Reach 2, 3 (Map segment 1)

DISTANCE, IN FEET

in Reaches 2, 3, and 5 tend to keep floodwater confined to the main channel, but overtopping floodwater from upstream is confined behind and along the left side of the berms and levees. In addition, the calculated water-surface elevations of the 100- and 500-year flood discharges are greater than the ground elevations along the top of the berms and levees in many locations in Reach 2. Thus, the amount of flood discharge on the left-flood plain continually increases in the downstream direction in Reach 2 as more floodwater from the channel spills over the top of the levees.

In some locations outside the split-flow reaches, the presence of berms and levees may affect the calculated water-surface elevations for the 100- and 500-year flood discharges. Conversely, in other locations outside the split-flow reaches, the presence of berms and levees likely has little effect on calculated water-surface elevations for the 100- and 500-year flood discharges. In order to determine the effect of the berms and levees, water-surface elevations were calculated for the 100- and 500-year flood discharges with levees in place (existing conditions) and with no levees in place (hypothetical conditions). The hypothetical (no-levee) condition was simulated by changing surveyed elevation data (in the model) at cross sections with levees to elevation data that were considered to be more typical of natural ground elevations. Calculated main-channel water-surface elevations for existing and hypothetical conditions are presented in table 4 (sheets 1, 2, and 3). Calculated water-surface elevations for the main channel and left-flood plain in the split-flow reaches are presented in table 5 (sheets

The simulations for the hypothetical (no-levee) condition indicated that split flow was eliminated in all reaches except Reach 7. Consequently, in Reaches 2, 3, and 5, calculated water-surface elevations for both the 100- and 500-year flood discharges were the same in the left-flood plain as in the main channel for the hypothetical (no-levee) condition. Figures 2 and 3 (sheet 1) show typical cross sections and calculated water-surface elevations for both existing conditions and no-levee conditions in Reaches 3 and 5. These figures also show that split-flow conditions no longer exist without the levee. For most cross sections in these reaches, the calculated water-surface elevations for the hypothetical (no-levee) condition are lower than the calculated water-surface elevations in the main channel under existing conditions. At these same cross sections, the calculated water-surface elevations under existing conditions are greater in the main channel than on the left-flood plain. At some cross sections (notably 22, 30, and 31), however, calculated water-surface elevations for the 100- and 500year flood discharges are as much as 1.5 ft higher for the hypothetical (no-levee) condition than for the existing condition. At these cross sections, the calculated water-surface elevations for the 100- and 500year flood discharges under existing conditions were greater on the leftflood plain than in the main channel.

The stream reaches, their hydraulic characteristics, and a more detailed description of the simulations are described in the following sections. The stream reaches and hydraulic calculations in the HEC-RAS model proceed in the upstream direction.

Reach 1 begins at the downstream study limits and includes cross sections 1-17.01. Four bridges cross the Jocko River in this reach (Map segment 1). The gaging station, Jocko River at Dixon (station 12388200), is located just downstream from the bridge at cross section 9. The stage-discharge relation for the gaging station was used to verify calculated water-surface elevations at cross section 9 simulated by the model for the flood discharge equivalent to the 1997 peak discharge. The water-surface elevations for the 100- and 500-year flood discharges at cross section 1 were calculated from the Manning equation using an energy slope (assumed to be equal to the channel-bed slope) of 0.002 ft/ft (Henderson, 1966). Because the energy slope is unknown at cross section 1, the reliability of the calculated watersurface elevations at cross section 1 (table 4) is less than that for other cross sections in this reach.

Cross section 1 is located close to the Flathead River, and calculated water-surface elevations for the Jocko River might be affected by water-surface elevations of the Flathead River. To investigate the potential for backwater effects from the Flathead River, a graphical relation between recorded annual-peak discharges on the Jocko River at Dixon and concurrent daily mean discharges of the Flathead River at Perma (station 12388700) was used to determine likely discharges for the Flathead River at the mouth of the Jocko River concurrent with 100- and 500-year flood discharges for the Jocko River at Dixon. A stage-discharge relation developed for the Flathead River at the mouth of the Jocko River was used to determine the watersurface elevations for the likely discharges. The water-surface elevations for the likely discharges on the Flathead River were substantially less than the calculated water-surface elevations for the Jocko River at cross section 1 based on use of the Manning equation. Thus, backwater effects from the Flathead River were considered to be negligible during 100- and 500-year flood discharges on the Jocko

In general, berms and levees in Reach 1 are discontinuous and low so their effect on calculated water-surface elevations for the 100and 500-year flood discharges is negligible. Thus, calculated watersurface elevations (table 4) are the same for existing and hypothetical (no-levee) conditions.

Reach 2—Split-Flow 1

Levees along the left bank of the Jocko River result in splitflow conditions for model simulations from cross section 17.02 to 23 (Map segment 1). In a shorter reach from sections 17.02 to 17.04, splitflow conditions are unique because simulations indicate that flood discharges can overtop the levee. The hydraulic analyses for the unique conditions (Reach 2, cross section 17.02 to 17.04, split-flow 1) and the split-flow condition in general (Reach 3, cross section 18 to 23, splitflow 2) are both described below. (Split-flow 2 is described in more detail in the section "Reach 3—Split-flow 2".)

simulating flow in two separate flow paths—the main channel and the left-flood plain. To estimate the distribution of flood discharge between the two flow paths, an initial distribution was assumed, and watersurface elevations were calculated in each flow path. The calculated water-surface elevations at the next cross section upstream from the split-flow reach (cross section 24) were compared for the separate analyses using the two flow paths. The distribution of flood discharge between the two flow paths was incrementally adjusted and the simulations were repeated until calculated water-surface elevations in the two flow paths at cross section 24 were the same. Calculated water-surface elevations (table 4) for the main-

For split-flow 1 and 2, hydraulic patterns were analyzed by

channel flow area also were compared with the elevations at the top of the levee to test for levee overtopping. Levee overtopping was considered to be substantial whenever the water-surface elevations for the 100- and 500-year flood discharges were substantially higher (more than about 1 ft) than the top of the levee at two or more adjacent cross sections. For cross sections 17.02 to 17.04 in Reach 2, levee overtopping was substantial, and the distribution of flood discharge between main channel and the left-flood plain was further adjusted to

minimize the overtopping. Thus, the distribution of discharge between from 17.02 to 17.04 (table 3). For the hypothetical (no-levee) condition in Reach 2, the calculated water-surface elevations for the 100-year in Reach 2, the calculated water-surface elevations for the 100-year flood discharge in the main channel are the same as those in the leftflood plain because split-flow conditions do not exist without the levee

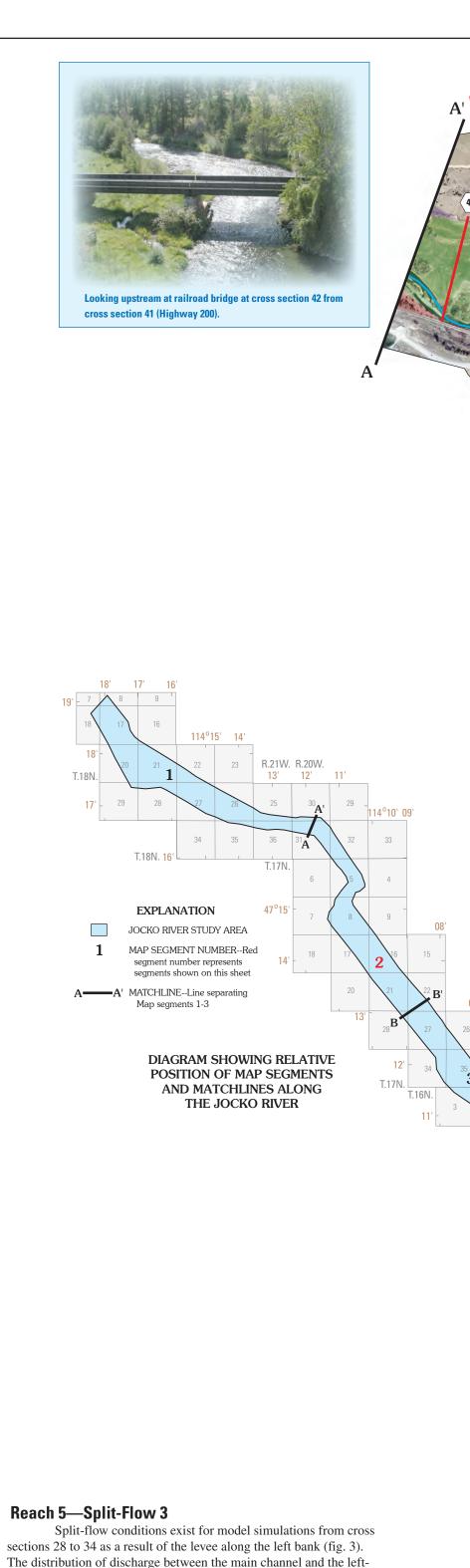
Split-flow hydraulic conditions are inherently complex and difficult to analyze without detailed channel and flood-plain geometry information between cross sections. A more detailed analysis of splitflow conditions and a more precise distribution of flood discharges between the main channel and the left-flood plain were beyond the scope of this study. Nevertheless, the estimated distribution of flood discharge and resultant water-surface elevations (tables 3 and 5) are considered sufficient and accurate to delineate the boundaries of the 100-year and 500-year flood discharge at the map scales used in this

Reach 3—Split-Flow 2

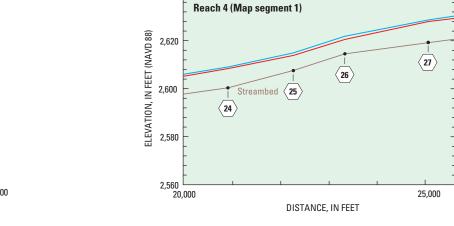
As previously described, split-flow conditions exist for model simulations from cross section 17.02 to 23 as a result of the levee along the left bank. From 18 to 23 (Map segment 1), the distribution of flood discharge between the main channel and the left-flood plain is the same at each cross section because the elevations of the top of the levee generally are at or above the calculated water-surface elevations for the 100- and 500-year flood discharges. Cross section 18 indicates typical channel and flood-plain conditions in this split-flow reach (fig. 2). Abandoned meander channels (shown in fig. 2) exist at many locations along the Jocko River. Most of these channels are not continuous and, thus, do not convey flood flows. Therefore, the water

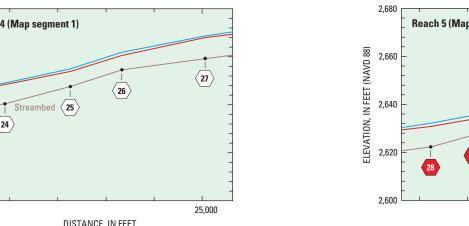
in these abandoned meander channels usually is considered to be ponded and not a part of the flood discharge as used for simulations in this report. Figure 2 shows the calculated water-surface elevations for both existing conditions and no-levee conditions and also shows that split-flow conditions no longer exist without the levee. Calculated water-surface elevations for the 100-year flood discharge are the same in the main channel and on the left-flood plain at each cross section for the simulated hypothetical (no-levee) condition (table 5).

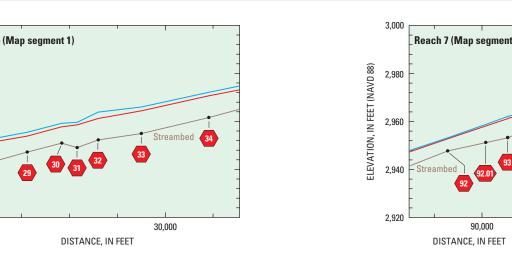
levees are either discontinuous or so low that model simulations do not result in split-flow conditions for the 100- and 500-year flood discharges. Thus, for Reach 4, the calculated water-surface elevations for the existing condition for the 100- and 500-year flood discharges are the same in the left-flood plain as the main channel. However, the levee at cross section 25 does result in higher calculated water-surface elevations for the existing condition than for the hypothetical (no-levee) condition (table 4).

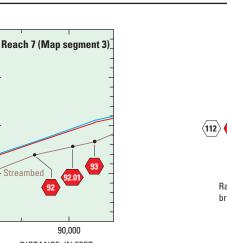


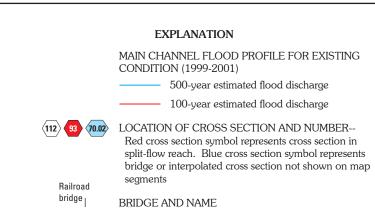
100 200 300 DISTANCE FROM LEFT EDGE, IN FEET EXPLANATION CALCULATED WATER SURFACE FOR 500-YEAR FLOOD DISCHARGE (existing and hypothetical conditions) CALCULATED WATER SURFACE FOR 100-YEAR FLOOD DISCHARGE (existing and hypothetical conditions) Figure 4. Cross section 63, which is typical of narrow channel and flood-plain conditions in Reach 6 along the Jocko River, western Montana.





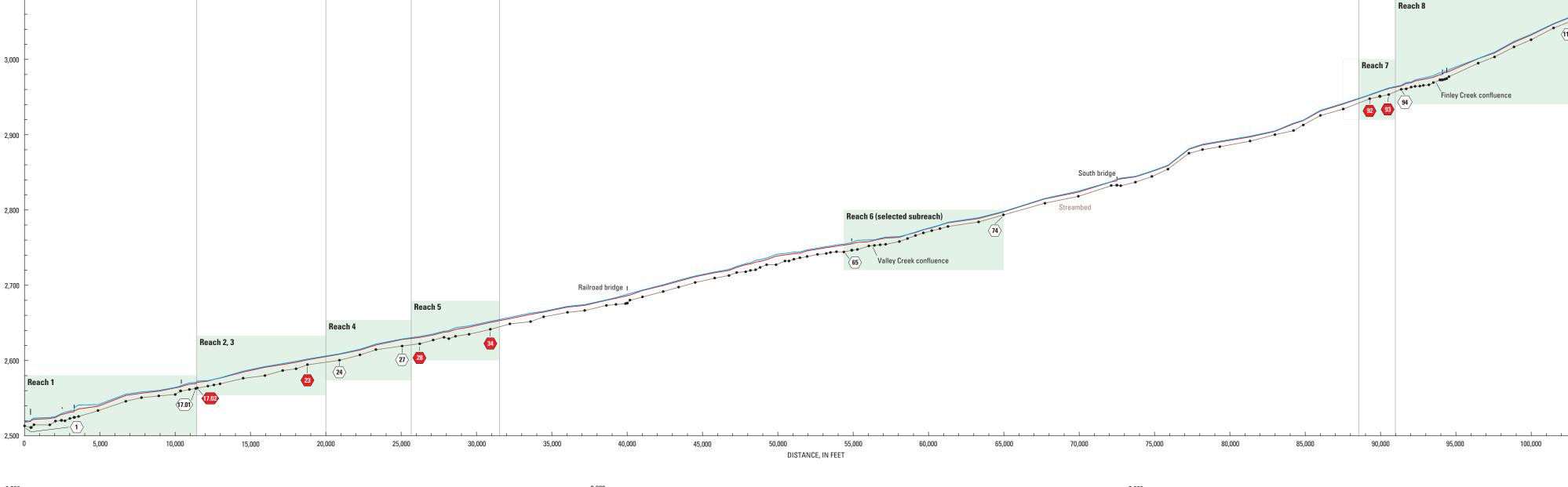






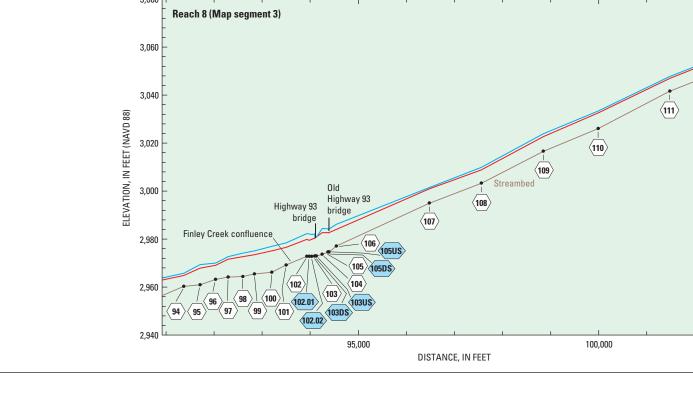
SCIENTIFIC INVESTIGATIONS MAP 2912

Chase and Parrett, 2006, Water-surface elevations and boundaries of the 100-year and 500-year floods and floodway for the Jocko River, western Montana



Reach 1 (Map segment 1) Reach 6 (selected subreach, Map segment 2) DISTANCE, IN FEET DISTANCE, IN FEET

GRAPHS SHOWING FLOOD PROFILES, STREAMBED ELEVATIONS, AND LOCATIONS OF REACHES, CROSS SECTIONS, AND BRIDGES ALONG THE JOCKO RIVER



EXPLANATION

FLOODWAY--Existing conditions (1999-2001)

NATIONAL GEODETIC SURVEY BENCH MARK AND NAME

and Kootenai Tribes of the Flathead Nation

——— CHANNEL CENTERLINE

CROSS SECTION AND NUMBER

AREA INUNDATED BY THE 100-YEAR ESTIMATED FLOOD

DISCHARGE--Includes floodway where floodway data were

AREA INUNDATED BY THE 500-YEAR ESTIMATED FLOOD

DISCHARGE--Includes the area inundated by the 100-year

ELEVATION-CONTROL POINT AND NAME--Data from Confederated Salish

SCALE 1:12,000

U.S. GEOLOGICAL SURVEY STREAMFLOW-GAGING STATION AND NUMBER

calculated water-surface elevations for the 100- and 500-year flood discharges at most of the cross sections. As in Reaches 2 and 3, an initial distribution of discharge between the two flow paths was assumed, and water-surface elevations were calculated for each flow path at each cross section. The distribution of discharge was incrementally adjusted and simulations were repeated until calculated water-surface elevations in the two flow paths at the next cross section upstream from the split-flow reach (cross section 35) were the same.

bank flood plain in Reach 5 is the same at each cross section, primarily

because the elevations at the top of the levee are at or above the

Reach 6, the longest in the study area, extends from cross section 35 upstream to cross section 91 (Map segments 1, 2, and 3). A railroad and a highway bridge cross the Jocko River at cross sections 41 and 42, respectively, but the highway bridge abutments and piers are well outside the flood plain and, thus, hydraulic data for these structures were not needed for the simulations. The channel and flood plain are relatively wide between cross sections 35 and 49.5, but both are relatively narrow from cross section 49.5 through cross section 65 (Map segment 2). Figure 4 (sheet 2) shows cross section 63, which is typical of the narrow channel and flood plain in this area. Both Spring Creek and Valley Creek enter the Jocko River near cross sections 68 and 69. The channel and flood plain widen again just downstream from the Valley Creek and Spring Creek confluences, and a wide flood plain with multiple channels is prevalent from cross section 69 upstream to the end of the reach (Map segments 2 and 3). Figure 5 (sheet 2) shows cross section 77, where the flood plain is wide with multiple channels, and figure 6 (sheet 2) shows cross section 78US at the South bridge, where calculated water-surface elevations indicate that the 100- and 500-year floods can overtop the road on both the left and right bank. For Reach 6, results in table 4 indicate that calculated watersurface elevations for the existing condition generally are not substantially different from those for the hypothetical (no-levee) conditions for both the 100-year and 500-year flood discharge. At cross section 51, however, calculated water-surface elevations for the 100and 500-year flood discharges for existing conditions are 1.2 and 1.1 ft higher, respectively, than those for the no-levee conditions.

Reach 7—Split-Flow 4

Split-flow conditions exist for model simulations in the short reach from cross section 92 to cross section 93 (Map segment 3). Floodwater that overtops the left bank in Reach 7, where the levee is largely absent or too discontinuous to have a substantial effect on floodflows, flows into an abandoned meander channel that has a lower streambed elevation than the streambed elevation in the main channel (fig. 7, sheet 3). Model simulations indicate that floodwater within the meander channel eventually joins floodwater in the main channel upstream from cross section 91.

The portions of 100- and 500-year flood discharges that overtop the left bank in this split-flow reach were calculated with the split-flow optimization routine and lateral-weir equations within the HEC-RAS model. Water-surface elevations for floodwater in the meander channel and in the main channel then were simulated separately. Water-surface elevations for the shallow flooding between the main channel and the meander channel are indeterminate, but flood depths in this area probably range from 1 to 2 ft. Calculated watersurface elevations for the 100- and 500-year flood discharges at each cross section are the same for the existing condition and the hypothetical (no-levee) condition in this split-flow reach (table 5).

Reach 8 extends from cross section 94 upstream to cross

section 112 at the study area boundary near the fish hatchery (Map segment 3). The channel and flood plain are very narrow from cross section 94 to cross section 101 (fig. 8, sheet 3), just downstream from the mouth of Finley Creek. From cross section 101 to the bridge at cross section 103, the flood plain widens slightly. Upstream from the bridge on old Highway 93 at cross section 105 (Map segment 3), the flood plain widens considerably and typically has multiple channels. This flood-plain condition continues upstream from cross section 105 to cross section 112 (fig. 9, sheet 3). Berms and levees in Reach 8 are discontinuous and generally low, and model simulations indicate that split-flow does not occur. At some locations, however, simulations show that water-surface elevations for the 100- and 500-year flood discharges are different for

the existing condition than for the hypothetical (no-levee) condition

hypothetical (no-levee) condition than for the existing condition (table

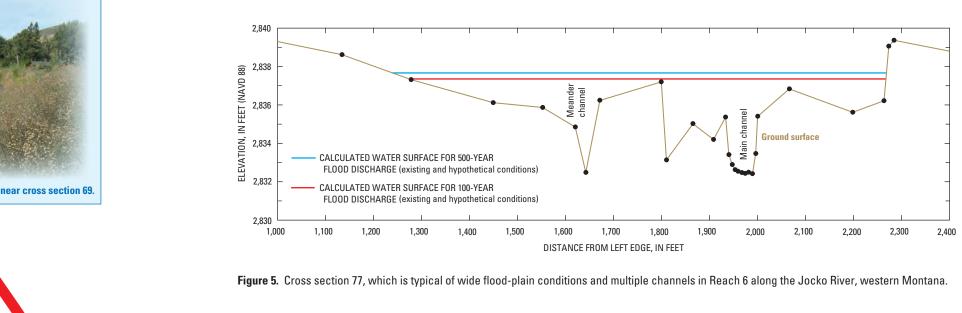
4). Likewise, the calculated water-surface elevation for the 500-year

flood discharge at cross section 97 is 1.9 ft lower for the hypothetical

condition than for the existing condition (table 4).

(table 4). For example, calculated water-surface elevation at cross

section 97 for the 100-year flood discharge is 1.7 ft lower for the



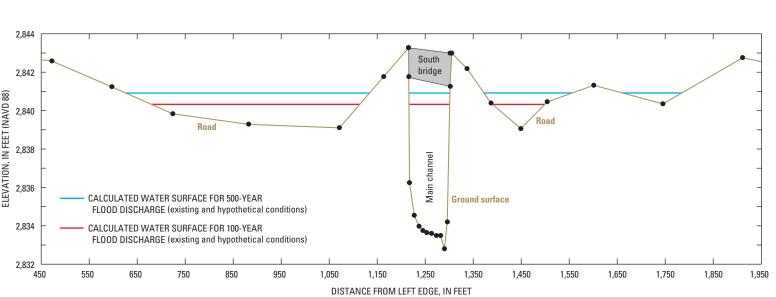


Figure 6. Cross section 78US (not shown on Map segment 2), which shows the upstream side of South bridge in Reach 6 along the Jocko River, western Montana.

The 100-year and 500-year flood discharges can overtop the road on both the left and right banks.

Table 4. Streambed- and calculated water-surface elevation data for the main channel of the Jocko River,

Cross section ¹	Distance upstream from cross section 1, in thousands of feet	Minimum streambed elevation, in feet	Calculated water-surface elevation, in feet, for indicated flood discharge and condition			
			100-year flood discharge		500-year flood discharge	
			Existing condition (with levee)	Hypothetical condition (no levee)	Existing condition (with levee)	Hypothetica condition (no levee)
		Reach 6 (N	Map segment 2) —	Continued		
40	38.62	2,673.2	2,679.8	2,679.5	2,680.6	2,680.1
41	39.89	2,675.7	2,685.6	2,685.6	2,687.3	2,687.3
42	39.99	2,676.2	2,685.9	2,686.1	2,687.7	2,688.0
42 DS ²	39.99	2,676.2	2,685.9	2,686.1	2,687.6	2,687.9
42 US ²	40.01	2,676.2	2,686.5	2,686.3	2,688.4	2,688.0
43	40.18	2,680.1	2,687.0	2,687.1	2,689.1	2,689.2
44	41.01	2,684.5	2,693.0	2,693.0	2,693.7	2,693.7
45	42.39	2,691.6	2,699.5	2,699.5	2,700.7	2,700.6
46	43.41	2,697.4	2,705.2	2,705.4	2,706.6	2,706.4
47	44.51	2,703.7	2,711.2	2,710.9	2,712.4	2,712.2
48	45.80	2,709.5	2,716.5	2,715.9	2,717.6	2,717.0
49	46.75	2,712.9	2,719.6	2,719.5	2,721.0	2,720.5
49.5	47.26	2,716.9	2,723.7	2,722.8	2,725.0	2,724.3
50	47.86	2,717.9	2,727.2	2,726.4	2,728.7	2,728.0
51	48.18	2,719.7	2,728.3	2,727.1	2,729.9	2,728.8
52	48.52	2,720.3	2,730.6	2,730.6	2,733.0	2,733.2
53	48.82	2,723.7	2,731.6	2,731.6	2,734.0	2,734.1
54	49.25	2,727.2	2,734.0	2,734.0	2,736.0	2,736.0
55	49.88	2,727.2	2,738.7	2,738.7	2,741.1	2,741.1
56	50.47	2,732.1	2,740.3	2,740.3	2,742.3	2,742.3
57	50.74	2,732.2	2,741.0	2,741.0	2,742.8	2,742.8
58	51.06	2,734.5	2,742.0	2,742.0	2,743.8	2,743.8
59	51.46	2,736.5	2,742.7	2,743.1	2,744.2	2,744.7
60	51.94	2,738.1	2,745.7	2,745.9	2,746.9	2,747.2
61	52.63	2,741.0	2,748.1	2,748.1	2,749.3	2,749.4
62	53.21	2,742.1	2,749.8	2,749.8	2,751.2	2,751.2
63	53.49	2,743.5	2,750.6 2,752.1	2,750.6 2,752.0	2,752.0 2,753.5	2,752.0 2,753.4
64 65	53.89 54.38	2,744.5				
65 66	54.90	2,744.2 2,746.4	2,753.2 2,755.1	2,753.4	2,754.5 2,756.7	2,754.9
66 DS ²		2,746.4	2,755.1	2,755.0		2,756.6
66 US ²	54.90 54.92	2,746.4		2,755.0 2,755.1	2,756.7 2,756.9	2,756.6 2,756.9
66 US 67	54.92 55.28	2,746.4 2,747.4	2,755.2 2,757.1	2,755.1 2,757.1	2,756.9 2,759.7	2,756.9 2,759.7
68	56.04	2,747.4	2,758.0	2,758.0	2,760.3	2,760.3
69	57.16	2,754.3	2,762.7	2,762.7	2,763.9	2,763.9
70	58.06	2,758.0	2,763.7	2,763.7	2,764.6	2,763.9
70	59.66	2,769.5	2,773.6	2,773.6	2,773.9	2,773.9
72	61.29	2,777.9	2,782.9	2,782.9	2,773.9	2,773.9
73	63.32	2,784.0	2,782.9	2,788.8	2,789.6	2,789.6
74	64.97	2,793.4	2,797.5	2,797.5	2,797.8	2,797.8
75	67.72	2,808.8	2,814.6	2,814.6	2,815.3	2,815.2
76	69.94	2,818.1	2,823.7	2,823.6	2,825.0	2,825.0
77	72.13	2,832.4	2,837.5	2,837.4	2,8 37.8	2,837.7
78	72.49	2,832.8	2,839.5	2,839.4	2,840.9	2,840.7
78 DS ²	72.49	2,832.8	2,839.6	2,839.4	2,840.9	2,840.9
78 US ²	72.51	2,832.8	2,840.3	2,840.3	2,840.9	2,840.9
79	72.75	2,832.1	2,841.4	2,841.5	2,842.4	2,842.4
80	73.73	2,836.9	2,843.9	2,843.8	2,844.6	2,844.6
81	74.82	2,844.5	2,850.9	2,850.8	2,851.5	2,851.5
82	75.89	2,854.2	2,858.6	2,858.1	2,859.3	2,858.7

Table 6. Floodway data for the Jocko River, western Montana. Continued
[Floodway determined for Reaches 1, 4, 5, 6, and 8 for existing (1999-2001) conditions. Floodway width was expanded to equal the width of the 100-year flood area at all cross sections in split-flow Reaches 2, 3, and 7. Vertical coordinate information referenced to North American Vertical
Datum of 1988 (NAVD 88). Abbreviations: DS downstream side of bridge US unstream side of bridge US

Cross section (Map segments 1-3)	Width of the 100-year flood area, in feet ¹	Floodway width, in feet ¹	water-surface elevation for the 100-year flood discharge, in feet	Calculated water-surface elevation with encroachment, in feet	Increas water-su elevati in fee				
Reach 6 (Map segment 2) — Continued									
40	1,050	900	2,679.8	2,679.9	.1				
41	160	100	2,685.6	2,685.6	.0				
42	130	130	2,685.9	2,685.9	.0				
42 DS ²	120	120	2,685.9	2,685.9	.0				
42 US ²	120	120	2,686.5	2,686.5	.0				
43	190	190	2,687.0	2,687.0	.0				
44	610	400	2,693.0	2,693.0	.0				
45	640	330	2,699.5	2,699.7	.2				
46	500	90	2,705.2	2,705.2	.0				
47	700	100	2,711.2	2,711.4	.2				
48	710	330	2,716.5	2,716.8	.3				
49	550	130	2,719.6	2,719.6	.0				
49.5	400	100	2,723.7	2,723.8	.1				
50	190	100	2,727 2	2,727.2	.0				
51	70	70	2,728.3	2,728.3	.0				
52 53	110	80 160	2,730.6	2,730.6	.0				
	160		2,731.6	2,731.8					
54	70	70	2,734.0	2,734.0	.0				
55	270	150	2,738.7	2,738.8	.1				
56 57	270 250	260 160	2,740.3	2,740.6	.3				
	300	300	2,741.0 2,742.0	2,741.1 2,742.3	.3				
58 59	310	240	2,742.0 2,742.7	2,742.3 2,742.7	.0				
60	290	260	2,742.7	2,742.7	.0				
61	300	300	2,748.1	2,743.8	.0				
62	320	320	2,749.8	2,749.8	.0				
63	280	240	2,750.6	2,750.6	.0				
64	280	280	2,752.1	2,752.1	.0				
65	160	130	2,753.2	2,753.2	.0				
66	80	80	2,755.1	2,755.1	.0				
66 DS ²	80	80	2,755.1	2,755.1	.0				
66 US ²	80	80	2,755.2	2,755.2	.0				
67	450	320	2,757.1	2,757.1	.0				
68	1,050	400	2,758.1	2,758.0	.0				
69	1,070	1,070	2,762.7	2,762.7	.0				
70	1,450	1,450	2,763.7	2,763.7	.0				
71	1,500	1,500	2,773.6	2,773.6	.0				
72	1,900	1,900	2,773.0	2,782.9	.0				
73	2,100	1,080	2,788.8	2,788.8	.0				
74	2,000	1,300	2,797.5	2,797.5	.0				
75	1,310	440	2,814.6	2,814.9	.3				
76	950	280	2,823.7	2,823.7	.0				
77	990	990	2,837.5	2,837.5	.0				
78	980	800	2,839.6	2,839.6	.0				
78 DS ²	980	800	2,839.6	2,839.6	.0				
78 US ²	980	800	2,839.0	2,839.0					
	980 980			*	.1				
79		660	2,841.4	2,841.4	.0				
80	520	280	2,843.9	2,843.9	.0				
81 82	1,300 930	300 240	2,850.9 2,858.6	2,851.4 2,858.6	.5 .0				

in meander channels (no effective conveyance of floodwater)

² Cross sections not shown on map segments.

Katherine J. Chase and Charles Parrett

Looking downstream at South bridge at cross section 78.

Aerial-photographic base (scanned) from Water Consulting, Inc.,

for the Confederated Salish and Kootenai Tribes of the Flathead

Nation, 1:3,600, 2002. Imagery flown by MAP, Inc. Lambert Conformal

Conic Projection State Plane Coordinate System (SPCS) Standard parallels

45°00' and 49°00'; central meridian -109°30'. North American Datum of 1983