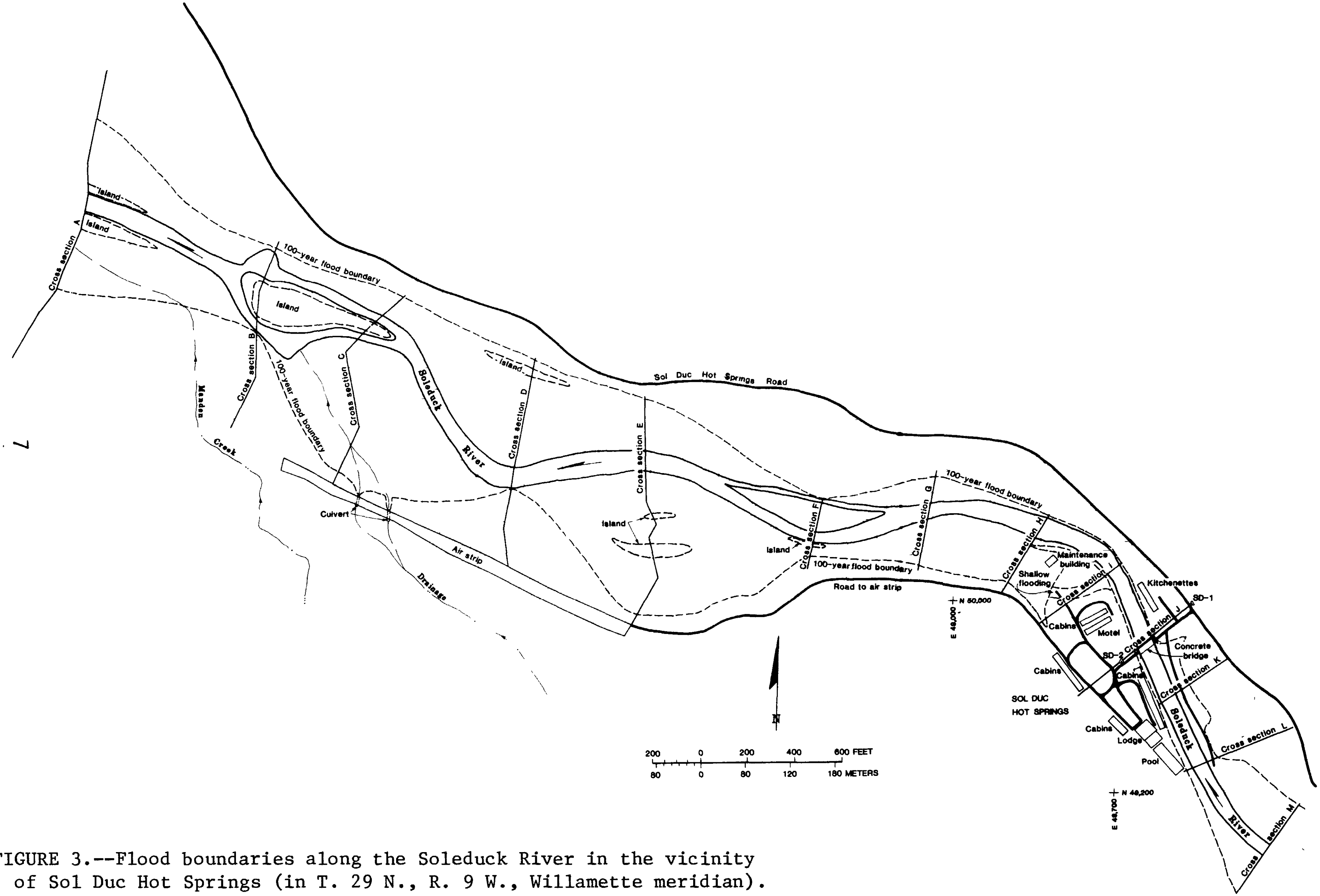

FIGURE 3.--Flood boundaries along the Soleduck River in the vicinity of Sol Duc Hot Springs (in T. 29 N., R. 9 W., Willamette meridian). Horizontal and vertical control taken from National Park Service control markers SD-1 and SD-2. Area between cross sections H and M shown in more detail in figures 4-7.

TABLE 1.--The 100-year flood elevations and velocities of the Soleduck River in the vicinity of the Sol Duc Hot Springs

Cross section (location shown in fig. 3)	100-year flood elevation, in feet above sea level	Average velocity (ft/s)
A	1,606.6	5.5
B	1,612.8	9.7
C	1,617.8	4.8
D	1,624.1	5.6
E	1,627.7	4.6
F	1,631.8	7.2
G	1,634.1	7.6
H	1,636.9	12.8
I	1,640.0	10.4
J	1,641.5	10.2
K	1,642.7	9.4
L	1,643.8	8.8
M	1,646.5	4.3

The 100-year flood boundaries are shown on a flood-boundary map (fig. 3) and on overlays to drawing 149/80,018 (figs. 4-7). The flood profile is shown in figure 8. The profile and the flood boundaries between cross sections are interpolated from those at the cross sections. The contours shown on drawing 149/80,018 were used as an aid in defining the flood boundaries between cross sections G through M, and a few surveyed ground points were used as an aid elsewhere.

The flows over the flood plain are generally less than 3 feet deep and have velocities (estimated) of less than 3 feet per second. The areas covered by these flows are shown on the overlays to drawing 149/80,018 (figs. 4-7). However, because the ground elevations are not described in the necessary detail except at cross sections, there may be a few places where floodwater may be slightly greater than 3 feet deep. Slightly higher flood elevations probably will occur where small streams are flowing onto the flood plain.

The 100-year flood would cause shallow overflow along the northeast bank upstream of the concrete bridge (cross section "J"). The overflow would not reach any existing building, but could cover some utilities. Little flood damage would be expected because the depths would be shallow and the velocities low. Because it would increase velocities in the main channel and retard local drainage, diking along the northeast bank upstream of the concrete bridge probably would cause accelerated erosion of the banks and ponding of the floodwater.

The dike on the southwest bank protects the resort from most flooding. A small amount of water from a 100-year flood would flow over the dike between cross sections I and J, causing shallow flooding. Very little water would flow through the low spot in the dike near section J. Thus, no shallow flooding from this breach is shown in figure 3. Flooding between sections I and J could be eliminated by raising the dike in two places by approximately 2 feet to match the existing dike line (fig. 8). Because the overflow through the dike breaches is negligible with respect to the total flow, flood elevations would not be increased by containing the flow in the channel at cross sections I and J.

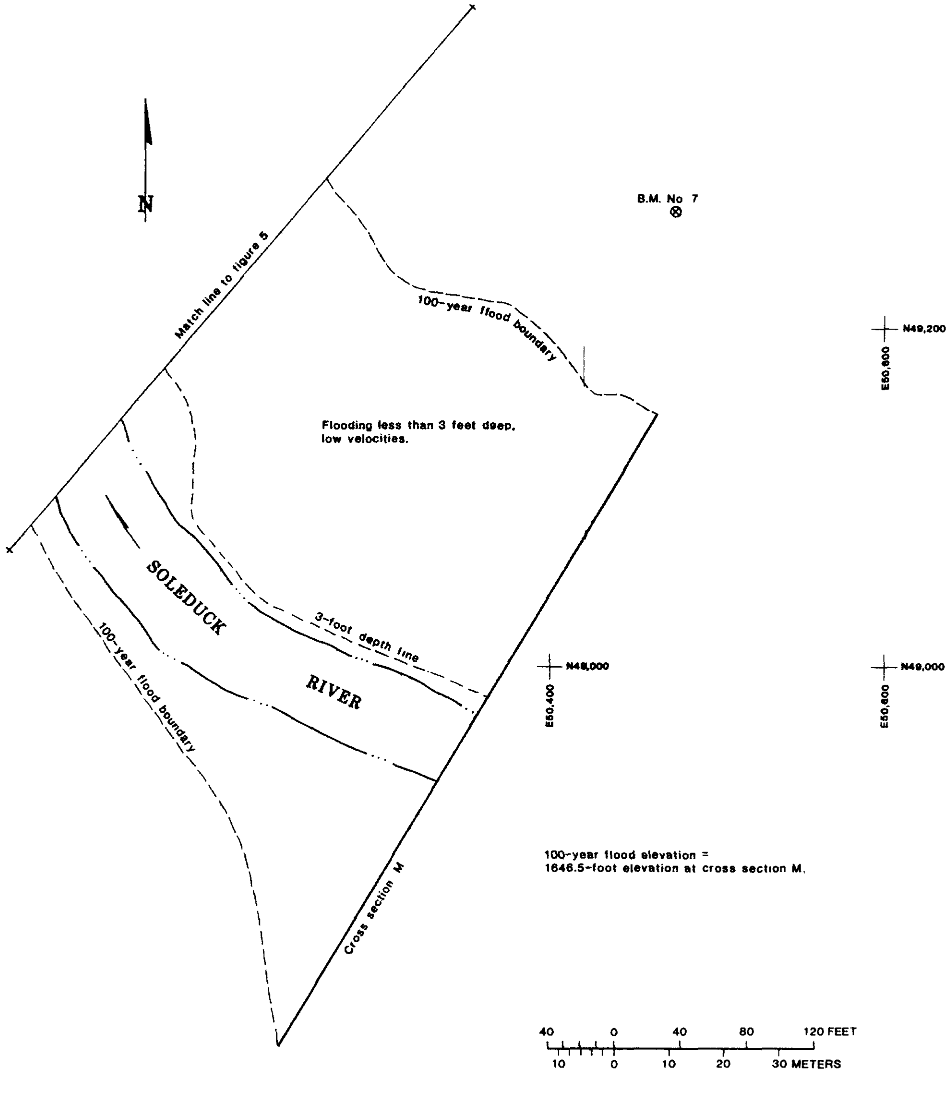

FIGURE 4.--Overlay to National Park Service drawing No. 149/80018 showing flood boundaries for the Soleduck River.

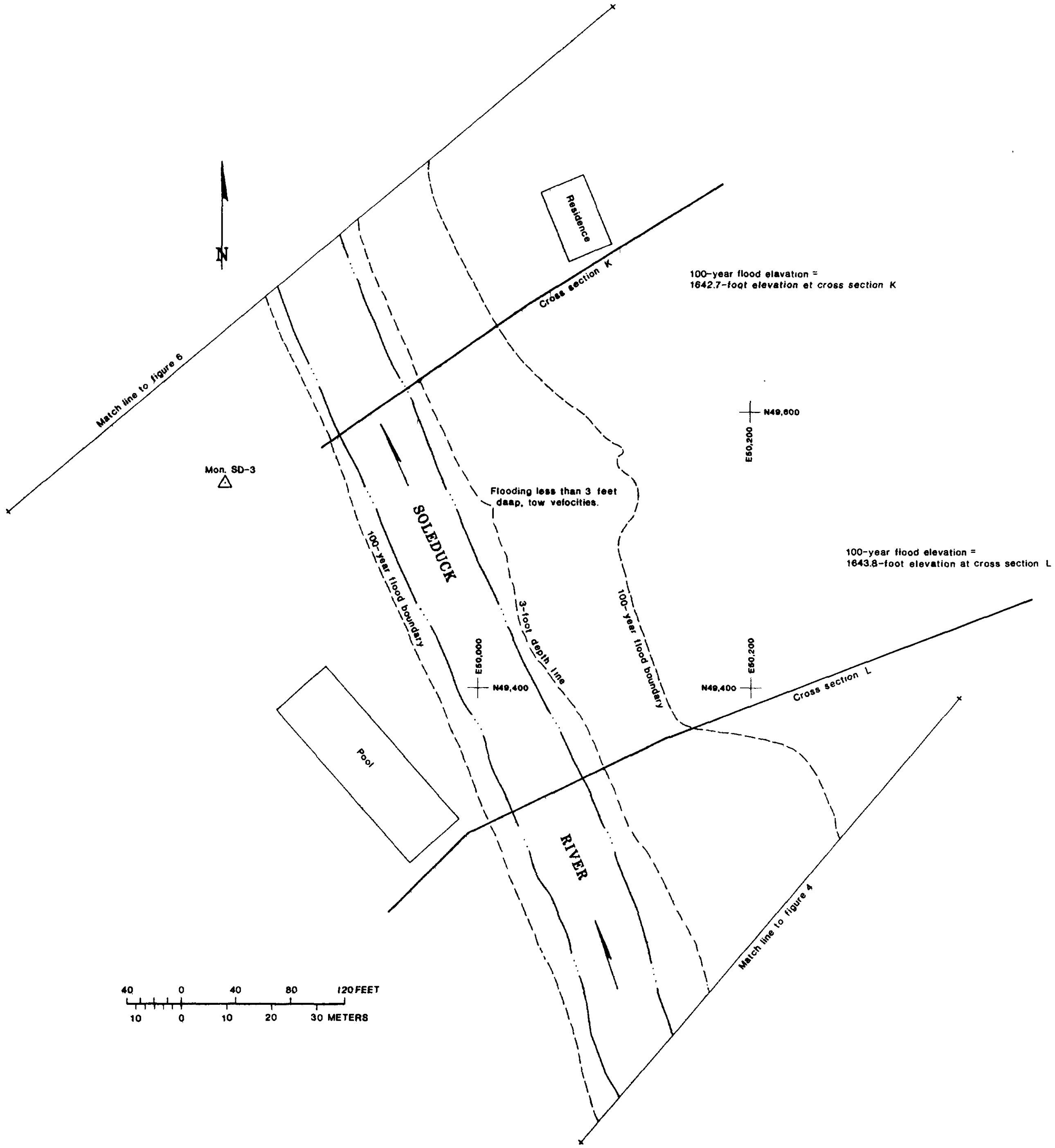

FIGURE 5.--Overlay to National Park Service drawing No. 149/80018 showing flood boundaries for the Soleduck River.

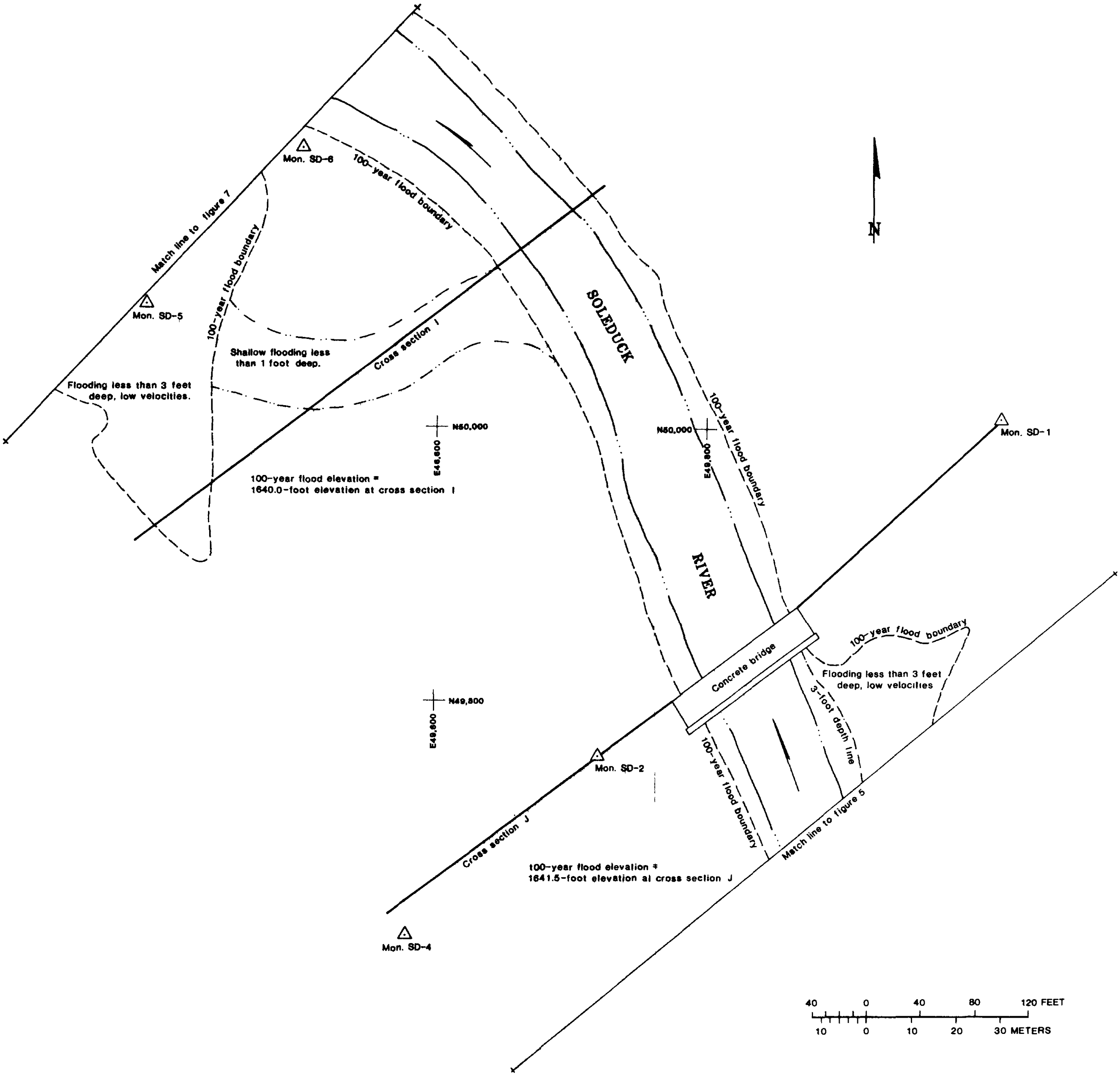

FIGURE 6.--Overlay to National Park Service drawing No. 149/80018 showing flood boundaries for the Soleduck River.

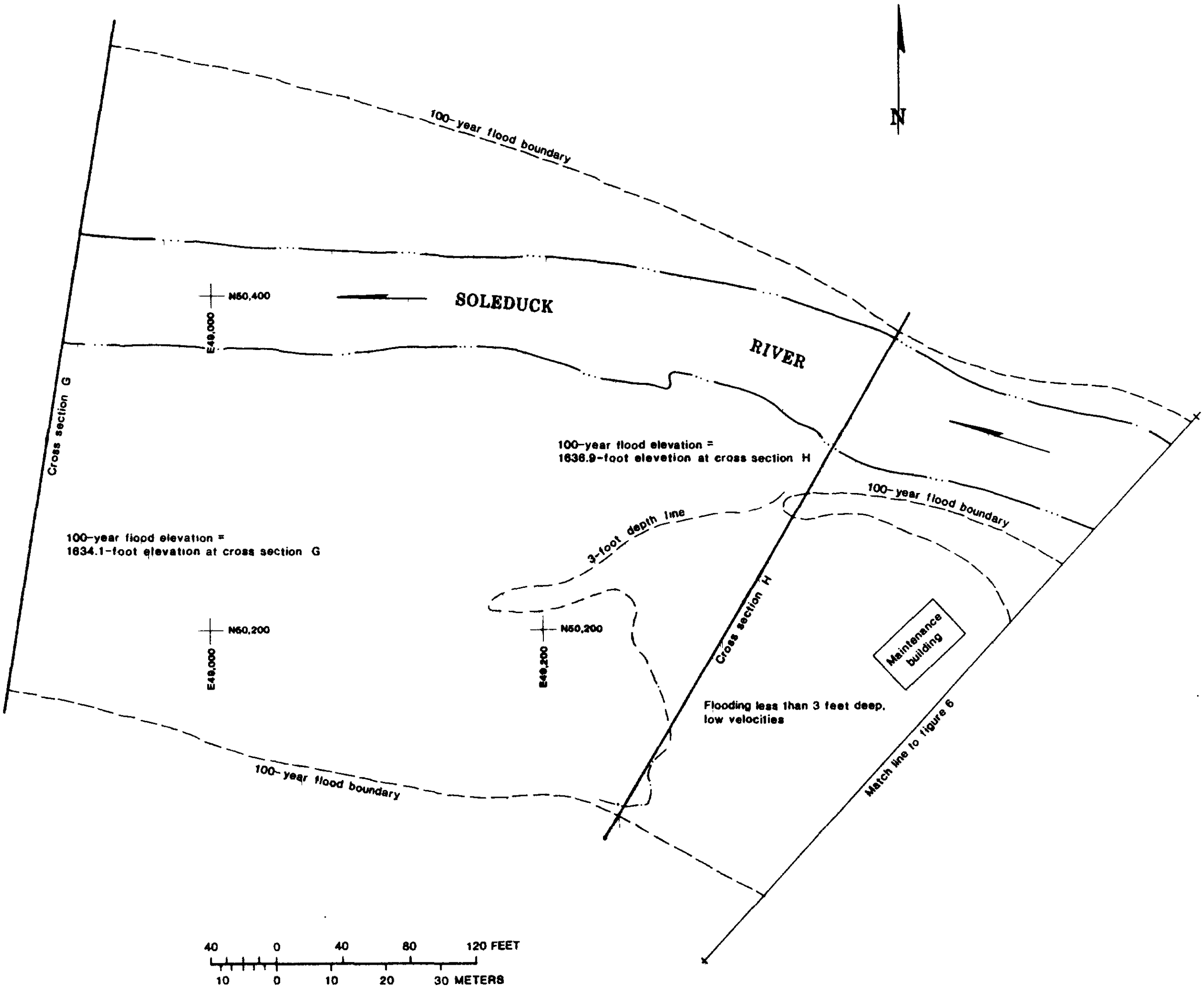

FIGURE 7.--Overlay to National Park Service drawing No. 149/80018 showing flood boundaries for the Soleduck River.

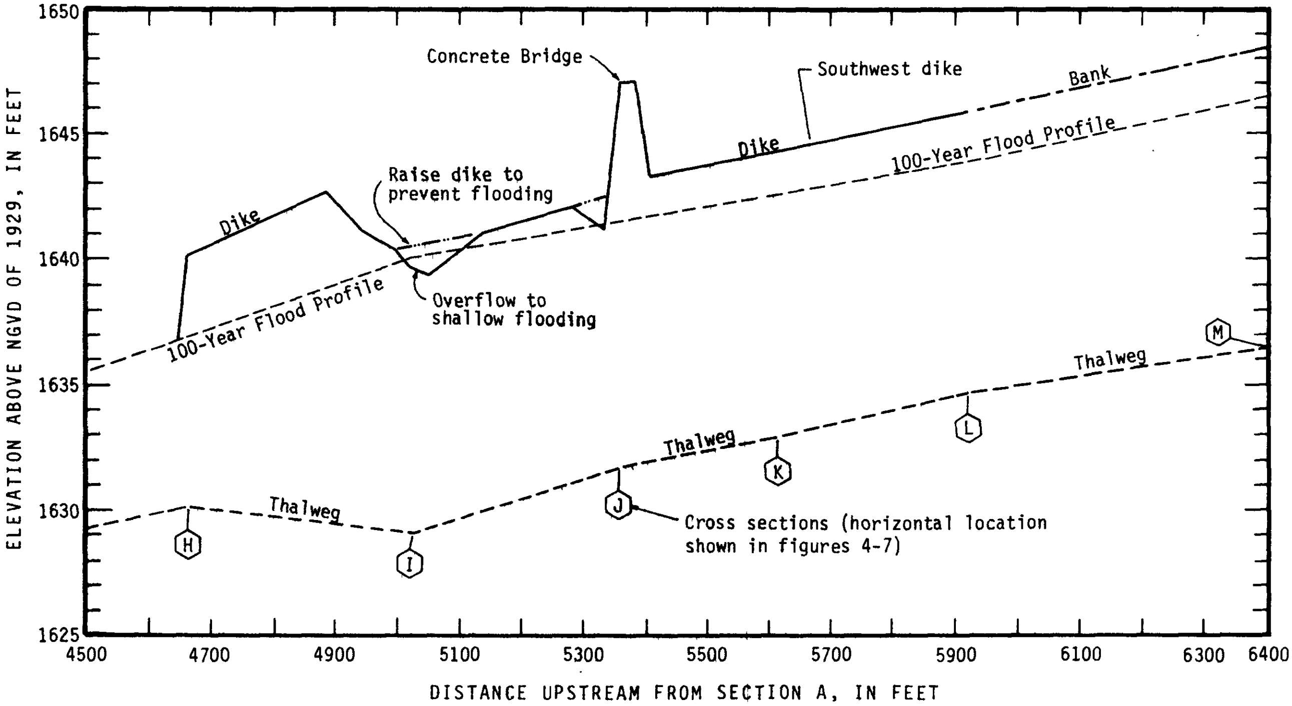

FIGURE 8.--The 100-year flood profile of the Soleduck River along the dike protecting the Sol Duc Hot Springs.

Shallow flooding has been reported at the maintenance building located between cross sections I and H. This flooding probably was caused by a combination of local drainage and slack water from the river. The dike appears to have been built another 200 feet downstream at one time and has been removed in several spots to provide release for local drainage. Replacing this part of the dike could reduce flood elevations from river water on the landward side of the dike. In fact, a dike could encircle all of the developed southwest area if a floodgate were used to release local drainage. Because the extension of the dike downstream would contain the floodwater in the main channel, the elevation of the slack water in the resort area would be lower. The amount of this reduction could be obtained from the profile shown in figure 9 by comparing the elevations at the end of the present dike to that of the extended dike.

The undeveloped airstrip lying between cross sections B and E lies outside the 100-year flood boundary. The area between the airstrip and the river, which is crossed by several small drainages and channels, shows evidence of past flooding. A few areas adjoining and toward the upstream end of the airstrip should be safe for construction of buildings. Manden Creek crosses the valley from the south to join the river near the western end of the airstrip. The overflow from this creek will likely join with local drainage to inundate the western part of the airstrip at times.

An area along the Soleduck River between cross sections C and E that has had previous development may be recommended for trailer camping or overflow parking in the future (Jeff Swan, National Park Service, written commun., 1982). Part of the area is subject to the 100-year flood. However, it could be used for these purposes without heavy flood damage, except during large floods.

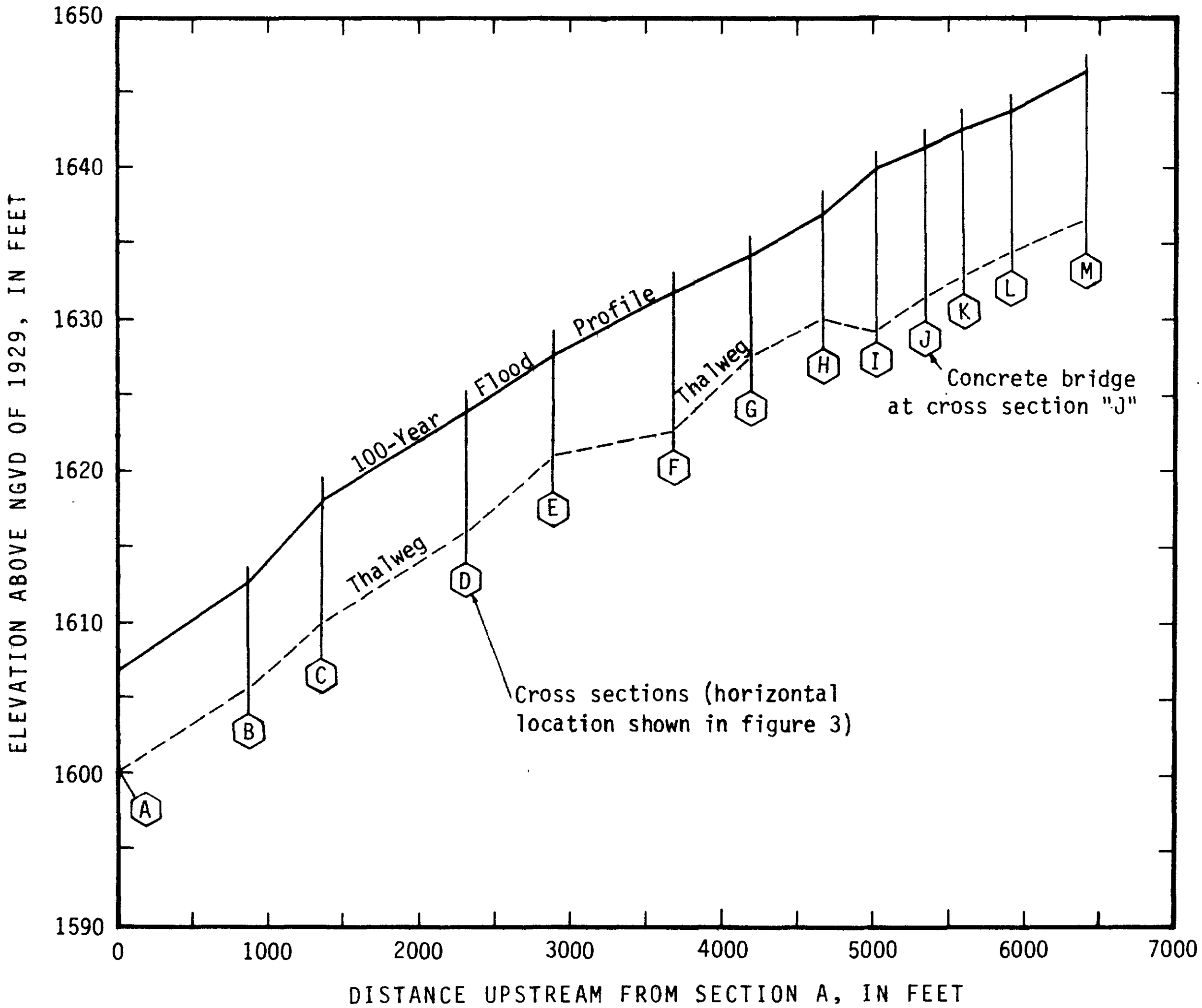

FIGURE 9.--The 100-year flood profile of the Soleduck River in the study area.

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Shearman, J. O., 1976, Computer applications for step-backwater and floodway analysis, Users manual: U.S. Geological Survey Open-File Report 76-499, 103 p.

U.S. Department of Housing and Urban Development, 1980, Flood insurance study, Clallam County, Washington: Federal Insurance Administration, 45 p., 75 pl.