FLOOD PROFILES AND INUNDATED AREAS ALONG THE SKOKOMISH RIVER WASHINGTON

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The Skokomish River will contain flows only as large as 4,650 cubic feet per second downstream from U.S. Highway 101, and the flood plain in this reach is subject to inundation on an average of about 10 days each year. From the highway upstream to the junction of the North and South Forks Skokomish River the river will contain flows as large as 8,900 cubic feet per second; such flows occur nearly every year and have occurred at least six times during one flood season. Storage and diversion at Cushman Dam No. 2 significantly reduces the magnitude of floods of the North Fork, On the main stem, 50- and 100-year floods are estimated to be 29,200 and 32,100 cubic feet per second, respectively. A 100-year flood is estimated to inundate most of the 1- and 2-mile wide valley downstream from river mile 9.0, with flood profiles indicating water-surface elevations of 8.7 feet at river mile 0.0, 26.9 feet at river mile 5.3, and 62.2 feet at river mile 9.0.

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UNITED STATES DEPARTMENT OF THE INTERIOR

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FLOOD PROFILES AND INUNDATED AREAS ALONG THE SKOKOMISH RIVER, WASHINGTON

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ABSTRACT

Flood profiles covering the main stem Skokomish River and reaches of the South and North Forks Skokomish River and Vance Creek were developed as part of a cooperative program with the State of Washington Department of Ecology to identify areas subject to flooding from streams. The main-stem channel of the Skokomish River will contain flows only as large as 4,650 cubic feet per second (132 cubic meters per second) downstream from U.S. Highway 101, and the flood plain in this reach is subject to inundation on an average of about 10 days each year. The main-stem channel between U.S. Highway 101 and the junction of the North and South Forks will contain flows as large as 8,900 cubic feet per second (252 cubic meters per second); such flows occur nearly every year, and have recurred at least six times during one flood season. Flooding is minimal on the three main tributaries above their confluence at river mile 9.0 (kilometer 14.5). Storage and diversion at Cushman Dam No. 2 significantly reduces the magnitude of floods of the North Fork Skokomish River. On the main stem, 50- and 100-year floods are estimated to be 29,200 and 32,100 cubic feet per second (827 and 909 cubic meters per second), respectively. A 100-year flood is estimated to inundate most of the 1- to 2-mile (1.61- to 3.22-kilometers) wide valley downstream from river mile 9.0 (kilometer 14.5), with the flood profiles developed indicating water-surface elevations of 8.7 feet (2.65 meters) at river mile 0.0 (kilometer 0.0), 26.9 feet (8.20 meters) at river mile 5.3 (kilometer 8.53), and 62.2 feet (19.0 meters) at river mile 9.0 (kilometer 14.5).

INTRODUCTION

Flood profiles covering the main stem Skokomish River and reaches of the South and North Forks Skokomish River and Vance Creek were developed as part of a cooperative program with the State of Washington Department of Ecology to identify areas subject to flooding from streams. A summary of the flood-profile data collected on these streams for 1970-72, together with an analysis of flood characteristics, is given for the reaches of the streams studied. The report was prepared in the Tacoma District office under the supervision of L. B. Laird, district chief. The constructive criticism and suggestions of colleagues Donald Richardson and L. L. Hubbard of the Geological Survey materially benefited the report.

DATA-COLLECTION SITES

River-Profile Stations

Crest-stage gages, which record the maximum stage occurring between inspections, were installed in June 1970 at seven locations. Four existing stream-gaging stations also were utilized. The locations of the gages (profile stations) are along the Skokomish River from its mouth to the junction of the North and South Forks at river mile 9.0 (kilometer 14.5)[1] up the North Fork 1.1 miles or 1.77 km (kilometers), along the South Fork 3.2 miles (5.15 km), and along Vance Creek 1.7 miles (2.74 km) upstream from its junction with the South Fork. The locations of the profile stations and river miles are shown in figure 1 and are described in table 1.

Streamflow-Gaging Stations

Augmenting the data gathered at the crest-stage gages are data from gaging stations operated by the Geological Survey in the Skokomish River basin for many years (fig. 1). Table 2 presents descriptions of the four stations more pertinent to this study, with data on maximum discharges.

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[1] See table 3 on page 7 for factors for converting British hydraulic units to metric units.

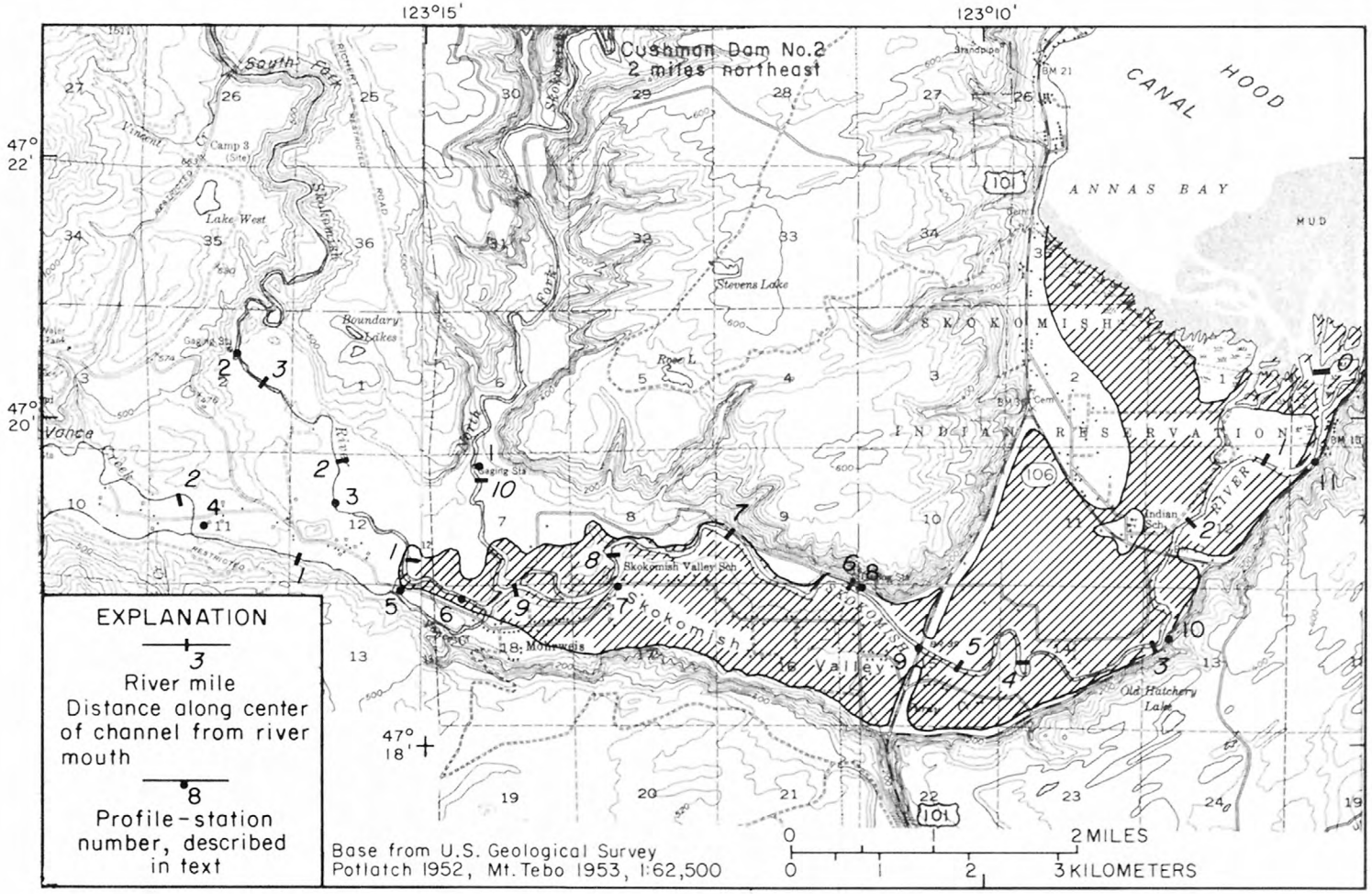

FIGURE 1.--Lower Skokomish River basin, showing river miles, locations of flood-profile stations, and area of flood plain probably subject to inundation during 100-year flood (shown by pattern).

TABLE 1.--River-profile stations

Profile station number	Stream	River mile	Location
1	North Fork (head of Skokomish River)	10.1	USGS gage No. 12059500, in NE¼NW¼ sec.7, T.21 N., R.4 W., on left bank 1.1 mi upstream from junction with South Fork.
2	South Fork	3.2	USGS gage No. 12060500, in SW¼NE¼ sec.2, T.21 N., R.5 W., on right bank.
3	South Fork	1.7	In SE¼NW¼ sec.12, T.21 N., R.5 W., on right bank.
4	Vance Creek	1.7	On south line of NW¼ sec.11, T.21 N., R.5 W., on left bank at downstream side of county road bridge.
5	Vance Creek	0.1	In NW¼NE¼ sec.13, T.21 N., R.5 W., on right bank on downstream side of county road bridge, on the left (main channel) distributary* of the split Vance Creek channels.
6	South Fork	0.3	In NW¼ sec.18, T.21 N., R.4 W., on right bank 0.3 mi upstream from North Fork.
7	Skokomish River	8.2	On line between SW¼ sec.8 and NW¼ sec.17, T.21 N., R.4 W., on right bank.
8	Skokomish River	5.9	In NE¼NE¼ sec.16, T.21 N., R.4 W., on left bank at discontinued gage house No. 12061500.

TABLE 1.--River-profile stations--Continued

Profile station number	Stream	River mile	Location
9	Skokomish River	5.3	USGS gage No. 12061500, in SE¼NW¼ sec.15, T.21 N., R.4 W., on right bank at upstream side of U.S. Highway 101 bridge pier.
10	Skokomish River	2.9	In SW¼NW¼ sec.13, T.21 N., R.4 W., on right bank just upstream from old sheet-metal building.
11	Skokomish River	0.6	In NW¼NW¼ sec.7, T.21 N., R.3 W., on right bank.

*Vance Creek splits into two channels just upstream from profile-station 5. The right distributary channel enters the South Fork at river mile 0.2.

TABLE 2.--Data for selected streamflow-gaging stations, Skokomish River basin

Station number and name	River mile	Drainage area (sq mi)	Years of operation	Maximum discharge	
				ft^3/s	Date
12059500. N.F. Skokomish River near Potlatch (profile-station 1)	10.1	[a]117	1944-49, 1950-present	7,740	Nov. 4, 1955
12060500. S.F. Skokomish River near Union (profile-station 2)	3.2	76.3	1931-present	21,600	Jan. 22, 1935 Nov. 26, 1949
12061000. Vance Creek near Potlatch	[b]3.6	15.6	1955-56	3,840	Nov. 18, 1954
12061500. Skokomish River near Potlatch[c] (profile-station 9)	5.3	[a]227	1943-present	27,000	Nov. 3, 1955

[a]Includes 99 sq mi above Cushman Dam No. 2 which is normally noncontributing.

[b]Listed at mile 4.3 by Pacific Northwest River Basins Commission (1969).

[c]Station operated at river mile 5.9, profile-station 8, prior to 1964.

TABLE 3.--Factors for converting British hydraulic units to metric units

Multiply	By	To get
Inches	2.54	centimeters (cm)
Feet (ft)	.3048	meters (m)
Miles (mi)	1.609344	kilometers (km)
Square miles (mi^2)	2.58999	square kilometers (km^2)
Cubic feet per second (ft^3/s)	.028317	cubic meters per second (m^3/s)

FLOOD DISTRIBUTION

Lower Valley

Three principal streams--the North and South Forks Skokomish River and Vance Creek--join to form the main stem Skokomish River which flows for 9 miles (14.5 km) in the lower valley. Vance Creek, with a drainage area of 24.8 mi^2 (square miles) or 64.2 km^2 (square kilometers) and the South Fork Skokomish, with a drainage of 104 mi^2 (269 km^2) are unregulated. The North Fork (118 mi^2 or 306 km^2 at mouth) is regulated, and at Cushman Dam No. 2 (drainage area 99.2 mi^2 or 257 km^2) the entire flow normally is diverted to a powerplant on Hood Canal. Infrequent spills and releases down the North Fork and natural runoff from about 19 mi^2 (49.2 km^2) below the dam constitute the source of streamflow from this tributary. Potential floodflows from the area upstream from the dam are significantly reduced or excluded by the regulation and diversion.

Overbank flooding was observed during this study in the main stem Skokomish River. (See fig. 6.) Flooding appears to occur first at points downstream from U.S. Highway 101. At a river discharge of 4,650 ft^3/s (cubic feet per second) or 132 m^3/s (cubic meters per second) at profile-station 9,[2] shallow overbank flow was observed to be spreading in the NE¼ sec. 15, the northerly ¾ of sec. 14, the south half of sec. 11, the NW¼ of sec. 12, and the SW¼ of sec. 1, T.21 N., R.4 W. Discharges in the lower reach of the river exceed 4,650 ft^3/s (132 m^3/s) several times each winter and therefore parts of the valley flood plain downstream from U.S. Highway 101 are submerged frequently. From records of flow obtained since 1943 at the U.S. Highway 101 gage, some degree of flooding is estimated to occur in this reach on a yearly average of 1 day in November, 3 days in December, 3 days in January, 2 days in February, and 1 day in March. During the flood of January 20, 1972 (discharge of 18,500 ft^3/s (524 m^3/s) and stage of 26.3 ft (feet) or 8.02 m (meters) at profile-station 9), water was observed at a depth of 8 ft (2.44 m) in some low spots in the E½ of sec.14.

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[2]Water-surface elevations referred to are based on U.S. Coast and Geodetic Survey datum of 1929, supplemental adjustment of 1947.

Upstream from U.S. Highway 101 the channel presently appears to contain flows up to approximately 8,900 ft^3/s (252 m^3/s) at a 24.4 ft (7.44 m) elevation at profile-station 9. At flows greater than this, overbank flooding occurs in the E½ sec. 18, T.21 N., R.4 W., with water overflowing south across the county road. The south riverbank also is topped in secs. 17 and 8, and, at higher flows, in secs. 9 and 16. Specific information was not obtained regarding flooding along the entire county road in N½ sec. 16 and N line sec. 17. Flows greater than 8,900 ft^3/s (252 m^3/s) have occurred at least once each year since 1943, and as many as six times during one year. In only two water years since 1943 (1946 and 1962) was overbank flooding upstream from U. S. Highway 101 considered insignificant at the times of peak annual flows.

The maximum flow since 1943 in the lower reach--27,000 ft^3/s (755 m^3/s)--occurred on November 3, 1955. It is estimated that about 5,800 ft^3/s (164 m^3/s) of the total flow was in the overbank area south of the river channel upstream from U.S. Highway 101. High-water marks at profile-stations 8 and 9 were determined to be 32.0 and 26.6 ft (9.75 and 8.11 m), respectively.

Overflow was measured shortly after the peak flow of November 20, 1959 (22,100 ft^3/s (626 m^3/s), stage 30.9 ft (9.42 m) at profile-station 8). The line on which the overflow measurement was made was along the county road south of profile-station 8 and between secs. 15 and 16. A plot of this cross section is shown in figure 2, indicating the areas where flow was measured and the respective water-surface elevations. The total overflow measured at a stage about 0.3 ft (0.091 m) below the peak was 3,280 ft^3/s (92.9 m^3/s). At this discharge the water surface at the south side of the area was at an elevation 6 to 7 ft (1.83 to 2.13 m) lower than that of the main channel at profile-station 8.

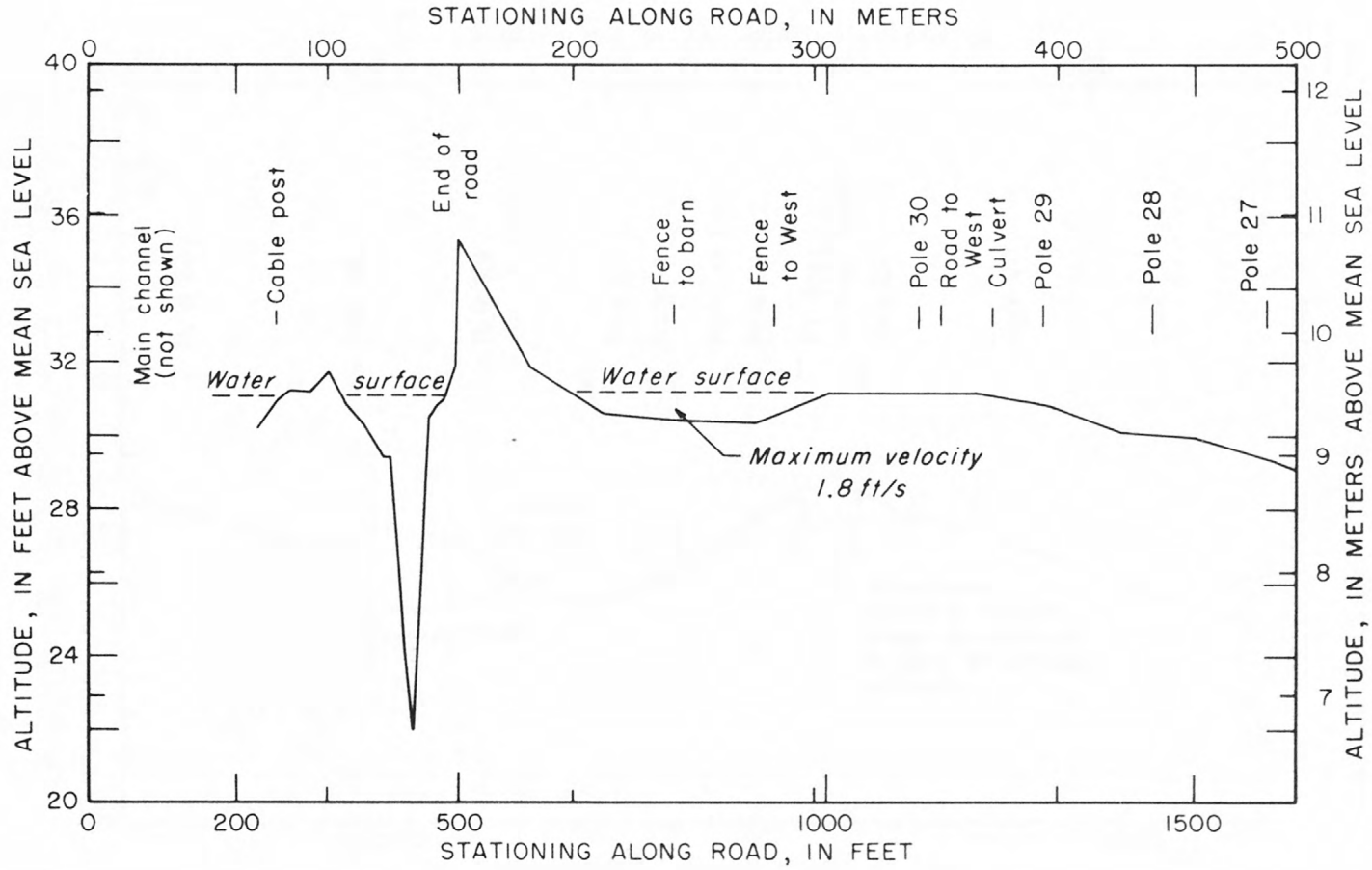

FIGURE 2.--Water-surface profile across Skokomish River flood plain along line between sections 15 and 16, at time of overflow measurement of November 20, 1959.

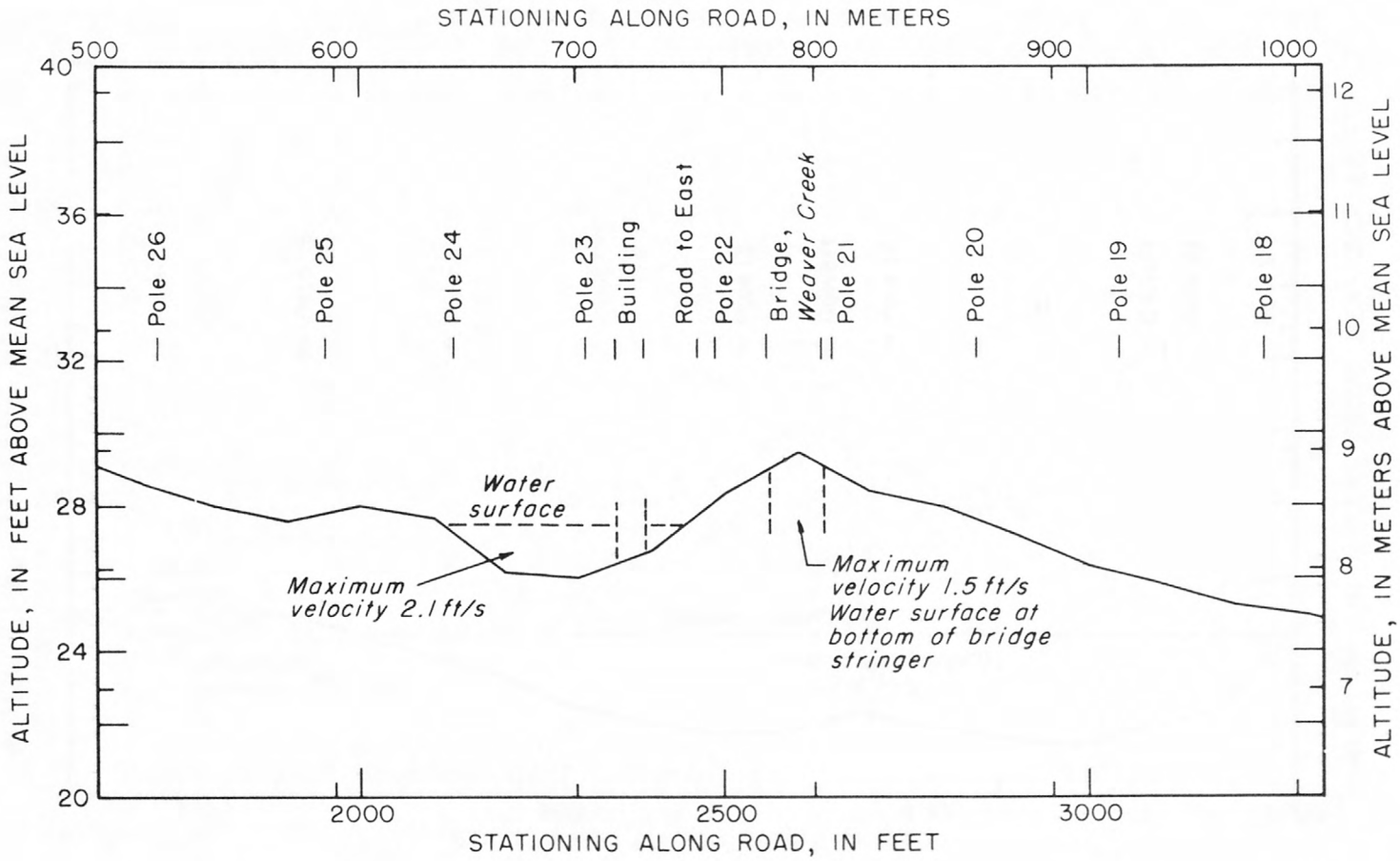

FIGURE 2.--Part 2

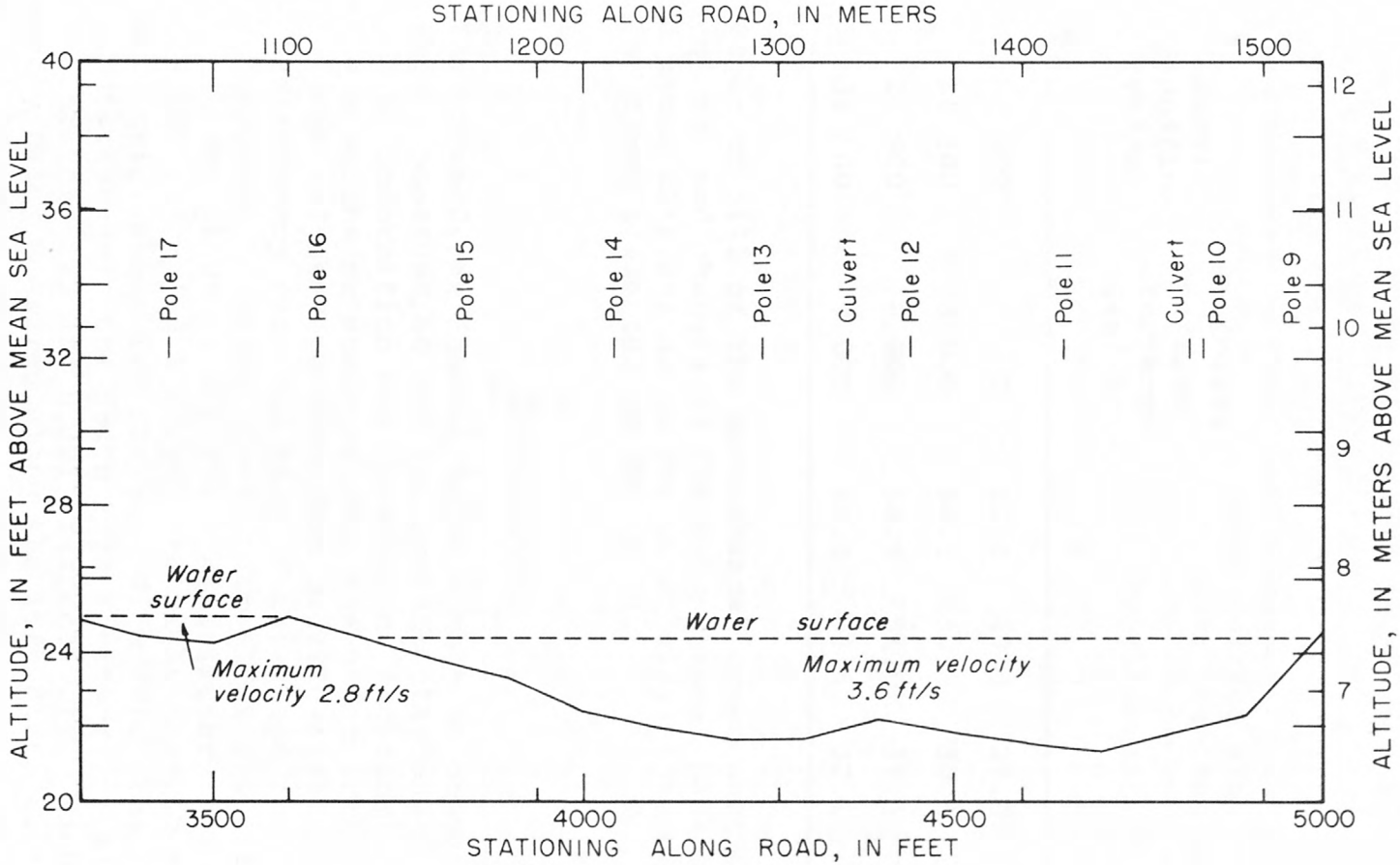

FIGURE 2.--Part 3

The following table gives total flow and estimated overflow south of the main channel and upstream from U.S. Highway 101, as referred to water-surface elevations at profile-stations 6 through 9 for present conditions.

Total floodflow (ft^3/s)	Estimated overflow discharge (ft^3/s)	Water-surface elevation (ft above mean sea level)			
		Profile station			
		6	7	8	9
8,900	0	61.6	49.0	27.8	24.4
18,500	3,000	64.0	50.8	30.6	26.3
25,900	6,000	64.9	51.8	31.5	26.6
31,600	9,000	65.6	52.5	32.1	26.8

Scour or fill of the main-channel cross section, debris or logjams, and changes of the main-channel bank elevations would cause alterations to the water elevations and distribution of flows presented in the table.

Vance Creek

The Vance Creek channel appears able to contain the flood discharges observed at the two profile stations during the study. No information was obtained on flooding between the profile stations or upstream from the upper station. The channel splits just upstream from profile-station 5, with the left distributary carrying most of the flood runoff. The left channel appears to carry flows up to about 2,000 ft^3/s (56.6 m^3/s) before it overflows to the right distributary. When the flow is about 3,500 ft^3/s (99.1 m^3/s), the right distributary is estimated to carry about 100 ft^3/s (2.83 m^3/s). The left and right distributaries join the South Fork at its river miles 0.8 and 0.2 (kilometers 1.3 and 0.32), respectively. With mileages presently being measured along the left distributary, a -0.7 mile (-1.13 km) correction is applicable to river mileages greater than 0.7 (kilometers greater than 1.13) given in the river-mile index for Vance Creek.

Flood of January 20, 1972

The two largest floods during the 1970-72 field study occurred on January 20 and March 5, 1972, and discharged 18,500 ft^3/s (524 m^3/s) and 19,700 ft^3/s (558 m^3/s), respectively, at the U.S. Highway 101 gage (profile-station 9). Elevations at the profile stations for the January 20 flood are given below.

Profile station	Water-surface elevation (ft above mean sea level)
1	69.35
2	110.49
3	87.9
4	106.9
5	70.8
6	63.8
7	50.7
8	30.7
9	26.26
10	14.8
11	9.2

The peak discharges during the flood were 1,920 ft^3/s (54.4 m^3/s) in the North Fork, about 13,700 ft^3/s (388 m^3/s) in the South Fork, and about 4,600 ft^3/s (130 m^3/s) in Vance Creek Because these peak flows were not simultaneous, their sum is greater than the maximum discharge of Skokomish River on January 20.

FLOOD FREQUENCIES

Flood-frequency curves based on annual peaks during the period of streamflow record were developed for profile-stations 2 and 9, using the log-Pearson Type-III method of curve fitting. A flood-frequency curve for the North Fork at profile-station 1 was developed for observed flows as regulated at Cushman Dam No. 2 for the period 1945-71. A flood-frequency curve for Vance Creek was developed by use of the regional-analysis methods given by Bodhaine and Thomas (1964).

The flood-frequency curves indicate recurrence intervals for selected floods at the U.S. Highway 101 gage as follows:

Date	Discharge (ft^3/s)	Recurrence interval (years)
Nov. 3, 1955	27,000	30
Jan. 20, 1972	18,500	4
Mar. 5, 1972	19,700	5.3

Discharges of floods having 50- and 100-year recurrence intervals at various stations are given as follows:

Recurrence interval (years)	Discharge (ft^3/s)				
	Profile station				
	1	2 and 3	4	5	7-11
50	8,000	24,500	5,200	6,200	29,200
100	9,200	26,800	5,800	7,000	32,100

As discussed earlier, joining of the above peak flows from the various tributaries is not simultaneous or directly additive. The peak flow listed for stations 7-11 is not contained within the main channel below station 6. Based on a rating extended above stages of measured overflow, it is estimated that about 7,800 and 9,500 ft^3/s (221 and 269 m^3/s) would be in the overbank flood plain south of station 8 during the 50- and 100-year floods, respectively.

FLOOD PROFILES

At each profile station the projected elevations of floods having recurrence intervals of 50 and 100 years are as follows:

Profile station	Water-surface elevation (ft above mean sea level) Flood-recurrence interval 50 year	100 year
1	74.2	74.9
2	112.4	112.8
3	89.6	90.0
4	107.7	108.1
5	71.9	72.4
6	65.6	66.0
7	52.2	52.5
8	31.9	32.2
9	26.8	26.9
10	15.1	15.2
11	10.0	10.1

The profiles of the flood of January 20, 1972 and the 100-year flood are shown in figures 3, 4, and 5, for the Skokomish River, the North and South Forks Skokomish River, and Vance Creek, respectively.

The elevations for 50- and 100-year floods were determined from logarithmic extensions of the curve of stage-discharge relation that was developed for each of the profile stations. The elevation of water surface at river mile 0.0 (kilometer 0.0) was used as maximum tide level for all profiles. An estimated high tide of 8.4 ft (2.56 m) at Union on January 20 was based on transference of the maximum tide observed at Seattle. An arbitrary value of 8.7 ft (2.65 m) was used for the river level at the mouth of the Skokomish for predicting flood profiles. The tidal influence extends upstream to some point below river mile 5.3 (kilometer 8.5); however, the exact location of the point was not a significant factor. The elevations projected for the 50- and 100-year floods at each profile station are believed to be highly accurate for stations along the North and South Forks and the main stem, and of less accuracy for Vance Creek stations.

The approximate area subject to inundation during a 100-year flood is shown in figure 1.

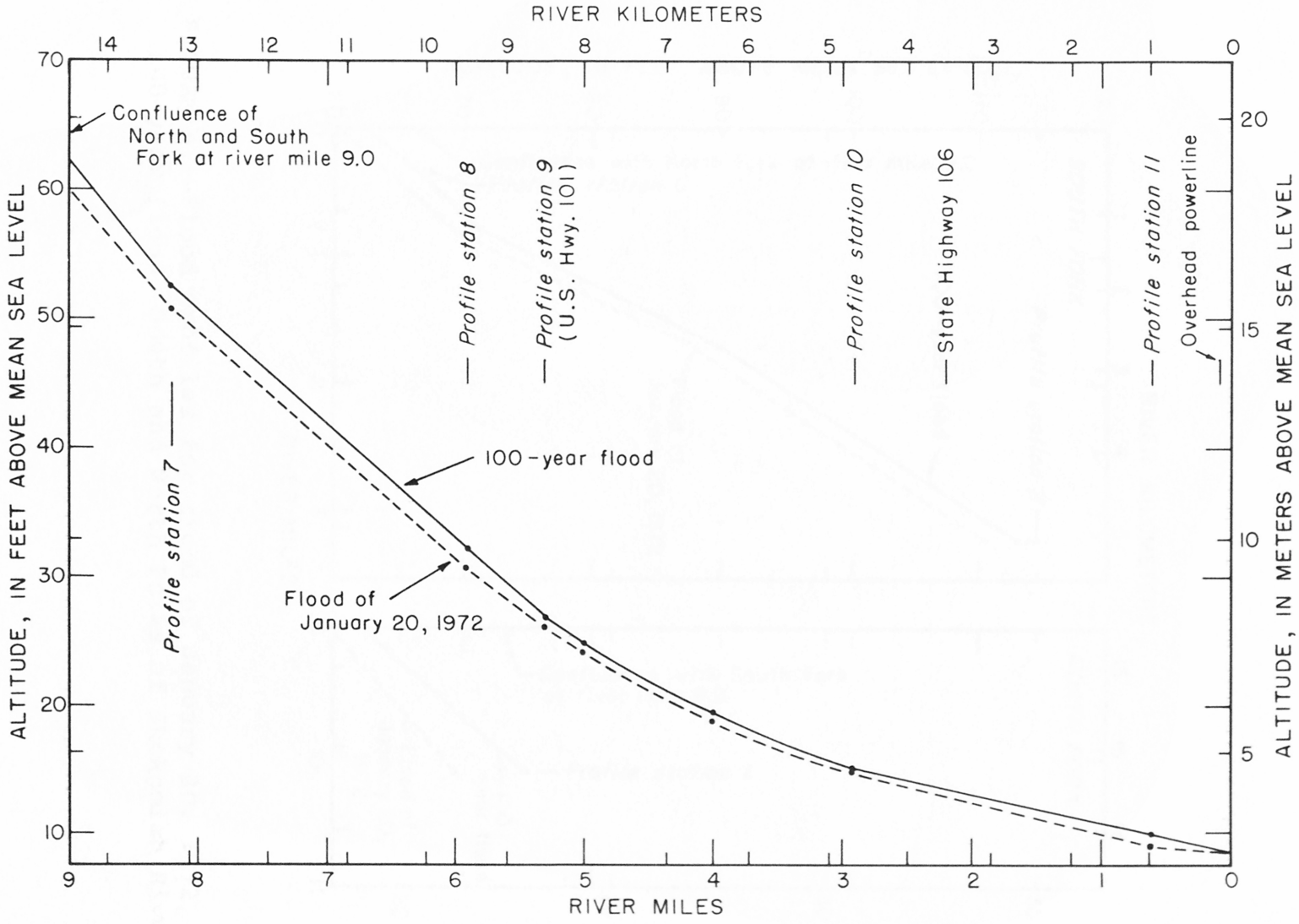

FIGURE 3.--Flood profile for flood of January 20, 1972, and 100-year flood, Skokomish River.

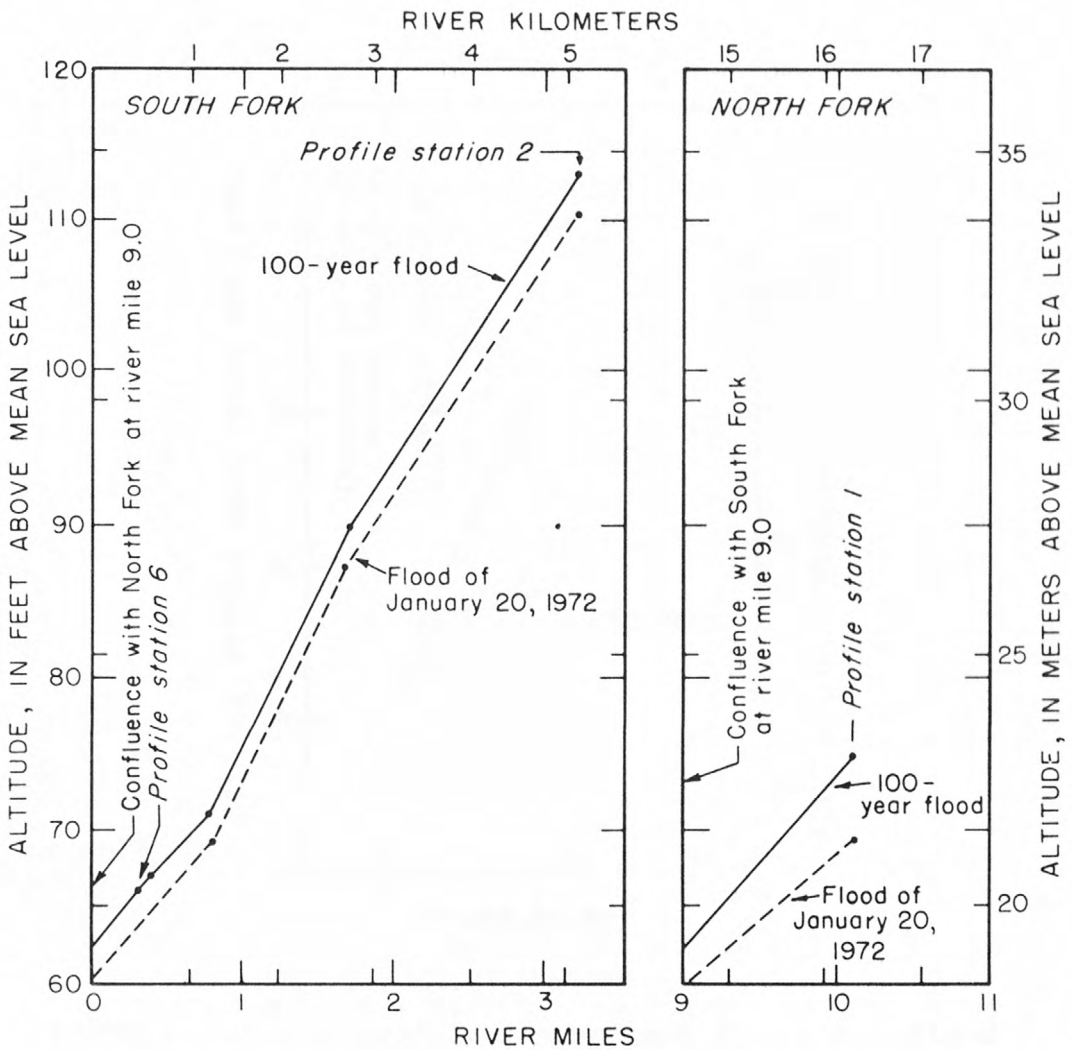

FIGURE 4.--Flood profiles for flood of January 20, 1972, and 100-year flood, South and North Forks of Skokomish River.

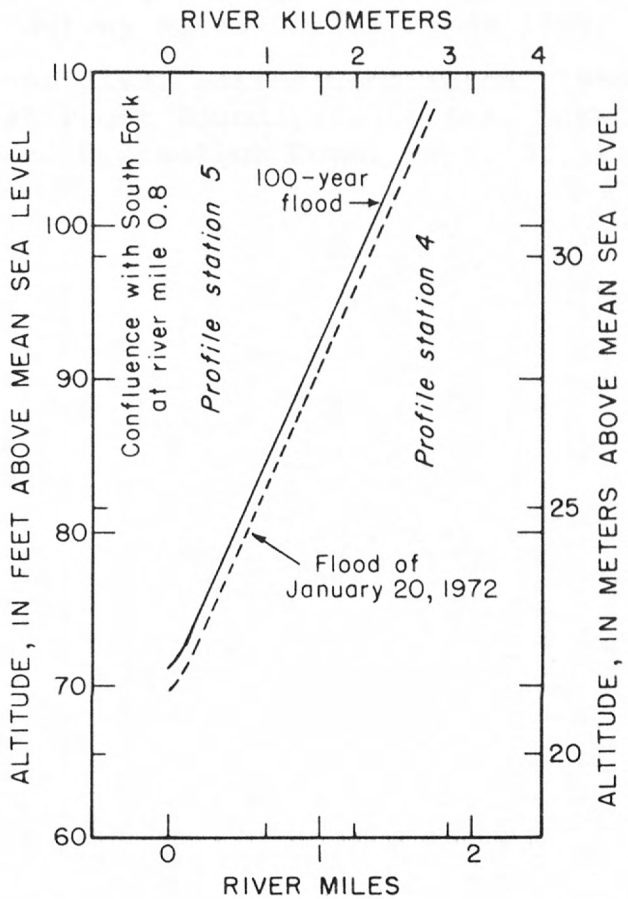

FIGURE 5.--Flood profiles for Vance Creek for flood of January 20, 1972, and 100-year flood.

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